University *of Ljubljana*
Faculty *of Mechanical Engineering*

Advanced Strength of Materials 5 ECTS

Lecturer: **Assoc. Prof. Dr. Miha Brojan**

Lectures: 30h | Tutorials: 10h | Labs: 20h | Project: 65h | Lang. :

Objectives

The objectives of this course are to learn how to use advanced mathematical tools in mechanics, learn how to build physical and mathematical models of complex stress-strain states in deformable bodies, rheological responses and to learn how to design statically multiply indeterminate structures. With this course the students will get the following competences:

- ability to use advanced mathematical tools in mechanics,
- ability to build physical and mathematical models of complex stress-strain states in deformable bodies,
- design statically multiply indeterminate structures.

Programme

Obligations for following and completing the course; Presentation of relevant study literature; Overview of course topics; Concept of a 3D continuum; Cauchy's definition of stress vector, normal and shear stresses, static equilibrium on a finite volume in a deformed body, Cauchy's stress theorem; Stress tensors (Cauchy, 1st Piola-Kirchhoff, 2nd Piola-Kirchhoff, Biot, etc.); Deviatoric and hydrostatic part of the stress tensor; Principal stresses and maximum shear stresses in 3D; Invariants of the stress tensor and invariants of the deviatoric part of the stress tensor; Strain theory; Displacement vector, deformation gradient, deformation tensors, small/finite strain theory; Geometric interpretation of the small strain tensor; Compatibility conditions for strains; Elastic strain energy of a body due to external loads; Energy methods, strain energy density per unit volume; Principle of virtual work; Ideally elastic material, Green elasticity; Material anisotropy; Isotropy, Linearly elastic material; Determining material constants from experiments; Hooke's law, Hyperelasticity; Volumetric and distortion work/energy; Effects of temperature; Navier-Lame equations; Specific stress-strain states; Airy stress function; Computer simulations with FEM; Complex real-life examples and case studies

Prerequisites

Meeting the enrolment conditions for the Master's study programme of Mechanical Engineering - Research and Development program.

Learning outcomes

Thorough professional theoretical and practical knowledge in a selected field of expertise that is supported with a broad theoretical and methodological basis.

- In-depth understanding of stress and strain states in general deformable bodies
- In-depth understanding of the failure mechanisms in structural elements
- In-depth understanding of mathematical structure of rheological models

Assessment

- 20% Examination (lectures - theory)
- 60% Examination (exercises – design calculations)
- 10% Laboratory exercises
- 10% Homework

Literature

- J.N. Reddy: An Introduction to Continuum Mechanics
- A. Bower: Introduction to continuum mechanics
- W.D. Lai, M. Rubin, E. Krempl: Introduction to Continuum Mechanics
- Y.C. Fung: First Course in Continuum Mechanics
- M.E. Gurtin: An Introduction to Continuum Mechanics
- G.T. Mase, G.E. Mase: Continuum mechanics for engineers
- G.E. Mase: Schaum's outline of theory and problems of continuum mechanics
- S. Timoshenko: Theory of elasticity.
- G.A. Holzapfel: Nonlinear Solid Mechanics: A Continuum Approach for Eng.
- R.W. Ogden: Non-Linear Elastic Deformations