

## Syllabus

### Course description

<b>Course title</b>	Advanced Topics on Machine Design I – Materials behavior and machine elements II – Finite Element Method (FEM)
<b>Course code</b>	47503
<b>Scientific sector</b>	ING-IND/14
<b>Degree</b>	Master in Industrial Mechanical Engineering
<b>Semester</b>	1 and 2
<b>Year</b>	<i>I / II</i>
<b>Academic year</b>	2021/22
<b>Credits</b>	5+5
<b>Modular</b>	Yes

<b>Total lecturing hours</b>	28
<b>Total lab hours</b>	
<b>Total exercise hours</b>	18
<b>Attendance</b>	
<b>Prerequisites</b>	none
<b>Course page</b>	<a href="https://www.unibz.it/en/faculties/sciencetechnology/master-industrial-mechanical-engineering/">https://www.unibz.it/en/faculties/sciencetechnology/master-industrial-mechanical-engineering/</a>

<b>Specific educational objectives</b>	The course aims to introduce the design mindset 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.
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<b>Module 1</b>	<b>Materials behavior and machine elements</b>
<b>Lecturer</b>	Franco Concli Email: <a href="mailto:franco.concli@unibz.it">franco.concli@unibz.it</a> Ph.: 0471017748 Office: K0.05
<b>Scientific sector of the lecturer</b>	ING-IND/14
<b>Teaching language</b>	English
<b>Office hours</b>	By appointment
<b>Teaching assistant (if any )</b>	no
<b>Office hours</b>	15
<b>List of topics covered</b>	The course covers the following main topics: <ul style="list-style-type: none"> <li>• Principle of virtual work</li> <li>• Shafts and shaft components</li> </ul>

	<ul style="list-style-type: none"> <li>a. Interference fits (hub and key)</li> <li>b. Deflections</li> <li>c. Natural frequencies</li> <li>d. Hyperstatic structures</li> <li>• Gears <ul style="list-style-type: none"> <li>a. Failure modes (bending - pitting - micro pitting - scuffing)</li> <li>b. Gear types (spur - helical - bevel - worm)</li> <li>c. Gear configurations (parallel axis, orthogonal axis, planetary)</li> <li>d. Synthetic factors (sizing)</li> <li>e. Strength calculation (ISO 6336)</li> <li>f. Gear efficiency (Power losses)</li> <li>g. Gear stiffness (Deformation under load)</li> <li>h. Examples of gearboxes (motorcycle and car transmissions)</li> </ul> </li> <li>• Bearings (journal bearing) <ul style="list-style-type: none"> <li>a. Full-Sommerfeld theory</li> <li>b. Half-Sommerfeld approximation</li> <li>c. Ocvirk's short-bearing approximation</li> </ul> </li> <li>• Bolted connections (screwed joints) <ul style="list-style-type: none"> <li>a. Pretension</li> <li>b. Tearing</li> <li>c. Sheetyielding</li> </ul> </li> <li>• Belts (flat - V – Round - Timing) <ul style="list-style-type: none"> <li>a. Types</li> <li>b. Forces</li> </ul> </li> <li>• Welded connections</li> <li>• Pressure vessel</li> <li>• Low cycle fatigue of materials <ul style="list-style-type: none"> <li>a. Masing Hp.</li> <li>b. Ramberg-Osgood eq.</li> <li>c. Neuber Hp.</li> <li>d. Basquin-Coffin-Manson eq.</li> <li>e. Loading spectra</li> </ul> </li> </ul>
<b>Teaching format</b>	Frontal lectures, exercises, labs, projects, etc.

