MODULE INFORMATION SHEET

Name of Module Unit	**Strength of materials and structural mechanics**
Name in polish language	Wytrzymałość Materiałów i Mechanika Budowli
Module type	compulsory / ~~elective~~
Form of studying	full-time day courses
Level of study	undergraduate course (B.Sc. level)
Type of study (for extra-mural courses)	-
Programme	Environmental Engineering
Speciality	Environmental Engineering
Responsible department	Department of Hydro-Engineering and Hydraulics
Responsible person	prof. Zbigniew Kowalewski, dr Szymon Imiełowski

Semester	Lectures(E)	Tutorials	Laboratory	Computer Exercises	Projects	ECTS
2	30 (Exam)	15	15	-	-	4

Objectives (summary)

The subject is a basic engineering course and is a branch of applied mechanics that deals with the behavior of solid bodies subjected to various types of loading. The solid bodies considered in this course include axially loaded members, shafts in torsion, beams, and columns, as well as structures that are assemblies of these components. The attention is paid to analysis of determinate planar structures : beams, trusses, frames. The objectives of a strength of materials analysis are the determination of the stresses, strains, and displacements, produced by the loads. Knowing these quantities for all values of load up to the failure load gives a complete picture of the mechanical behavior of the body. Classroom lectures are supplemented with physical demonstrations. The course includes a laboratory where students have an opportunity to build an appreciation for the phenomenon being discussed in lecture. The course also includes a design project where a link between theory and application will be made.

Prerequisites

Background in basic physics and mathematics

Rules of integrated grade setting

Exam grade (40%), Tutorial grade (40%), Laboratory grade (20%)

Recommended readings

Beer, F.P., and Johnston, E.R. (1992). "Mechanics of Materials," Second Edition, McGraw Hill Publishing Co., New York, NY.
Gere, J.M., and Timoshinko, S.P. (1997). "Mechanics of Materials," Fourth Edition, PWS Publishing Co., Boston, MA.
Gere , M.J., " Mechanics of Materials" , Thomson Learning .
Subramanian, R., " Strength of Materials", Oxford University Press, 2005.

Contents of lectures (syllabus)

	Topics	**Time** (hrs.)	**Scope** (S / Ex)
1	Newton's laws, forces, moments and resultants, couples and distributed forces, free body diagram, 2D constraints and reactions, classification of structures and components.	2	S
2	State of equilibrium, equation of equilibrium of different sets of planar forces.	2	S
3	Statically determinate and indeterminate problems, analysis of determinate planar structures: beams, trusses and frames.	2	S
4	Elements of 3D statics: reduction of a set of forces to resultant force and moment, 3D structural constraints, equation of equilibrium of 3D set of forces.	2	S
5	Fundamentals of strength of materials, model of deformable body, external loads and concept of internal forces. Analysis of stress and strain: definition of stress, stress at a point, normal stress and shear stress, allowable stress and factor of safety, definition of strain – shear and normal strains. Axial loading: tension, compression, normal stress under axial loading, stress and strain distribution under axial loading; Saint-Venant's principle, principle of superposition, stress-strain diagram, Hooke's law; modulus of elasticity, Poisson's ratio, elastic versus plastic behavior of a material, deformations of members under axial loading, statically indeterminate structures subjected to axial forces, problems involving temperature changes.	2	S
6	Moment of inertia of plane cross-section: moments of inertia of plane areas (second moment of area) - moment of inertia with respect to an axis and a pole, products of inertia, moments of inertia with respect to parallel axes - parallel-axis theorem (Steiner's theorem).	2	S
7	Stress and strain analysis under uniaxial, biaxial, triaxial states: notion of stress – normal stress, stresses on inclined plane in an axial member.	2	S
8	Determination of principal stresses, shearing, maximum shear stress, Hooke's law under shearing, graphical approach for stress analysis - Mohr's circle for plane stress, general state of stress, application of Mohr's circle to the three-dimensional analysis of stress, volume variation under triaxial stress state.	2	S
9	Pure bending: relation between transverse loads, shear and bending moments, internal forces in beams subjected to bending; the concept of shear force T and bending moment M_b; relation between T i M_b, shear and bending moment diagrams for beams, prismatic members in pure bending, deformations in a symmetric member in pure bending, stresses and deformations in the elastic range	2	S
10	Design of beams and shafts for strength**:** ultimate and allowable stress, analysis of stress or strain, factor safety, etc., basic considerations for the design of prismatic beams, shear and bending-moment diagrams, principal stresses in a beam.	2	S
11	Torsion: torsional moment diagrams, deformations in a circular shaft, stresses in the elastic range, angle of twist in the elastic range, statically indeterminate shafts, design of transmission shafts	2	S

