# COURSE OUTLINE

## 1. GENERAL

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| **SCHOOL** | SCHOOL OF ENGINEERING | | |
| **ACADEMIC UNIT** | DEPARTMENT OF MINERAL RESOURCES ENGINEERING | | |
| **LEVEL OF STUDIES** | *Undergraduate* | | |
| **COURSE CODE** | MRE302 | **SEMESTER** | 3rd |
| **COURSE TITLE** | Mechanics – Strength of Materials | | |

| **INDEPENDENT TEACHING ACTIVITIES** | **WEEKLY TEACHING HOURS** | **CREDITS** |
|---|---|---|
| Lectures | 2 | 5 |
| Laboratory or Tutorials | 2 | |
| Overall | 4 | |
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| **COURSE TYPE** | General Background - Scientific Area |
| **PREREQUISITE COURSES:** | Mechanics - Structures (MRE204) |
| **LANGUAGE OF INSTRUCTION and EXAMINATIONS:** | Greek |
| **IS THE COURSE OFFERED TO ERASMUS STUDENTS** | NO |
| **COURSE WEBSITE (URL)** | |

## 2. LEARNING OUTCOMES

**Learning outcomes**

Teaching of the course aims:

a. to acquire knowledge for analysis (in engineering terms) and the design of various engineering structures, such as buildings, pipelines, bridges, geotechnical & underground works, etc.
b. to determine the normal and shear stresses, deformations and displacements that develop in thin-walled structures of open-air or closed sections, due to external loads which cause bending and torsion in beams.
c. in the acquisition of knowledge about the elastic and plastic behavior of materials.
d. in the analysis of constructions with energy methods whose knowledge is fundamental e.g. for the numerical solution with the method of finite elements of complex constructions.
e. in the knowledge of the phenomenon of instability of the structures that occurs in their compression members.

Upon successful completion of the course students will have the ability to:

- Understand the fundamental concepts of building structures design.
- Distinguish the type, form and character of stresses.
- Understand the behavior of basic structural elements in simple and complex stresses.
- Analyse and Design structural elements in simple and complex stresses.
- Calculate the forces, loads, actions, normal and shear stresses, displacements and deformations in axial or lateral load, which cause normal or lateral bending and torsion and elastic and elastoplastic behavior of material as well as the stored energy in construction.
- Calculate maximum bending moments or loads that a structure can withstand.
- Check the failure either due to exceeding the collapse bending moment (mechanism) when it comes to bending or exceeding the critical load when it comes to buckling.
- Calculate the forces developed in the structural elements due to external loads/actions and check the probability of failure of the structure based on the strength of the material from which it is made of.
- Plan a construction/structure for a given load, that is, to determine the materials, section properties and the dimensions of the structural elements, so that there is no exceeding of the allowable strength limits (member capacity) that leads to failure (Ultimate Limit States (ULS)).
- Calculate the deformations of the structural elements so that its functionality is not hindered (Serviceability Limit States (SLS)).
- Dimension-control the structural elements in simple and complex stress conditions.

| **General Competences** |
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| The course contributes to the acquisition of the following skills:<br>• Applying knowledge in practice,<br>• Researching, Analyzing & Synthesizing Data & Information using necessary technologies,<br>• Adapting to new situations,<br>• Decision-making,<br>• Working independently,<br>• Working in an international environment,<br>• Working in groups (Teamworking),<br>• Promoting Free, Creative & Inductive thinking. |

## 3. SYLLABUS

Generally: Factor of Safety. Allowable stresses (actions). Tension-Compression: ductile, brittle materials. Stress analysis: triaxial, biaxial. Bending: plane, lateral. Shear: shearing, normal, bending with shearing. Torsion: Composite flexion. Core. Neutral area. Deformation Energy/Work. Flexure line. Hyperstatic systems. Thermal stress. Bending. Resistance to complex stress: failure criteria. Complex strains. Shell bodies. Composite beams. Fatigue. Conditions and problems of elasticity. Laboratory: experiments of simple, complex stresses. Mechanical properties of materials. Tension-deformation measurements. Research methods. Experimental Analysis of stress. Instrumentation, measuring techniques and machines.
Theory: Introductory concepts. Mechanical properties of materials. Allowable and Ultimate Design Conditions. Tension-Compression-Shear. Bending. Torsion. Complex bending-shear-torsion stresses. Bending. Fatigue. Introduction to elasticity. Shell structures.
Tutorial exercises: Design of Frames-Design criteria. Solving exercises in tension-compression-shear-bending-torsion-complex stresses-calculus and fatigue.
Determine whether a structure is statically determinate, indeterminate or a mechanism. - Construct free body diagrams and use them to solve mechanics problems. - Calculate the reactions at the supports of statically determinate structures. - Calculate stresses and strains due to bending and torsion. - Solve statically-determinate plane trusses. - Calculate, and plot diagrams of, the internal actions of statically-determinate beams. - Calculate the deflection due to bending at different points of a beam. - Calculate the critical buckling load of elastic struts. - Interpret experimental data to deduce structural or material behaviour. - Assess whether theoretical assumptions are supported by laboratory observations. Stress and strain in 2D/3D. Free edge conditions. - The way that stress and strain transform in 2D. - The concept of principle stresses and strains.

