240IME11 - Machine Elements Calculation

Coordinating unit: 240 - ETSEIB - Barcelona School of Industrial Engineering  
Teaching unit: 712 - EM - Department of Mechanical Engineering  
Academic year: 2019  
Degree: MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2014). (Teaching unit Optional)  
ECTS credits: 4,5  
Teaching languages: Catalan

Teaching staff

Coordinator: Joaquim M. Veciana Fontanet  
Others: Joaquim M. Veciana Fontanet  
Jordi Ramon Martinez Miralles

Prior skills

Knowledge of Continuum Mechanics and Materials Science.

Degree competences to which the subject contributes

Specific:  
CEME103. Ability for the design and assays in machines.

Teaching methodology

The academic workload of the course is of 4.5 ECTS. Half of them are taught in theory classes (1.5 h per week) and the other half in seminar sessions (1.5 h per week).

The nominal group in a theory class is around 45 students. This type of class is dedicated to the presentation of the different chapters of the program, emphasizing in the most important concepts of each chapter and the procedural aspects. In the seminar sessions, where the nominal group is a third of the theory class (15 students), the teacher introduces practical exercises, often inspired in real applications. The students, working in groups of 2 or 3, discuss and solve them by their own and guided by the teacher. It is important that the students come to the seminars with the subject of the exercise previously prepared. This requires two hours of home study before the seminar sessions.

The students also have other sources of information to work with this subject: Short questions, solved exercises and suggested exercises. Among the information available in ATENEA they may also find exams from previous courses.

Learning objectives of the subject

General Objective:

To acquire the knowledge and become familiar with the procedures to calculate and dimension the main types of mechanical components that made up the machines.

Specific objectives:
To know the different types of elements commonly used in mechanical design, its advantages and disadvantages.

To learn how to apply the knowledge acquired in previous subjects (Mechanics, Mechanisms and Machine Theory, Continuum Mechanics, and Materials Science) in the analysis of the stresses of machine elements.

To acquire a general understanding on topics and concepts shared for the majority of machine elements such as safety factor, static and fatigue failure theories, cumulative damage, wear, etc.

To be able to give a complete and right solution to situations similar to real applications that can be found during the design and development of a new machine or mechanical device.

**Study load**

<table>
<thead>
<tr>
<th>Total learning time: 112h 30m</th>
<th>Hours large group: 20h 15m</th>
<th>18.00%</th>
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<tbody>
<tr>
<td>Hours small group: 20h 15m</td>
<td>18.00%</td>
<td></td>
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<tr>
<td>Guided activities: 0h</td>
<td>0.00%</td>
<td></td>
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<tr>
<td>Self study: 72h</td>
<td>64.00%</td>
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## Content

### Failure modes in machine elements

**Description:**

**Specific objectives:**
To introduce the different types of mechanical failures that can be found in machines. To review the formulation of the main static theories and the criteria to be properly applied. To understand the concepts of stress, strength and safety factor, and the design recommendations according to the loads and the material used. To briefly introduce the fatigue failure (in parallel a more detailed explanation is being taught in the subject Machine Technology).

**Learning time:** 4h 30m
- Practical classes: 1h 30m
- Laboratory classes: 0h
- Self study: 3h

### Bolts and bolted joints

**Description:**
Technology of the bolted joints. Bolted joints under static axial loads and dynamic ones (fatigue). Bolted Joints under static shear loads.

**Related activities:**
To do practical exercises about bolted joints.

**Specific objectives:**
To introduce the bolted joints technologies and standards. To calculate a bolted joint under static axial loads and dynamic ones (fatigue) by means of the high quality and the standard quality procedures. To calculate a bolted joint under shear loads.

**Learning time:** 33h
- Practical classes: 6h
- Laboratory classes: 6h
- Self study: 21h

### Shaft-hub attachments

**Description:**
Friction attachments: clamping, and cylindrical and conical interference fits. Shape attachments: keys, splines and taper pins.

**Related activities:**
To do practical exercises about shaft-hub attachments.

**Specific objectives:**
To introduce the general layout and the different types of shaft-hub attachments. To calculate clamping interference fits, and cylindrical and conical interference fits. To calculate a key shaft-hub attachment.

**Learning time:** 28h 30m
- Practical classes: 4h 30m
- Laboratory classes: 6h
- Self study: 18h
## Pressures in surface Hertzian contacts

**Learning time:** 4h 30m  
Practical classes: 1h 30m  
Laboratory classes: 0h  
Self study: 3h

**Description:**  
Surface Hertzian contact theory. Introduction to the calculation at a constant pressure (static failure) and at a variable pressure (surface fatigue failure).

**Specific objectives:**  
To introduce the types of surface contacts that are usual between pairs of machine elements. To introduce the general formulation of surface pressures for punctual and linear Hertz contacts. To evaluate the stresses involved. To calculate the allowable strength for static and variable loads (fatigue).

## Cylindrical gears with parallel axes

**Learning time:** 42h  
Practical classes: 7h 30m  
Laboratory classes: 8h  
Self study: 26h 30m

**Description:**  
Cylindrical gears with parallel axes geometry. Fatigue failure due to stress at the tooth bottom. Surface fatigue failure (pitting). Cylindrical gears first design iteration procedure.

**Related activities:**  
To do practical exercises about cylindrical gears with parallel axes.

**Specific objectives:**  
To introduce and calculate the basic geometry of spur and helical cylindrical gears. To introduce the dynamics of the teeth meshing and the common failure modes. To learn how to check cylindrical gears by calculating the stress at the tooth bottom and the stress at the tooth flank surfaces. To be able to calculate cylindrical gears by following the first design iteration procedure.
Qualification system

The mark is based on two evaluations: a mid-term exam and a final exam (where all the program is evaluated). In both of them, theoretical and practical knowledge is evaluated. Both have a theory evaluation part, with written questions, and one or two practical exercises to be solved. To obtain a numerical mark of this subject, it is required the final exam to be done. Otherwise, the final mark that will be considered is Not Submitted (NP).

In the evaluation of the exercises it is always considered the problem statement, the analysis of the stresses on the machine element to be calculated and the application of the calculation procedure to reach a valid and feasible solution.

The mid-term exam takes place outside class timetable, and its duration is about 1.5 h to 2 h.

The algorithm to calculate the final mark is:

Final mark = Max \[NEF; 0.6 \cdot NEF + 0.4 \cdot NAC\]

where NEF is the final exam, and NAC is the mid-term exam.

Re-evaluation:

The format of the re-evaluation exam is the same as the final exam. The mark obtained in the re-evaluation exam, NRE, replaces, in the algorithm, the mark of the final exam, NEF.

Regulations for carrying out activities

The students cannot have any documentation during the theory evaluation part of both exams. However, they can have the available bibliography for the practical exercises.

It is not allowed to have any storage or data transmission devices, such as mobile phones or equivalent devices.

Bibliography

Basic:


Fenollosa, J . ; Martínez, J ; Veciana, J. M. Quadern CM5 : qüestions i exercicis resolts. Barcelona: Copisteria Imatge, 2013.


Complementary:


