MILITARY UNIVERSITY OF TECHNOLOGY, WARSAW, POLAND (MUT)
FACULTY OF MECHANICAL ENGINEERING (FME)

COURSE CARD

Course	***Introduction to Elasticity and Plasticity Theory***
Code	WMEMRCNM-IEPT
Academic year	2023/2024
Language	English
Profile of education	general-academic | ~~practical~~
Form of study	part-time study
Type of study	graduate (M.Sc.)
Type of course	obligatory | ~~elective~~
Forms of teaching, number of hours /rigor, total number of hours, ECTS credits	Lectures: 24 / exam Problem-solving: 14 / pass Laboratory: - / - Project: – / – Seminar: – / – **Total: 38 ECTS credits: 3**
Prerequisites	Mathematics: linear algebra, Euclidean geometry, multivariable calculus, differential equations General Physics: Newtonian mechanics, conservation laws of mass/momentum/energy, gravitation Engineering Mechanics: kinematics, dynamics, statics; force systems Strength of materials: stress and strain, constitutive relations, displacements
Programme	I semester / Mechanics and Machine Design / Computer Techniques in Mechanical Engineering
Author(s)	**Andrzej Morka, Ph.D.**
Course contents	Introduction to tensor calculus, elasticity theory assumptions, stress and strain states, governing equations, example solutions, basics of plasticity theory
Course contents (extended description)	<u>Lectures / visual materials presentation:</u> • Introduction to tensor calculus (8h): metatheory and classification of science, elements of logic, set theory and number theory, linear algebra, eigenvalue problems, tensor calculus, classical field theory • Assumptions of elasticity theory (2h): continuum model, elasticity • Description of strain state (2h): selected strain measures, interpretation of components, principal values and directions • Description of stress state (2h): stress vector, Cauchy stress tensor, interpretation of tensor components, decomposition into spherical and deviatoric parts • Energy analysis (2h): elastic energy and work, specific energy • Equations of elasticity theory (2h): equilibrium equations, Hooke's law, formulation of elasticity problems, Lamé equations, Beltrami–Mitchell equations • Example solutions of elasticity problems (2h): plane problem – Airy stress function method, spherically symmetric and axisymmetric problems • Basics of Plasticity Theory (4h)

	Problem-solving: • Mathematical introduction (4h): Scalars, vectors, tensors. Summation convention. Vector space. Index and absolute notation. Transformations of reference frames. • Concept of a tensor (4h): Tensor space. Basis and polybasis. Tensor representation. Operations on tensors. Types and properties of tensors. Rotation tensors. Euclidean tensors. Linear tensor mappings. Tensors of valence 2 and higher. • Strain state (2h): Displacement, strain tensor, geometric interpretation, principal strains, dilatation, compatibility equations. Deformation gradient. Deformation tensors. • Stress state (2h): Stress vector. Stress tensor. Cauchy's theorem. Equilibrium equations. Stress tensor in plane stress state. Principal stresses. Invariants of the stress tensor. Deviator of the stress tensor. Octahedral stress, stress intensity. • Solutions of simple problems in linear elasticity theory (2h): Plane problems, axial symmetry or spherical symmetry.
Recommended reading	**Literature:** **Basic:** • Walczak J., *Strength of Materials and Fundamentals of Elasticity and Plasticity Theory*, PWN, 1977 • Bednarski T., *Mechanics of Plastic Flow*, PWN, Warsaw 1995 • Landau L., Lifshitz E., *Mechanics of Continuous Media*, PWN 1954 **Supplementary:** • McGinty B., continuummechanics.org • Bower A.F., *Applied Mechanics of Solids*, CRC Press, 2010
Learning outcomes and competences	*Symbol and number / learning outcome / reference to programme outcome* W1 / has knowledge of the fundamentals of elasticity theory with respect to strain and stress states, equilibrium equations and elasticity equations, basics of plasticity theory / K_W01, K_W09 U1 / is able to correctly formulate an elasticity theory problem and solve it in selected cases of plane or spherically/axisymmetric problems / K_U01 K1 / understands the need and possibilities of continuous learning; is able to inspire and organize the process of improving professional, personal and others' qualifications / K_K01
Learning methods	Lectures are conducted using multimedia presentations. Problem-solving based on multimedia presentations
Assessment criteria	The course is completed on the basis of a pass of the problem solution and exam in the test form. Course completion is conducted in written form. The condition for passing is obtaining a positive grade from the written test. Achievement of outcomes W1, U1 – assessed based on theoretical knowledge of elasticity and plasticity theory. Achievement of outcome K1 – assessed based on the written test. Grades (according to the opinion of the WIM Quality Assurance Committee): Very good: 91–100% Good plus: 81–90% Good: 71–80%

	Satisfactory plus: 61–70% Satisfactory: 51–60% Fail: ≤50% General grade “pass”: >50% General grade “fail”: ≤50%
ECTS calculation	**ECTS balance (student workload)** Activity / student workload in hours 1. Participation in lectures / 24 2. Participation in problem-solving / 14 3. Individual study of lecture topics / 19 4. Individual study of problem-solving / 14 5. Participation in consultations / 6 6. Preparation for assessment / 10 Total student workload: **88 hours / 2.95 ECTS (rounded to 3 ECTS**) Classes with teacher participation: 46 hours / 1 ECTS Practical classes: 0 hours / 0 ECTS