Freie Universität Bozen
Libera Università di Bolzano
Università Liedia de Bulsan

Syllabus
Course description

Course title	**Materials science and structural mechanics**
Course code	42175
Scientific sector	ICAR/08 – ING-IND/22
Degree	Bachelor in Industrial and Mechanical Engineering
Semester	I
Year	II
Academic year	2021/22
Credits	12 (6+6)
Modular	*yes*

Total lecturing hours	76 (40+36)
Total lab hours	-
Total exercise hours	39 (15+24)
Attendance	Recommended
Prerequisites	None
Course page	https://next.unibz.it/en/faculties/sciencetechnology/bachelor-industrial-mechanical-engineering/course-offering/

Specific educational objectives	The specific educational objectives include the understanding and knowledge of the fundamentals of material science and structural mechanics. The students will learn mechanical properties of engineering materials and structural elements and how they may be analyzed. This includes modelling abstractions, solution methods and the interpretation of results of relevant engineering mechanics problems.

Module 1	**Mechanics of structures**
Lecturer	Dr. techn. Thomas Moosbrugger
Scientific sector of the lecturer	
Teaching language	German
Office hours	18h (by appointment: ThomasFranzXaver.Moosbrugger@unibz.it)
Teaching assistant *(if any)*	-
Office hours	-

List of topics covered	**Part I: Stereostatics – the mechanics of rigid structures**
	• Statics of rigid bodes:
	  ◦ Force, force systems
	• Centroids of volumes, surfaces and lines
	• Structures as load-bearing assemblies
	  ◦ Structural elements

- Supports and links
- Static determinacy
- Superposition principle

- Statics of rigid bars
  - Analysis of single rigid bars
  - Analysis of rigid cables
  - Analysis of rigid trusses
- Statics of rigid beams
  - Analysis of single rigid beams
  - Analysis of rigid arches
  - Analysis of rigid frames
- Work and potential energy of rigid structures
  - Work and potential energy
  - Virtual displacement and virtual work
  - Principle of virtual work
- Friction
  - Static friction
  - Kinetic friction
  - Belt friction

Part II: Elastostatics – the mechanics of deformable structures

- Statics of elastic bodies
  - Stress
  - Strain
  - Constitutive law
  - Mohr's circle
  - Principal axes and values
  - Strength hypotheses
- Statics of elastic bars
  - Thermal loading
  - Static determinacy
  - Analysis of single elastic bars
  - Analysis of elastic trusses
- Statics of elastic beams
  - Assumptions of beam theory
  - Moment of inertia
  - Deflection of beams
  - Static determinacy
  - Analysis of single elastic beams
  - Analysis of elastic frames
  - Superposition of loads
- Torsion
- Energy methods in elastostatics
  - Deformation energy

	◦ Methods of Maxwell, Castigliano, etc. • Stability in elastostatics ◦ Buckling of elastic beams ◦ Euler's buckling cases
Teaching format	Frontal lectures, exercises

Module 2	**Material Science and Technology**
Lecturer	**Prof. Stefano Rossi PhD** stefano.rossi@unibz.it, and stefano.rossi@unitn.it, 0471-017092, https://www.unibz.it/it/faculties/sciencetechnology/academic-staff/person/1075-stefano-rossi
Scientific sector of the **lecturer	ING IND22
Teaching language	Italian
Office hours	18 h
Teaching assistant (if any)	n.d.
Office hours	Before lectures
List of topics covered	In the course the followings topics about materials will be considered. **Introduction**: the materials and their use in the industrial production. Technological properties of materials: different type of materials and their typical properties; correlation between microstructure and mechanical properties; basis of thermodynamics and equilibrium diagrams. **Metals**: characteristics and properties of iron alloys (steel and cast iron), copper and aluminum alloys; alloys with high performances. The mechanical workability; thermal treatments. **Ceramics and glasses**: ceramics for building; the production and utilization of ceramic materials; materials for high temperatures; the characteristics of glass; the production of glass components. **Polymers**: production and properties of polymeric materials; production of components in polymeric matter; utilization of polymers. **The composite materials**: production, properties, utilization of composite materials. **Testing standard about of materials**: the use of standard in the classification and in the properties testing of materials.
Teaching format	Class lectures in which topics are presented by the teacher. The lecture topics will be arguments of exercises and practical activities explained by the teacher and the teaching assistants. Generally, PowerPoint presentations will be used during the lectures. The lessons will then be integrated with classroom exercises and video with comments. They will try to encourage students to independently perform some exercises as a self-

	learning test. The PowerPoint presentations will be given to students as material for the study track, for the preparation of the final examination.