12	Stress under general loading conditions: components of stress, analysis of three-dimensional states of stress and strain in materials, equilibrium equations, relationships between strain and displacement, strain compatibility, three-dimensional stress-strain relationship for elastic solids (generalized Hooke's law), the limitations of elastic response, Lame's constant, elastic modulus, bulk modulus, relationship between different elastic constants, mechanical properties – elasticity, plasticity, creep, fatigue, buckling etc.	2	S
13	Fundamental strength hypotheses	2	S
14	Stresses under combined loadings**:** combined stress systems, equivalent stress, basic cases of combined stress systems - determination of maximum equivalent stress. Asymmetric bending.	2	S
15	Special cases of complex loading: general case of eccentric axial loading, combination of bending and torsion, combination of bending and tension or compression. Transverse loading: transverse loading of prismatic members, basic assumption regarding the distribution of the normal stresses, determination of the shear on a horizontal plane, determination of the shearing stresses in a beam, shearing stresses in common types of beams	2	S
	Total	**30**	**hours**

S – topics listed in the legal study programme standards from 12.07.2007
Ex – extended topics

Lecturers

prof. dr hab. inż. Zbigniew Kowalewski, dr inż. Szymon Imiełowski

Assessment method

Exam

Contents of tutorials

	Topics	Time (hrs.)	Scope (S / Ex)
1	Repetition of the elements of statics, equilibrium equations.	1	S
2	Statically determinate bar structures subjected to tension and compression - diagrams of normal forces and normal stresses, determination of allowable loading and dimensions, determination of strains and displacements.	1	S
3	Diagrams of internal forces - normal, shear and bending moment - for beams – simple cases.	1	S
4	Diagrams of internal forces - normal, shear and bending moment - for beams - complex cases.	1	S
5	Diagrams of internal forces (normal, shear and bending moment) for frames – simple cases.	1	S
6	Diagrams of internal forces (normal, shear and bending moment) for frames - complex cases	1	S
7	Calculation of the moments of inertia of plane areas - Steiner's theorem – simple plane objects	1	S
8	Calculation of the moments of inertia of plane areas - Steiner's theorem – complex plane objects	1	S
9	Determination of stresses in simple beams. Estimation of allowable loading or dimensions.	1	S
10	Determination of stresses and twisting angles for circular shafts. Calculation of stresses and deformations.	1	S
11	Determination of principal stresses in arbitrary plane stress system. Mohr's circle.	1	S
12	Stresses in structures subjected to non-uniform compression/tension.	1	S
13	Determination of equivalent stress in shafts subjected to combined loading: tension/compression and torsion.	1	S
14	Determination of equivalent stress in shafts subjected to combined loading: bending and torsion.	1	S
15	Coursework	1	
	Total	**15**	**hours**

S – topics listed in the legal study programme standards from 12.07.2007
Ex – extended topics

Persons responsible for tutorials

prof. dr hab. inż. Zbigniew Kowalewski,
dr inż. Szymon Imiełowski

Assessment method for tutorials

Coursework 60% and homework 40%

Contents of laboratory

	Topics	Time (hrs.)	Scope (S / Ex)
1	**Measurements of forces and displacements** Transducers for measurements of forces and displacements. Description of testing stands for calibration of forces and displacements. Calibration of transducers and elaboration of their characteristics. Error analysis. Report elaboration.	5	S
2	**Standard tension test** Description of testing stand, technical parameters of tension testing machine. Working principles of extensometer for strain measurements. Description of specimens. Tension test realization. Elaboration of the results, stress parameters, strain parameters. Analysis of a failure type. Error analysis. Report elaboration.	5	S
3	**Standard compression test** Description of testing stand, technical parameters of compression testing machine. Working principles of extensometer for strain measurements. Description of specimens. Compression test realization for metallic and concrete specimens. Elaboration of the results, stress parameters, strain parameters. Analysis of a failure type. Error analysis. Report elaboration.	5	S
	Total	**15**	**hours**

S – topics listed in the legal study programme standards from 12.07.2007
Ex – extended topics

Persons responsible for laboratory

prof. dr hab. inż. Zbigniew Kowalewski,
dr inż. Szymon Imiełowski
dr inż. Paweł Popielski

Assessment method for laboratory

Reports and their successful defend.

Remarks

Although students will work in groups, every student will be responsible for submitting a separate report showing his/her own effort. The lab report shall include a cover page with the names of all partners in the group, course and test titles, and date. The report itself shall contain the objective of the test, procedure, a sketch of equipment used, tables of data recorded, presentation of results in charts and graphs, and conclusions. The report should emphasize the technical aspect of the test. Emphasis of grading will be placed on the technical content of the report as well as clarity, creativity, and correctness of writing.