240141 - Machine and Mechanism Theory

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 Compulsory)
BACHELOR'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2011). (Teaching unit Optional)
ECTS credits: 6
Teaching languages: Catalan, Spanish

Teaching staff
Coordinator: SALVADOR CARDONA FOIX

Degree competences to which the subject contributes

Specific:
1. Knowledge on machines and mechanisms theory principles.
2. Knowledge and capacities to calculate, design and test machines.

Teaching methodology

The teaching load of the course is 6 ECTS; 5 of which are taught in slate lectures, theory and problems, in nominally groups of around 75 students; the remaining credit is taught in lab classes in groups of around 25 students.

In slate lectures, twice a week in one and a half hours, the basic theory concepts are exposed with the support of teaching material and a good number of examples. Exercises are presented, analysed and solved often inspired in real situations and are proposed to be done as personal work.

In lab classes, five during the semester and each two hours long, practices are carried out with material available in the Machines Lab, the program of analysis of machinery is introduced which is used in an exercise of simulation of mechanism.

The additional personal dedication to the slate and lab lectures is expected of 90 hours uniformly divided throughout the course but with slightly more emphasis on the last issues.

Simulation exercise
Is an exercise based in the cinematic and dynamic analysis of a mechanical system mechanism which is due to help the professors. It is developed during the course and must be handed in November 30th. To perform it some concepts must be taken into account:
- Must be performed in groups of 3 students
- The report must have a length of 3 pages with a format that conforms the guidelines which can be found on the subject's website.

Practices
P1 Mechanism of a sewing machine. Schematization
P2 Simulation by computer of mechanisms. Mechanism analysis.
P3 Simulation exercise
P4 Machinery elements. Analysis of various mechanisms.
P5 Gear box and differential in an automobile

Practices P1, P4 and P5 are carried out in the Machinery Lab (Laboratori de Màquines). G Pavilion Floor -1 and practices P2 and P3 will be carried out in the Transports Lab. F Pavilion Floor 1.
240141 - Machine and Mechanism Theory

Learning objectives of the subject

General objectives
- To integrate the Theory of Machines and Mechanisms in Engineering studies using prior knowledge taught in previous subjects, working the capabilities of engineering and making it attractive and useful for students, willing or not to opt for a mechanical profile.
- To sensitize the students about the relationship between technology and society by analyzing the role of machines in this binomial and the sustainability of the current model of human activity.

Specific objectives
- Doing the kinematic, static and dynamic analysis of the mechanisms and machines, from the concepts of rigid body mechanics and using the basic and operational tools.
- Using computer applications for the calculation and the simulation of mechanisms.
- Recognizing the mechanical components and basic mechanical groups of the machines and mechanisms from examples taken of real situations.
- Doing the energy balances and calculations of performance applied to the machines.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group:</th>
<th>50h</th>
<th>33.33%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Hours small group:</td>
<td>10h</td>
<td>6.67%</td>
</tr>
<tr>
<td></td>
<td>Guided activities:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Self study:</td>
<td>90h</td>
<td>60.00%</td>
</tr>
</tbody>
</table>
# 240141 - Machine and Mechanism Theory

## Content

<table>
<thead>
<tr>
<th>1 MACHINE AND MECHANISM</th>
<th>Learning time: 10h 30m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 4h 30m</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 6h</td>
</tr>
</tbody>
</table>

**Description:**

**Related activities:**

<table>
<thead>
<tr>
<th>2 MOBILITY</th>
<th>Learning time: 13h 30m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 5h 30m</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 2h</td>
</tr>
<tr>
<td></td>
<td>Self study: 6h</td>
</tr>
</tbody>
</table>

**Description:**

**Related activities:**
Practice 2: Elements of machines. Analysis of various mechanisms.

<table>
<thead>
<tr>
<th>3 KINEMATICS OF MECHANISMS</th>
<th>Learning time: 29h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 10h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 4h</td>
</tr>
<tr>
<td></td>
<td>Self study: 15h</td>
</tr>
</tbody>
</table>

**Description:**

**Related activities:**
Practice 3: Simulation of mechanism by computer. Analysis of a mechanism. Tutoring session 1: Explanation of course project.
### 4 GEAR AND GEAR TRAINS

| Learning time: | 15h 30m |
| Theory classes: | 4h 30m |
| Laboratory classes: | 2h |
| Self study: | 9h |