Learning outcomes	**<u>Module I Mechanics of structures:</u>** <u>Knowledge and understanding:</u> 1. Knowledge and understanding of the fundamentals of structural mechanics. <u>Applying knowledge and understanding:</u> 2. Applying theoretical methods to analyze engineering structures and structural systems. <u>Making judgments:</u> 3. Analyzing structural engineering devices/systems requires a deep understanding and the ability to show judgment regarding methods, results and designs. <u>Communication skills:</u> 4. Communication skills to convey and transfer structural mechanics knowledge. 5. Communication skills to interpret results of structural mechanics analyses and their consequences with respect to design. <u>Ability to learn:</u> 6. Learning skills to study independently the large and complex field of structural mechanics for specific applications beyond this lecture. **<u>Module II Material Science and Technology:</u>** <u>Knowledge and understanding:</u> 1. Knowledge and understanding of the different properties of materials and different technologies and production processes. <u>Applying knowledge and understanding:</u> 2. Applying knowledge and understanding through the development of skills and the ability to choose the suitable materials and the technology for a particular industrial product. In addition, the students should develop the ability to apply the knowledge on the behavior of materials in the performance of laboratory technological tests. <u>Making judgments</u>

	3. Connect the properties of different materials with their microstructure; capacity to evaluate the experimental data obtained in laboratory tests. Communication skills 4. Communication skills to present the acquired knowledge with their own lexicon of the discipline and to be able to prepare a technical report about materials tests. Ability to learn 5. Acquire skills to deepen the topics covered during the course in order to apply them to simple practical cases. 6. Acquire the ability to interpret experimental test data obtained in material characterization tests.

Assessment

Module I Mechanics of structures:
Formative assessment:

Form	Length /duration	ILOs assessed
Exercises in the lecture hall	In the process of the exercises sessions	1-5

Summative assessment

Form	%	Length /duration	ILOs assessed
Written examination (compiling a calculation example)	60	1,5 h	1-5
Oral examination (in a small group)	40	30 min	1-5

Module 2 Material Science and Technology:
Formative assessment:

Form	Length /duration	ILOs assessed
Exercises in the lecture hall	In the process of the exercises sessions	1-5

Summative assessment:

	Form / **Length /duration** / **ILOs assessed** Written exam with questions and exercises / 2 h / 1,2,3,4,5
Assessment language	Module I Structural Mechanics: German Module II Material Science and Technology: Italian
Evaluation criteria and criteria for awarding marks	Module I Structural Mechanics: Written examination (in German) will include derivations and numerical examples to evaluate the ability to solve structural-mechanics problems as well as comprehension questions. **Form**: Written exam **Evaluation criteria and weight**: Theoretical knowledge (30%); Appropriate use of methods (30%); Ability to solve problems (30%); Appropriate use of units (10%) Module II Material Science and Technology: Written exam Theoretical knowledge of the subject (40%); Ability to link different topics highlighting the similar peculiarities and characteristics (30%); Ability to apply the concepts relating to materials and production technologies, for examples of objects and products (20%); Mastery of technical language (10%). Final mark: 50% Module I Structural Mechanics 50% Module II Material Science and Technology Note: Students must pass both modules in order to pass this course

Required readings	Lectures notes. The slides, supplied during class, are a useful to follow the lectures and for the individual study. However, they are NOT sufficient for the successful exam preparation.
Supplementary readings	Module I Mechanics of structures: German:

	• Gross, D., W. Hauger, J. Schröder, and W. A. Wall (2013). Technische Mechanik 1: Statik (12 ed.). Springer • Gross, D., W. Hauger, J. Schröder, and W. A. Wall (2014). Technische Mechanik 2: Elastostatik (12 ed.). Springer. English: • Gross, D., W. Hauger, J. Schröder, W. A. Wall, and J. Bonet (2011). Engineering mechanics 2: Mechanics of materials (1 ed.). Springer. • Gross, D., W. Hauger, J. Schröder, W. A. Wall, and N. Rajapakse (2013). Engineering mechanics 1: Statics (2 ed.). Springer. Italian: • Curti, G. and F. Curà (2006). Fondamenti di meccanica strutturale. Clut. Further literature will be discussed during the lectures and exercises. <u>Module II Material Science and Technology:</u> • William F. Smith "Scienza e Tecnologia dei Materiali" Mc Graw-Hill 2021 • A. Bugini, C. Giardini, R. Pacagnella, G. Restelli "Tecnologia Meccanica vol I, Lavorazioni per fusione e deformazione plastica" Città Studi Edizioni 1995 • A. Bugini, C. Giardini, R. Pacagnella, G. Restelli "Tecnologia Meccanica vol II, Lavorazioni per asportazione di truciolo" Città Studi Edizioni 1995

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Specific educational objectives	The specific educational objectives include the understanding and knowledge of the fundamentals of material science and structural mechanics. The students will learn mechanical properties of engineering materials and structural elements and how they may be analyzed. This includes modelling abstractions, solution methods and the interpretation of results of relevant engineering mechanics problems.

