

FACULTY OF CIVIL ENGINEERING

SUBJECT CARD

Name in English: Theory of elasticity and plasticity
Name in Polish: Teoria sprężystości i plastyczności
Main field of study (if applicable): *Civil Engineering*
Specialization (if applicable): Civil Engineering
Level and form of studies: ~~1st~~ / 2nd level*, full-time / ~~part-time~~*
Kind of subject: obligatory / ~~optional~~ / ~~university-wide~~*
Subject code: CEB008361
Group of courses: ~~YES~~ / NO*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	15			
Number of hours of total student workload (CNPS)	60	60			
Form of crediting	Examination / crediting with grade *	Examination / crediting with grade *	Examination=/crediting with grade *	Examination / crediting with grade *	Examination=/crediting with grade *
For group of courses mark (X) final course					
Number of ECTS points	2	2			
including number of ECTS points for practical (P) classes		0,8			
including number of ECTS points for direct teacher-student contact (BK) classes	1,1	0,6			

* delete as appropriate

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. The student has necessary knowledge of selected topics of mathematics and physics as a base of structural analysis.
2. The student has knowledge of structural mechanics and strength of materials.
3. The student has knowledge of partial differential equations and Fourier series.

SUBJECT OBJECTIVES

- C1. Introduction to three dimensional problem of theory of elasticity
- C2. Presentation of physical basis and assumptions in plane problems.
- C3. Presentation of assumptions, equations and analytical solutions in Kirchhoff theory of thin plates
- C4. Presentation of assumptions, equations and analytical solutions in Kirchhoff-Love theory of thin shells
- C5. Introduction to theory of plasticity. Presentation of limit load theory for thin plates.
- C6. To set a conviction about necessity of knowledge continuous extension in field of theory of elasticity and plasticity.

SUBJECT EDUCATIONAL EFFECTS	
Relating to knowledge:	
PEK_W01	The student knows and understands the equilibrium, geometrical and physical relations for linear-elastic, isotropic body.
PEK_W02	The student knows and understands the differences between linear and nonlinear descriptions and isotropic anisotropic bodies.
PEK_W03	The student knows and understands assumptions, internal forces definitions and boundary conditions in plates and shells.
PEK_W04	The student knows and understands the differences between bending and membrane shells theories.
PEK_W05	The student knows and understands basic terms of theory of plasticity, definitions and theorems of limit load theory.
Relating to skills:	
PEK_U01	The student recognizes properly plane problems and thin plates or shells issues.
PEK_U02	The student is capable of use analytical solutions for selected discs, plates and membrane shells problems.
PEK_U03	The student is capable of evaluate limit load for plates using kinematic approach.
Relating to social competences:	
PEK_K01	The student has a conviction about necessity of knowledge continuous extension in field of theory of elasticity and plasticity.

PROGRAMME CONTENT		
Form of classes - lecture		Number of hours
Lec1	Introduction. Index notation. Stress tensor: differential equilibrium equation	2
Lec2	Stresses tensor (cont.): kinetic boundary conditions, transformation, invariants, principal stresses and directions.	2
Lec3	Continuous body motion: Lagrange and Euler description, strain tensors, compatibility equations. Linear elastic material models. General Hooke's law. Theory of elasticity equations set. Lamé and Beltrami-Mitchell equations.	2
Lec4	Elastic strain energy. Total potential energy. Virtual work principle. Lagrange theorem. Stable and unstable equilibrium.	2
Lec5	Plane problems. Airy stress function for plane stress.	2
Lec6	Plane problem in polar coordinates – application of Airy stress function, third order differential equation for axial symmetry case.	2
Lec7	Thin plates. Kirchhoff theory: assumptions, stresses and internal forces, equilibrium equations, boundary conditions.	2
Lec8	Analytical solutions for plates. Rectangular plate – Navier approach.	2
Lec9	Plate stability. Second order bending theory.	2
Lec10	Annular plates. Fourth and third order differential equations for axial symmetry case.	2
Lec11	Thin shells. Assumptions. Geometrical description. Stresses distribution and internal forces. Bending theory application for cylindrical container.	2
Lec12	Membrane theory for shells of revolution. Equilibrium equations. Analytical solutions for spherical and conical geometry and axis-symmetrical load.	2
Lec13	Basis of theory of plasticity: plastic body models, general plasticity conditions, plasticity conditions for plates, Definitions and theorems of limit load theory.	2
Lec14	Lecture summary. Examples of test tasks.	2
Lec15	Test	2
Total hours		30

