Freie Universität Bozen
Libera Università di Bolzano
Università Liedia de Bulsan

Syllabus
Course description

Course title	Advanced Topics on Machine Design I – Materials behavior and machine elements II – Finite Element Method (FEM)
Course code	47503
Scientific sector	ING-IND/14
Degree	Master in Mechanical Engineering and Industrial Management
Semester	1 and 2
Year	*I / II*
Academic year	2020/21
Credits	5+5
Modular	Yes

Total lecturing hours	60 (32 + 28)
Total lab hours	
Total exercise hours	30 (12 + 18)
Attendance	
Prerequisites	none
Course page	https://www.unibz.it/en/faculties/sciencetechnology/master-industrial-mechanical-engineering/

Specific educational objectives	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.

Module 1	**Materials behavior and machine elements**
Lecturer	Franco Concli Email: franco.concli@unibz.it Ph.: 0471017748 Office: K0.05
Scientific sector of the lecturer	ING-IND/14
Teaching language	English
Office hours	By appointment
Teaching assistant (if any)	no
Office hours	15
List of topics covered	The course covers the following main topics: • Principle of virtual work

	• Shafts and shaft components a. Interference fits (hub and key) b. Deflections c. Natural frequencies d. Hyperstatic structures • 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) • Bearings (journal bearing) a. Full-Sommerfeld theory b. Half-Sommerfeld approximation c. Ocvirk's short-bearing approximation • Bolted connections (screwed joints) a. Pretension b. Tearing c. Sheetyielding • Belts (flat - V – Round - Timing) a. Types b. Forces • Welded connections • Pressure vessel • Low cycle fatigue of materials a. Masing Hp. b. Ramberg-Osgood eq. c. Neuber Hp. d. Basquin-Coffin-Manson eq. e. Loading spectra
Teaching format	Frontal lectures, exercises, labs, projects, etc.

Module 2	**Finite Element Method (FEM)**
Lecturer	Carlo Gorla
Scientific sector of the lecturer	ING-IND/14
Teaching language	English
Office hours	15
Teaching assistant (if any)	Franco Concli
Office hours	By appointment
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 analysis will be provided and the different type of elements will be introduced. In detail: • Introduction to FEM: the method of displacement applied to FEM • Formal Procedure For FEM: discretization, Shape functions, displacement, strain, stress, stiffness matrix, solution, recovery of results. • Bar, Simple Beam, 2D and 3D Beam Element. Property and limitations of beam elements • Plane Elements, Plane stress and plane strain, linear and quadratic triangular and quadrilateral elements. Properties and limitations of plane elements • Isoparametric elements. Properties, limitations • Solid Elements, linear and quadratic tet and hex elements. Solid of Revolution. Properties, limitations Nonlinear analyses, contact analysis, large deformation analysis, modal analysis and structural instability analysis will also be addressed. 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. 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.
Teaching format	Frontal lectures, exercises, labs, projects, etc.

Learning outcomes	**Intended Learning Outcomes (ILO)** By the end of the course, students should be able to:

	<u>Knowledge and understanding</u> 1. Handle the analysis methods used in structural design of mechanical systems. <u>Applying knowledge and understanding</u> 2. Know how to face a new project of a mechanical system starting from its functional design. <u>Making judgements</u> 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. <u>Communication skills</u> 5. Oral communication skills (technical language) <u>Ability to learn</u> 6. Ability to autonomously extend the knowledge acquired

Assessment	**Formative 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%)
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
Supplementary readings	• R.S.KHURMI AND J.K. GUPTA, A Textbook of Machine Design, S Chand (ENG) • 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) • P. DAVOLI, A. BERNCASCONI, M. FILIPPINI, S. FOLETTI, Comportamento meccanico dei materiali, McGraw-Hill (ITA) Olek C Zienkiewicz, Robert L Taylor, J.Z. Zhu, The Finite Element Method: Its Basis and Fundamentals, Seventh Edition (ENG) Robert D. Cook, Finite Element modeling for stress analysis, L Wiley & Sons, 1995 (ENG)