Modul 1	**Mechanics of structures**
Dozent	Dr. techn. Thomas Moosbrugger
Wissenschaftlich-disziplinärer Bereich des Dozenten	
Unterrichtssprache	Deutsch
Sprechzeiten	18h (nach Vereinbarung: ThomasFranzXaver.Moosbrugger@unibz.it)
Wissenschaftlicher Mitarbeiter	-
Sprechzeiten	-
Auflistung der behandelten Themen	**Teil I: Stereostatik – die Mechanik starrer Strukturen** • Statik starrer Körper: ◦ Kraft, Kraftgruppen • Schwerpunkt von Volumen, Flächen und Linien

- Tragwerke
  - Strukturelemente
  - Lager und Gelenke
  - Statische Bestimmtheit
  - Überlagerungsprinzip
- Statik starrer Stäbe
  - Analyse einzelner starrer Stäbe
  - Analyse starrer Seile
  - Analyse starrer Fachwerke
- Statik starrer Balken
  - Analyse einzelner starrer Balken
  - Analyse starrer Bögen
  - Analyse starrer Rahmen
- Arbeit und potentielle Energie starrer Strukturen
  - Arbeit und potentielle Energie
  - Virtuelle Verrückung und Virtuelle Arbeit
  - Prinzip der Virtuellen Arbeit
- Reibung
  - Haftreibung
  - Gleitreibung
  - Seilreibung

Teil II: Elastostatik – die Mechanik verformbarer Strukturen

- Statik elastischer Körper
  - Spannung
  - Verzerrung
  - Mohr`scher Kreis
  - Hauptachsen und -werte
  - Stoffgesetz
  - Fetigkeitshypothesen
- Statik elastischer Stäbe
  - Wärmeausdehnung
  - Statische Bestimmtheit
  - Analyse einzelner elastischer Stäbe
  - Analyse elastischer Fachwerke
- Statik elastischer Balken
  - Annahmen der Balkentheorie
  - Flächenträgheitsmomente
  - Biegelinie einachsiger Biegung
  - Statische Bestimmtheit
  - Analyse einzelner elastischer Balken
  - Analyse elastischer Rahmen
  - Überlagerte Belastungen
- Torsion

	• Arbeitssatz in der Elastostatik ◦ Formänderungsenergie ◦ Sätze von Maxwell, Castigliano, etc. • Stabilität in der Elastostatik ◦ Knickung elastischer Balken ◦ Eulerschen Knickfälle
Unterrichtsform	Vorlesungen, Übungen

Modulo 2	**Scienza e Tecnologia dei materiali**
Docente	**Prof. Stefano Rossi PhD**, stefano.rossi@unibz.it, e stefano.rossi@unitn.it, 0471-017092, https://www.unibz.it/it/faculties/sciencetechnology/academic-staff/person/1075-stefano-rossi
Settore scientifico disciplinare del docente	ING-IND/22
Lingua ufficiale del corso	Italiano
Orario di ricevimento	18 h - prima delle lezioni ed esercitazioni
Collaboratore didattico (se previsto)	n.d.
Orario di ricevimento	13:00 – 14:00
Lista degli argomenti trattati	Durante il corso verranno considerati i seguenti aspetti: **Introduzione**: i materiali e il loro utilizzo nei prodotti industriali **Le basi delle proprietà di interesse tecnologico dei materiali**: classi di materiali e loro proprietà caratterizzanti; relazioni generali fra microstruttura e proprietà; accenni di termodinamica delle trasformazioni di stato. Il comportamento meccanico dei diversi tipi di materiali. **I materiali metallici**: generalità sulle leghe ferrose; le leghe di rame ed alluminio; leghe speciali. Lavorazioni e trattamenti termici dei materiali metallici. **I materiali ceramici e vetro**: ceramici per l'edilizia, loro produzione ed utilizzo; ceramici refrattari. La produzione di componenti in vetro. **I materiali polimerici**: produzione e proprietà dei polimeri; lavorazione ed utilizzi dei materiali polimerici. **I materiali compositi**: produzione, proprietà ed utilizzi dei materiali compositi. **Le normative nel campo dei materiali**: come si leggono e come si utilizzano
Attività didattiche previste	Il corso si basa su lezioni frontali in aula tenute dal docente. Le lezioni verranno quindi integrate con esercizi in aula e la proiezione di video che verranno commentati dal docente. Si cercherà di stimolare gli studenti a svolgere autonomamente alcuni esercizi e prove in modo da avere una valutazione dell'autoapprendimento. Generalmente si utilizzeranno presentazioni PowerPoint che verranno fornite agli studenti come materiale traccia per lo studio.

