University *of Ljubljana*
Faculty *of Mechanical Engineering*

Mechanics of Structural Elements 5 ECTS

Lecturer: **Assoc. Prof. Dr. Miroslav Halilovič**

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

Objectives

The objectives of this course are to learn mathematical formulations of theories in the field of mechanics for structural analysis, to learn the procedures of mechanical analyses of structural elements (trusses, beams, shafts, in-plane loaded plates, lateral loaded plates, shells), mastery the skills of treating real construction with mathematical models, which requires critical thinking on the idealization of structures and the synthesis of individual theories. With this course student will get the following competences:

- mastering the advanced theoretical knowledge used for analytical or numerical mechanical analysis of structures,
- the ability to perform advanced analytical and numerical analysis of frame and plane structures,
- the ability to analyse problems critically and analytically through the study of advanced theories in mechanics.

Programme

The aim of the course is to characterize the mechanical response of structural elements and present the calculation methods for determining their response. Namely, calculations of real constructions are normally performed by decomposing a construction into several structural elements. In this process, certain assumptions need to be adopted and it is crucial that all assumptions are valid for the elaborated case. We will study basic theories of structural mechanics and present typical examples of individual structural elements.

The course covers the following topics: basics of continuum mechanics (displacements, strains, stresses), a definition of the boundary value problem in elastostatics (a problem domain, basic equations and boundary conditions), a definition of structural elements according to their geometric dimension (frame, plane and three-dimensional structures) and according to their curvature (straight/curved beams, plate/wall/ shell). We will present the theoretical background of frame elements, shafts, membranes, plates and shells, and discuss the mechanical response that is provided by different theories, e.g. Bernoulli/Timoshenko, Kirchhoff/Mindlin-Reissner etc. We will also learn how to compute the response of structural elements using analytical and numerical methods (the finite difference and the finite element methods). All computations will be performed in Wolfram Mathematica. We will also present the concept of geometrical symmetry and structure periodicity – axial and planar symmetry, and planar and cyclic periodicity; the referential subdomain concept; the division of external loads to the symmetric and the antisymmetric part; present the properties of vector and tensor response fields for the symmetric/asymmetric and periodic load case.

Prerequisites

No conditions.

Learning outcomes

In-depth theoretical knowledge of analysing different structures. Knowledge of advance numerical techniques such as finite element method for solving 1-d and 2-d structural problems. Analytical knowledge to understand and perform mechanical analysis independently.

- Performing complex mechanical analysis of 1-d and plane structures
- The ability to synthesize acquired knowledge to examples of real structures
- The ability to critically analyse results and evaluate their validity

Assessment

- 50% Theory
- 30% Practical work
- 20% Coursework

Literature

- Hartmann: The Mathematical Foundation of Structural Mechanics, Springer-Verlag, 1985.
- Armenakas: Clasical Structural Analysis – A Modern Approach, McGraw-Hill, 1988.
- Young, Budynas: Roark's Formulas for Stress and Strain, McGraw-Hill, 2012