# Syllabus

## Course description

| Course title | Advanced Topics on Machine Design  
I - Materials behavior and machine elements (**47503A / 47517**)  
II - Finite Element Method (FEM) (**47503B / 47517**) |
<table>
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<tbody>
<tr>
<td>Course code</td>
<td>47503</td>
</tr>
<tr>
<td>Scientific sector</td>
<td>ING-IND/14</td>
</tr>
<tr>
<td>Degree</td>
<td>Master in Industrial Mechanical Engineering</td>
</tr>
<tr>
<td>Semester</td>
<td>2 and 3</td>
</tr>
<tr>
<td>Year</td>
<td>I</td>
</tr>
<tr>
<td>Academic year</td>
<td>2018/19</td>
</tr>
<tr>
<td>Credits</td>
<td>10 (5+5)</td>
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<tr>
<td>Modular</td>
<td>Yes</td>
</tr>
<tr>
<td>Total lecturing hours</td>
<td>32 + 28</td>
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<tr>
<td>Total lab hours</td>
<td>28</td>
</tr>
<tr>
<td>Total exercise hours</td>
<td>12 + 18</td>
</tr>
<tr>
<td>Attendance</td>
<td></td>
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<tr>
<td>Prerequisites</td>
<td>Suggested: Machine Design</td>
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<tr>
<td>Course page</td>
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### Specific educational objectives

The course aims to introduce the design mind-set and the main methods for the design of mechanical systems, to provide exposure to the practice of design through application and to encourage understanding of the broader implications of design.

Students will learn, in the first module, fundamental concepts and methodologies for understanding and modelling mechanical systems. In the second module, the theory of numerical finite element methods is introduced. Emphasis is given to practical applications, especially considering the advantages achievable with the latest technologies.

### Module 1

**Materials behavior and machine elements**

| Lecturer      | Dr. Franco Concli  
Email: franco.concli@unibz.it  
Ph.: 0471017748  
Office: K0.05 |
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<tr>
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<tbody>
<tr>
<td>Scientific sector of the lecturer</td>
<td>ING-IND/14</td>
</tr>
<tr>
<td>Teaching language</td>
<td>English</td>
</tr>
<tr>
<td>Office hours</td>
<td>By appointment</td>
</tr>
<tr>
<td>Teaching assistant (if any)</td>
<td>no</td>
</tr>
<tr>
<td>Office hours</td>
<td>15</td>
</tr>
<tr>
<td>List of topics covered</td>
<td>The module will cover:</td>
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</table>
1. **Principle of virtual work**
   a. Shafts and shaft components
   b. Interference fits (hub and key)
   c. Deflections
   d. Natural frequencies
   e. Hyper-static structures

2. **Gears**
   a. Failure modes (bending - pitting - micro pitting - scuffing)
   b. Gear types (spur - helical - bevel - worm)
   c. Gear configurations (parallel axis, orthogonal axis, planetary)
   d. Synthetic factors (sizing)
   e. Strength calculation (ISO 6336)
   f. Gear efficiency (Power losses)
   g. Gear stiffness (Deformation under load)
   h. Examples of gearboxes (motorcycle and car transmissions)

3. **Bearings** (journal bearing)
   a. Full-Sommerfeld theory
   b. Half-Sommerfeld approximation
   c. Ocvirk's short-bearing approximation

4. **Bolted connections** (screwed joints)
   a. Pretension
   b. Tearing
   c. Sheet yielding

5. **Welded connections**

6. **Pressure vessel**

7. **Low cycle fatigue of materials**
   b. Ramberg-Osgood eq.
   d. Basquin-Coffin-Manson eq.
   e. Loading spectra

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**Teaching format**

The topics are presented by the professor by means of Power Point presentations or the blackboard.

A selection of the material presented in class as well as online resources and useful material will be available in the course reserve collection database.

Further deepening material will be supplied or recommended by the teacher.

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<table>
<thead>
<tr>
<th>Module 2</th>
<th>Finite Element Method (FEM)</th>
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<tbody>
<tr>
<td>Lecturer</td>
<td>N.N.</td>
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<tr>
<td>Scientific sector of the</td>
<td>ING-IND/14</td>
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</table>
List of topics covered

The second module of the course introduces the finite element method FEM for the analysis of solid structural problems. The background of the finite element method and its solution procedures for linear and nonlinear analyses, contact analysis, large deformation analysis, modal analysis and structural instability analysis will be presented.

Beside the theoretical part, students will apply the above-mentioned approaches to the design of real mechanical component such as those presented in the first module (shafts, slider and rolling-elements bearings, springs, threaded fasteners, power transmission and gears, pressure vessels, welding) and more complex systems for which an analytical approach is not available.

Teaching format

Frontal lectures by means of Power Point presentations or on the blackboard, exercises and case studies, computer laboratory.

Learning outcomes

Knowledge and understanding

1) Handle the analysis methods used in structural design of mechanical systems.

Applying knowledge and understanding

2) Know how to face a new project of a mechanical system starting from its functional design.

Making judgements

3) Identify the critical zones and the corresponding stress states of all components of a mechanical system, under service loading conditions.

4) Choose the geometry and materials able to satisfy the requirements of each component in terms of strength, deformation, fatigue life, and so on and realizing the technical drawing of the system.

Communication skills:

5) Oral communication skills (technical language)

Learning skills

6) Ability to autonomously extend the knowledge acquired

Assessment

Formative assessment
In class and exercises and activities (2,3,4)

Summative assessment
The assessment of the course is:
<table>
<thead>
<tr>
<th>Written exam (3/4 exercises)</th>
<th>Oral Exam</th>
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<tr>
<td>Open-ended questions</td>
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<tr>
<td>- Theoretical knowledge (40%)</td>
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<tr>
<td>- Ability to provide examples/applications of the theoretical concepts (30%)</td>
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<td>- Ability to establish relationships between topics (20%)</td>
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<tr>
<td>- Mastery of language (also with respect to teaching language) (10%)</td>
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**Assessment language**

| English |

**Evaluation criteria and criteria for awarding marks**

The final mark will be obtained combining the evaluations of the final written test and of the oral examination.

**Required readings**

Lecture notes and documents for exercise will be available on the reserve collections.

There is no single textbook that covers the entire course. The course material is collected from various sources that will be announced during the course.

A selection of the material presented in class and useful material will be available in the course reserve collection database.

**Supplementary readings**

**Module I**

- Shigley’s Mechanical Engineering Design, McGraw-Hill (ENG)
- G. NIEMANN, H. WINTER, Maschinenelemente, Springer (GER)
- P. HAEFELE, L. ISSLER, H. RUOSS, fertigkeitslehre - Grundlagen, Springer (GER)
- P. DAVOLI, M. FILIPPINI, C. GORLA, A. LO CONTE, Lezioni sugli organi di macchine, Politecnica (ITA)

**Module II**

- BERND KLEIN, Grundlagen und Anwendungen der Finite-Element-Methode im Maschinen- und Fahrzeugbau, Springer Verlag (GER)
- GIOVANNI BELINGARDI, Il metodo degli elementi finiti nella progettazione meccanica, Levrotto&Bella (ITA)