

## Course guide

### 240IME11 - 240IME11 - Machine Elements Calculation

**Last modified:** 17/07/2023

**Unit in charge:** Barcelona School of Industrial Engineering  
**Teaching unit:** 712 - EM - Department of Mechanical Engineering.

**Degree:** MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2014). (Optional subject).

**Academic year:** 2023    **ECTS Credits:** 4.5    **Languages:** Catalan

#### LECTURER

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**Coordinating lecturer:** Joaquim M. Veciana Fontanet

**Others:** Joaquim M. Veciana Fontanet

Xavier Fàbregas Massana

#### PRIOR SKILLS

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Knowledge of Mechanics and Mechanisms and Machine Theory.  
Knowledge of Continuum Mechanics and Materials Science.

#### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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**Specific:**

CEMEI03. Ability for the design and assays in machines.

#### TEACHING METHODOLOGY

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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 groups are smaller (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

Type	Hours	Percentage
Self study	72,0	63.94
Hours large group	20,3	18.03
Hours small group	20,3	18.03

**Total learning time:** 112.6 h

## CONTENTS

### Failure modes in machine elements

**Description:**

Failure modes in machine elements. Static failure theories. Safety factor. Introduction to fatigue failure.

**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).

**Full-or-part-time:** 4h 30m

Practical classes: 1h 30m

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.

**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.

**Related activities:**

To do practical exercises about bolted joints.

**Full-or-part-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.

**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.

**Related activities:**

To do practical exercises about shaft-hub attachments.

**Full-or-part-time:** 28h 30m

Practical classes: 4h 30m

Laboratory classes: 6h

Self study : 18h

### Pressures in surface Hertzian contacts

**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).

**Full-or-part-time:** 4h 30m

Practical classes: 1h 30m

Self study : 3h

### Cylindrical gears with parallel axes

**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.

**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.

**Related activities:**

To do practical exercises about cylindrical gears with parallel axes.

**Full-or-part-time:** 42h

Practical classes: 7h 30m

Laboratory classes: 8h

Self study : 26h 30m

## GRADING 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 2 h.

The algorithm to calculate the final mark is:

$$\text{Final mark} = \text{Max} [\text{NEF}; 0.6 \cdot \text{NEF} + 0.4 \cdot \text{NAC}]$$

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.

## EXAMINATION RULES.

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

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### Basic:

- Fenollosa, J.; Veciana, J. M.; Martínez, J. Unions cargolades [on line]. 2a ed. Barcelona: Edicions UPC, 2016 [Consultation: 13/09/2022]. Available on: <https://upcommons.upc.edu/handle/2117/82360>. ISBN 9788498805574.
- Fenollosa, J. ; Martínez, J. ; Veciana, J. M. Quadern CM5 : qüestions i exercicis resolts. Barcelona: Copisteria Imatge, 2013.
- Niemann, G. Elementos de Máquinas : Volumen I. Barcelona: Ed. Labor, 1987. ISBN 8433563262.
- Veciana, J.M.; Martínez, J.. Engranatges cilíndrics d'eixos paral·lels. Geometria i càlcul resistent . Barcelona: Jordi Martínez Miralles, 2017. ISBN 978-84-697-6876-1.

### Complementary:

- Martínez, J. ; Veciana, J.M.. Quadern CM6 : recull de qüestions i problemes d'examen. Barcelona: Jordi Martínez Miralles, 2014. ISBN 9788461720552.
- Decker, K. H. Elementos de Máquinas. Bilbao: Urmo S.A. Ediciones, 1980. ISBN 8431403403.
- Budynas, R.G. Diseño en Ingeniería Mecánica de Shigley [on line]. 11a ed. Ciudad de México: Mc Graw Hill, 2021 [Consultation: 29/03/2023]. Available on: <https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=5485813>. ISBN 9781456287610.
- Juvinall, R. C. Fundamentos de Diseño para Ingeniería Mecánica. 2a ed. Mèxic: Limusa, 2013. ISBN 9786070504365.
- Norton, R. L. Diseño de Máquinas : un enfoque integrado. México: Prentice-Hall, 2011. ISBN 9786073205900.
- Juvinall, R. C.. Engineering Considerations of Stress, Strain, and Strength. USA: McGraw-Hill Book Company, 1967.
- Henriot, Georges. Traité théorique et pratique des engrenages. 4ème ed. Paris: Dunod, 1968-1972. ISBN 2040058362.
- Bickford, John H. Introduction to the design and behavior of bolted joints : non-Gasketed joints [on line]. 4th ed. Nova York: CRC Press, Taylor & Francis Group, cop. 2008 [Consultation: 24/03/2023]. Available on: <https://www-taylorfrancis-com.recursos.biblioteca.upc.edu/books/mono/10.1201/9780849381874/introduction-design-behavior-bolted-joints-john-bickford>. ISBN 9780849381768.
- Veciana, Joaquim M ; Jordi Martínez Miralles. Quadern CM7 : recull de qüestions i problemes d'examen (2014-2019) : càlcul de màquines. [Barcelona]: Escola Tècnica Superior d'Enginyeria Industrial de Barcelona, Departament d'Enginyeria Mecànica, febrer 2022. ISBN 9788409384327.