**Description:**
- Gears
- Gearing condition
- Conjugated profiles
- Involute and cycloidal profiles
- Pressure line and pressure angle
- Gear Types
- Fixed gear and planetary gear trains
- Velocities ratio
- Differential mechanism

**Related activities:**
- Practice 4: Gearbox and differential of a car

### 5 DYNAMIC ANALYSIS

| Learning time: | 18h 30m |
| Theory classes: | 4h 30m |
| Laboratory classes: | 2h |
| Self study: | 12h |

**Description:**
- Vectorial theorems
- Free body diagram
- D'Alembert's inertia forces
- Direct and inverse dynamic analysis of mechanisms
- Solution using matrices
- Static and dynamic balance of rotors
- Balance of mechanisms

**Related activities:**
- Tutoring session 2: Analysis of the normalized representation of the chosen mechanism

### 6 CONTACT FORCE. CONSTRAINT FORCE. PASSIVE RESISTANCES

| Learning time: | 16h |
| Theory classes: | 7h |
| Self study: | 9h |

**Description:**
- Constraint forces and passive resistances
- Resistance to sliding, rolling and pivoting motions
- Friction and rolling resistance models
- Extreme conditions in the kinematic pairs
- Wedging in guides and joints
- Mechanisms based on friction
<table>
<thead>
<tr>
<th><strong>7 VIRTUAL POWER METHOD</strong></th>
<th><strong>Learning time:</strong> 22h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 7h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 15h</td>
</tr>
</tbody>
</table>

**Description:**
Virtual power associated to a system of forces. Virtual Motions. Obtaining motion equations and constraint forces. Generalized forces.

**Related activities:**
Tutoring session 3: Presentation of results of the simulation of the studied mechanism.

<table>
<thead>
<tr>
<th><strong>8 WORK AND POWER IN MACHINES</strong></th>
<th><strong>Learning time:</strong> 25h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 7h</td>
</tr>
<tr>
<td></td>
<td>Self study: 18h</td>
</tr>
</tbody>
</table>

**Description:**
### Planning of activities

**COURSE PROJECT**

**Description:**
- It is a project that must be presented and defended at the end of the course. For its development it must be taken into account:
  - It provides a teaching load of 25 hours per student.
  - The project must be done in groups of 3 students. Each of these groups will have 6 tutoring sessions of 1.5 hours throughout the semester.
  - The defense, which needs the participation of all the members of the group, has a duration of 30 minutes and will take place the last days of the course in a timetable that will be definite.

---

**PARTIAL EXAM**

**Description:**
- Assessment of knowledge.

**Descriptions of the assignments due and their relation to the assessment:**
- Solved exam.

---

**FINAL EXAM**

**Description:**
- Assessment of knowledge.

**Descriptions of the assignments due and their relation to the assessment:**
- Solved exam.

---

**Qualification system**

The final mark, $N_{final}$, rounded to the decimal point, will be the following weighted average:

$$N_{final} = \max(0.6 \cdot N_{ef} + 0.2 \cdot N_{parcial}, 0.8 \cdot N_{ef}) + 0.1 \cdot (\sqrt{N_{pràct} \cdot 4 \cdot 5 \cdot N_{exer}} + N_{pràct} \cdot 1 \cdot 2 \cdot 3)$$

where:
- $N_{final}$: final mark
- $N_{ef}$: mark of the final exam. The final exam will consist on a set of exercises of similar valuation. For its performance, three hours will be given.
- $N_{parcial}$: Mark of the partial exam. The partial exam will consist on a set of exercises of similar valuation. For its performance an hour and a quarter will be given.
- $N_{pràct}$: Mark of the practical exam which will be done the same time as the final exam.
- $N_{exer}$: Mark of the mechanism simulation exercise.
Regulations for carrying out activities

During the evaluations:
- Regarding to written material, students can only dispose of an A4 original manuscript, with the contents deemed necessary.
- Calculator and basic tools for writing are essential (pencil, rubber) so as to help neatness in presentation.
- It is forbidden to use any storage device or information transmission, mobile phone or other.
- Questions to professors may refer only to the comprehension of the statement.

Neatness, conciseness and accuracy while doing the exercises is valued.
To obtain the highest mark possible in an exercise, the numeric values must be found and indicate their units.

Bibliography

Basic:

Complementary:

Others resources:
Collection of problems and solved examples and other material:
http://www.em.upc.edu/docencia/estudis_grau/etseib/teoria_maquines