Learning outcomes	**Module I Mechanics of structures:** Knowledge and understanding: 1. Knowledge and understanding of the fundamentals of structural mechanics. Applying knowledge and understanding: 2. Applying theoretical methods to analyze engineering structures and structural systems. Making judgments: 3. Analyzing structural engineering devices/systems requires a deep understanding and the ability to show judgment regarding methods, results and designs. Communication skills: 4. Communication skills to convey and transfer structural mechanics knowledge. 5. Communication skills to interpret results of structural mechanics analyses and their consequences with respect to design. Ability to learn: 6. Learning skills to study independently the large and complex field of structural mechanics for specific applications beyond this lecture. **Module II Material Science and Technology:** Knowledge and understanding: 1. Knowledge and understanding of the different properties of materials and different technologies and production processes. Applying knowledge and understanding: 2. Applying knowledge and understanding through the development of skills and the ability to choose the suitable materials and the technology for a particular industrial product. In addition, the students should develop the ability to apply the knowledge on the behavior of materials in the performance of laboratory technological tests. Making judgments 3. Connect the properties of different materials with their microstructure; capacity to evaluate the experimental data obtained in laboratory tests. Communication skills

4. … to present the acquired skills with their own lexicon of the discipline and to be able to prepare a technical report about material tests.

Ability to learn

5. Acquire skills to deepen the topics covered during the course in order to apply them to simple practical cases.
6. Acquire the ability to interpret experimental test data obtained in material characterization tests.

Assessment

Module I Mechanics of structures:
Formative assessment:

Formative Bewertung (nicht Teil der Note)

Form	Dauer	Nr. Lernergebnisse
Übungen im Hörsaal	Im Laufe der Übungseinheiten	1-5

Summative Bewertung (Zusammensetzung der Note)

Form	Dauer	Nr. Lernergebnisse
Schriftliche Prüfung (60%, Erarbeiten eines Rechenbeispiels)	1,5 h	1-5
Mündliche Prüfung (40%, In der Kleingruppe)	30 min	1-5

Module 2 Material Science and Technology:
Formative assessment:

Form	Length /duration	ILOs assessed
Exercises in the lecture hall	In the process of the exercises sessions	1-5

Summative assessment:

Form	Length /duration	ILOs assessed
Written exam	2 h	1,2,3,4,5

Assessment language

Module I Structural Mechanics: German
Module II Material Science and Technology: Italian

Evaluation criteria and criteria for awarding marks

Module I Structural Mechanics:
Written examination (in German) will include derivations and numerical examples to evaluate the ability to solve structural-mechanics problems as well as comprehension questions.

Form	Evaluation criteria and weight
Written exam	Theoretical knowledge (30%) Appropriate use of methods (30%) Ability to solve problems (30%) Appropriate use of units (10%)

Module II Material Science and Technology:
Written exam (in Italian)
Theoretical knowledge of the subject (40%);
Ability to link different topics highlighting the similar peculiarities and characteristics (30%);
Ability to apply the concepts relating to materials and production technologies, for examples of objects and products (20%);
Mastery of technical language (10%).

Final mark:
50% Module I Structural Mechanics
50% Module II Material Science and Technology
Note: Students must pass both modules in order to pass this course

Required readings

Lectures notes.
The slides, supplied during class, are a useful to follow the lectures and for the individual study. However, they are NOT sufficient for the successful exam preparation.

Supplementary readings

Module I Mechanics of structures:

German:
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- Gross, D., W. Hauger, J. Schröder, and W. A. Wall (2014). Technische Mechanik 2: Elastostatik (12 ed.). Springer.

English:
- Gross, D., W. Hauger, J. Schröder, W. A. Wall, and J. Bonet (2011). Engineering mechanics 2: Mechanics of materials (1 ed.). Springer.
- Gross, D., W. Hauger, J. Schröder, W. A. Wall, and

	N. Rajapakse (2013). Engineering mechanics 1: Statics (2 ed.). Springer. Italian: • Curti, G. and F. Curà (2006). Fondamenti di meccanica strutturale. Clut. Further literature will be discussed during the lectures and exercises. <u>Module II Material Science and Technology:</u> • William F. Smith "Scienza e Tecnologia dei Materiali" Mc Graw-Hill 2021 • A. Bugini, C. Giardini, R. Pacagnella, G. Restelli "Tecnologia Meccanica vol I, Lavorazioni per fusione e deformazione plastica" Città Studi Edizioni 1995 • A. Bugini, C. Giardini, R. Pacagnella, G. Restelli "Tecnologia Meccanica vol II, Lavorazioni per asportazione di truciolo" Città Studi Edizioni 1995