<b>Module 2</b>	<b>Finite Element Method (FEM)</b>
<b>Lecturer</b>	Carlo Gorla
<b>Scientific sector of the lecturer</b>	ING-IND/14
<b>Teaching language</b>	English
<b>Office hours</b>	15
<b>Teaching assistant (if any)</b>	Franco Concli
<b>Office hours</b>	By appointment
<b>List of topics covered</b>	The second module of the course introduces the finite element method FEM for the analysis of solid structural

	<p>problems. The background of the finite element method and its solution procedures for linear analysis will be provided and the different type of elements will be introduced.</p> <p>In detail:</p> <ul style="list-style-type: none"> <li>• Introduction to FEM: the method of displacement applied to FEM</li> <li>• Formal Procedure For FEM: discretization, Shape functions, displacement, strain, stress, stiffness matrix, solution, recovery of results.</li> <li>• Bar, Simple Beam, 2D and 3D Beam Element. Property and limitations of beam elements</li> <li>• Plane Elements, Plane stress and plane strain, linear and quadratic triangular and quadrilateral elements. Properties and limitations of plane elements</li> <li>• Isoparametric elements. Properties, limitations</li> <li>• Solid Elements, linear and quadratic tet and hex elements. Solid of Revolution. Properties, limitations</li> </ul> <p>Nonlinear analyses, contact analysis, large deformation analysis, modal analysis and structural instability analysis will also be addressed.</p> <p>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.</p> <p>In particular a practical case study will be developed by the students in the application part and a report will issued. The report will be object of discussion in the oral exam.</p>
<b>Teaching format</b>	Frontal lectures, exercises, labs, projects, etc.
<b>Learning outcomes</b>	<p><b>Intended Learning Outcomes (ILO)</b></p> <p>By the end of the course, students should be able to:</p>

	<p><u>Knowledge and understanding</u></p> <p>1. Handle the analysis methods used in structural design of mechanical systems.</p> <p><u>Applying knowledge and understanding</u></p> <p>2. Know how to face a new project of a mechanical system starting from its functional design.</p> <p><u>Making judgements</u></p> <p>3. Identify the critical zones and the corresponding stress states of all components of a mechanical system, under service loading conditions.</p> <p>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.</p> <p><u>Communication skills</u></p> <p>5. Oral communication skills (technical language)</p> <p><u>Ability to learn</u></p> <p>6. Ability to autonomously extend the knowledge acquired</p>
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Assessment	Formative assessment			
	Form		Length /duration	ILOs assessed
	In class exercises		15 X 120 minutes	2, 3, 4
	Summative assessment			
	Form	%	Length /duration	ILOs assessed
	Written exam – exercises	50 %	3/4 exercises (2.5 hours)	2, 3, 4
	Oral exam – theory	50 %	open-ended questions - Theoretical knowledge (40%) - Ability to provide examples/applications of	1, 5, 6

	the theoretical concepts (30%) - Ability to establish relationships between topics (20%) - Mastery of language (also with respect to teaching language) (10%)
<b>Assessment language</b>	English
<b>Evaluation criteria and criteria for awarding marks</b>	The final mark will be obtained combining the evaluations of the final written test and of the oral examination.

<b>Required readings</b>	Lecture notes and documents for exercise will be available on the reserve collections
<b>Supplementary readings</b>	<ul style="list-style-type: none"> <li>• R.S.KHURMI AND J.K. GUPTA, A Textbook of Machine Design, S Chand (ENG)</li> <li>• Shigley's Mechanical Engineering Design, McGraw-Hill (ENG)</li> <li>• G. NIEMANN, H. WINTER, Maschinenelemente, Springer (GER)</li> <li>• P. HAEFELE, L. ISSLER, H. RUOSS, fertigteitslehre – Grundlagen, Springer (GER)</li> <li>• P. DAVOLI, M. FILIPPINI, C. GORLA, A. LO CONTE, Lezioni sugli organi di macchine, Politecnica (ITA)</li> <li>• P. DAVOLI, A. BERNCASCONI, M. FILIPPINI, S. FOLETTI, Comportamento meccanico dei materiali, McGraw-Hill (ITA)</li> </ul> <p>Olek C Zienkiewicz, Robert L Taylor, J.Z. Zhu, The Finite Element Method: Its Basis and Fundamentals, Seventh Edition (ENG)</p> <p>Robert D. Cook, Finite Element modeling for stress analysis, L Wiley &amp; Sons, 1995 (ENG)</p>