Form of classes - class		Number of hours
Cl1	Index notation – application examples.	1
Cl2	Stress tensor components transformation. Invariants, principal stresses and directions calculation.	2
Cl3	Application of Airy stress function in solution of plane stress problems.	2
Cl4	Plane problem in polar coordinates – stress concentration caused by a circular hole.	2
Cl5	Navier solution for plates.	2
Cl6	Hyperboloid membrane shell – different geometry parameterization	2
Cl7	Kinematic approach to limit load evaluation for rectangular and circular plates.	2
Cl8	Test.	2
Total hours		15

Form of classes - laboratory		Number of hours
Lab1		
...		
Total hours		

Form of classes - project		Number of hours
Proj1		
...		
Total hours		

Form of classes - seminar		Number of hours
Sem1		
...		
Total hours		

TEACHING TOOLS USED	
N1.	Lecture: traditional form.
N2.	Classes: analytical solutions of lecture related problems.
N3.	Office hours.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT		
Evaluation (F – forming (during semester), P – concluding (at semester end))	Educational effect number	Way of evaluating educational effect achievement
P (classes)	PEK_W01, PEK_W03, PEK_W05, PEK_U01 PEK_U02, PEK_U03.	test
P (lecture)	PEK_W01, PEK_W03, PEK_W05, PEK_U01	test

	PEK_U02, PEK_U03.	
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PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

1. Stephen P. Timoshenko and J.N. Goodier, Theory of Elasticity, McGraw-Hill, 1970.
2. A.I. Lurie and A.K. Belyaev, Theory of Elasticity (Foundations of Engineering Mechanics), Springer, 2005.

SECONDARY LITERATURE:

1. Y. C. Fung, Foundation of Solid Mechanics, Prentice-Hall, New Jersey 1965.
2. Kyuichiro Washizu, Variational methods in elasticity and plasticity, Pergamon Press, 1982.

SUBJECT SUPERVISOR (NAME AND SURNAME, DIVISION, E-MAIL ADDRESS)

Grzegorz Waśniewski, Zakład Wytrzymałości Materiałów, grzegorz.wasniewski@pwr.edu.pl

MEMBERS OF THE EDUCATIONAL TEAM (NAME AND SURNAME, E-MAIL ADDRESS)

Kazimierz Myślecki, kazimierz.myslecki@pwr.edu.pl, Ryszard Kutylowski, ryszard.kutylowski@pwr.edu.pl, Roman Szmigielski, roman.szmigielski@pwr.edu.pl, Grzegorz Waśniewski, grzegorz.wasniewski@pwr.edu.pl, Andrzej Helowicz, andrzej.helowicz@pwr.edu.pl, Tomasz Kasprzak, tomasz.kasprzak@pwr.edu.pl, Jacek Oleńkiewicz, jacek.olenkiewicz@pwr.edu.pl, Dawid Prokopowicz, dawid.prokopowicz@pwr.edu.pl, Marta Knawa-Hawryszków, marta.knawa@pwr.edu.pl

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT
Theory of elasticity and plasticity
AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY *Civil Engineering*
AND SPECIALIZATION **Civil Engineering**

Subject educational effect	Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)**	Subject objectives ***	Programme content ***	Teaching tool number ***
Knowledge				
PEK_W01	K2_W01, K2_W02, K2_W04, K2S_CEB_W16	C1, C2, C6	Lec1 ÷ Lec6 C11 ÷ C14	N1, N2, N3
PEK_W02	K2_W01, K2_W02, K2_W04, K2S_CEB_W16	C1, C6	Lec3, Lec4, Lec9	N1, N3
PEK_W03	K2_W01, K2_W02, K2_W04, K2S_CEB_W16	C3, C4	Lec7 ÷ Lec12, C15, C16	N1, N2, N3
PEK_W04	K2_W01, K2_W02, K2_W04, K2S_CEB_W16	C4, C6	Lec11, Lec12	N1, N3
PEK_W05	K2_W01, K2_W02, K2_W04, K2S_CEB_W16	C5, C6	Lec13, C17	N1, N2, N3
Skills				
PEK_U01	K2_U02, K2_U04, K2_U08, K2S_CEB_U19, K2S_CEB_U23	C2, C3, C4	Lec5 ÷ Lec12, C13 ÷ C16	N1, N2, N3
PEK_U02	K2_U02, K2_U06, K2_U08, K2S_CEB_U19, K2S_CEB_U23	C2, C3, C4	Lec5, Lec10, Lec12, C13 ÷ C16	N1, N2, N3
PEK_U03	K2_U02, K2_U06, K2_U08, K2S_CEB_U19, K2S_CEB_U23	C5	C17	N2, N3
Social competence				
PEK_K01	K2_K01	C6	Lec1, Lec3, Lec4, Lec9, Lec11, Lec13 ÷ Lec15, C11, C16, C18	N1, N2, N3

** - enter symbols for main-field-of-study/specialization educational effects

*** - from table above