More details:

- ✓ Introduction (Introductory concepts. Basic assumptions about the solid deformable body). Stresses (actions). Deformations. (The concept of deformation. Normal deformation. Shear deformation. The strain of the deformations. Reduced swelling. Deformations due to temperature).
- ✓ Materials in Engineering: Metals, ceramics, polymers and composites.
- ✓ Fundamentals: Atomic structure and interatomic bonding; electrons, atoms and molecules; the Periodic table; bonding and interatomic forces; the structure of crystalline solids; basic structures, unit cells; holes and lattices; imperfections in solids; point, linear, planar and volume defects; diffusion.
- ✓ Mechanical properties: Stress and strain; elasticity; tensile properties; hardness; strengthening mechanisms; recovery, recrystallisation and grain growth.
- ✓ Microstructures and their control: Phase diagrams; thermal processing; precipitation hardening
- ✓ Failure of metals: Failure; fracture, brittle and ductile failure; impact and fracture toughness; fatigue; creep.
- ✓ Nonmetallic materials and their properties: Ceramics and glasses; main classes, properties and uses; polymers; basic structures and bonding; polymerization; cross linking; thermoplastics and thermosets; composites; main classes, properties and uses.
- ✓ Materials in engineering applications: Case studies.
- ✓ Fundamental Concepts: Concepts, Units, Scalar & Vector
- ✓ Revision of statics (adding/resolving forces, moments), types of load/support.
- ✓ Equilibrium of rigid bodies. Free body diagrams. Static determinacy.

- ✓ Trusses: static determinacy, method of joints and method of sections.
- ✓ Stress, strain, elastic constants, Hooke's law
- ✓ Beams: shear force and bending moment diagrams, differential relationships
- ✓ Engineer's Bending Theory. First and second moments of area.
- ✓ Beam deflection due to bending, moment-curvature relationship.
- ✓ Differential equation of the deflection curve. Solution by integration.
- ✓ Shear stress in beams. Shear formula. Shear stress distribution in practical sections.
- ✓ Torsion of circular section shafts, polar second moment of area.
- ✓ Buckling of elastic struts. Concept of instability. Euler formula, effective length.
- ✓ Stress, strain, elastic constants, thermal strain, Hooke's law (2D/3D)
- ✓ Stresses in thin-walled cylinders subject to internal pressure.
- ✓ Two-dimensional analysis of stress.
- ✓ Stress transformation using Mohr circles.
- ✓ Principle stresses and strains.

## 4. TEACHING and LEARNING METHODS - EVALUATION

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| **DELIVERY** | In the classroom and in the laboratory (Face-to-face).<br>Webinars. Tutorials. Laboratory demonstrations. Possibility of distance lectures if required via Zoom Cloud Meeting. |
| **USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY** | Presentation of lectures using PC (presentations, experimental videos, etc.).<br>Support of learning process through the electronic platform eLearning and electronic communication with students (Online announcements and comments, forum, email etc.).<br>Self-assessment questionnaires in the eLearning environment of the course and asynchronous training platform - eclass.<br>Assistance in completing assignments through result files for each individual student. |
| **TEACHING METHODS** | (see table below) |

| *Activity* | *Semester Workload* |
|---|---|
| Lectures | 85 |
| *Laboratory exercises and processing of results with computational procedures* | 50 |
| *Individual assignments on laboratory exercises & theory (Coursework) and application exercises* | |
| *Independent Home Study* | |
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| ***Overall Course Set (26 hours of workload per credit unit)*** | ***125*** |

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| **STUDENT PERFORMANCE EVALUATION** | Written final theory exam that includes:<br>• Theoretical judgment questions in course subjects (short answer questions and multiple choice questions).<br>• Problem solving-exercises.<br>• Solving of laboratory exercises.<br><br>Delivery of assignments and oral examination that includes:<br>• Laboratory work (processing of results of laboratory exercises).<br>• Solving of application exercises.<br>• Examining the understanding of basic concepts. |

## 5. SUGGESTED BIBLIOGRAPHY


- Charalampakis, Nikos X, Strength of materials and structural elements. Concise theory and exercises, Tziola Publications, ISBN: 960-418-017-7, 2004, THESSALONIKI, 18548960.
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- RC Hibbeler. Materials Engineering, 10th edition, ISBN-13: 978-0134319650
- A. Papamichos E, Charalampakis N (2017). Strength of materials and structural elements, 2nd ed., Thessaloniki: Tziolas.
- B. Gere JM, Goodno BJ (2018). Strength of materials. 8th edition, Thessaloniki: Tziolas.
- A. Beer FP, Johnston Jr ER, DeWolf JT, Mazurek DF (2016). Materials engineering. 7th ed., Thessaloniki: Tziolas. 22693328
- V. Vardoulakis I (1999). Technical Engineering II. Athens: Symmetry.
- G. Tsamasfyros GI (1990). Mechanics of deformable bodies I and II. Athens: Symmetry.
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