Politechnika Krakowska im. Tadeusza Kościuszki

Karta przedmiotu

obowiązuje studentów rozpoczynających studia w roku akademickim 2020/2021

Wydział Inżynierii Lądowej

Kierunek studiów: Budownictwo Profil: Ogólnoakademicki

Forma sudiów: stacjonarne Kod kierunku: BUD

Stopień studiów: II

Specjalności: Structural Design and Management in Civil Engineering (profile: Structural Design),Structural Design and Management in Civil Engineering (profile: Construction Technology and Management),Building and Engineering Constructions (profile: Building Structures)

1 Informacje o przedmiocie

Nazwa przedmiotu	Teoria sprężystości i plastyczności
Nazwa przedmiotu w języku angielskim	Theory of Elasticity and Plasticity
Kod przedmiotu	WIL BUD oIIS C5 20/21
Kategoria przedmiotu	Major subjects
Liczba punktów ECTS	3.00
Semestry	1

2 Rodzaj zajęć, liczba godzin w planie studiów

Semestr	Wykład	Ćwiczenia audytoryjne	Laboratoria	Laboratoria komputerowe	Projekty	Seminarium
1	30	0	0	0	15	0

3 Cele przedmiotu

Cel 1 Introduction of the basic notions of Continuum Mechanics connected with material and spatial description of motion of a continuum concerning kinematics and dynamics of deformable solids as well as constitutive relations. Formulation of a boundary value problem of non-linear theory of elasticity and specification of conditions enabling linearization of the theory.

Cel 2 Presentation of a boundary value problem of linear theory of elasticity and of chosen methods of solving it - based both on local as well as on global (variational) formulation referring to the Finite Element Method.

Cel 3 Presentation of chosen problems of the linear theory of elasticity and of the methods of finding the solution.

Cel 4 Presentation of basic concepts of the theory of plasticity. Analysis of chosen problems of plastic bearing capacity of structural elements and structural systems.

Cel 5 Preparation of a student for performance of scientific and research tasks.

4 Wymagania wstępne w zakresie wiedzy, umiejętności i innych kompetencji

1 Basic skills in calculus - finding derivatives of a single- and multivariable function, definite and indefinite integrals, curvilinear integrals and multiple integrals.

2 Basic skills in matrix calculus - matrix addition, subtraction and multiplication, calculation of determinants, solving the eigenproblem.

3 Knowledge on classical principles of dynamics of a material points and rigid body.

5 Efekty kształcenia

EK1 Wiedza Student formulates the boundary value problem of non-linear theory of elasticity both in material and in spatial description, defines and explains the physical sense of various measures of deformation and stress, which are used in this formulation.

EK2 Umiejętności For a given deformation in each description student determines appropriate measures of deformation and stress.

EK3 Wiedza Student formulates the boundary value problem of linear theory of elasticity, understands the mathematical structure of obtained system of equations and explains chosen strict and approximate methods of solving it.

EK4 Umiejętności Student uses classical results of linear theory of elasticity in modeling and solving the problems of deformation of deformable solids.

EK5 Wiedza Student defines basic notions of theory of plasticity.

6 Treści programowe

Projekty		
Lp	Tematyka zajęć Opis szczegółowy bloków tematycznych	Liczba godzin
P1	Eigenvalue problem for a 3x3 and 2x2 symmetric matrix and its application to the deformation gradient	2
P2	Material and spatial description of deformation. Displacement vector, actual configuration, deformation gradient, deformation tensors, strain tensors, change of length, area and volume after deformation.	3
P3	Polar decomposition of the deformation gradient.	2

Projekty		
Lp	Tematyka zajęć Opis szczegółowy bloków tematycznych	Liczba godzin
P4	Determining body forces and surface tractions for given deformation or given stress state.	2
P5	Solving the problems of plane elastic structures with the use of Finite Difference Method.	2
P6	Bearing capacity of cross-sections subject to chosen load cases.	2
P7	Determining the plastic bearing capacity of a structural system.	2

Wykład		
Lp	Tematyka zajęć Opis szczegółowy bloków tematycznych	Liczba godzin
W1	Introduction to Continuum Mechanics. Characterization of elastic, plastic and rheological phenomena. Introduction to kinematics - displacement, velocity, acceleration vector, Material and spatial description of motion.	2
W2	Kinematics of deformable solids - deformation gradient and its polar decomposition, stretch tensors, rotation tensor, deformation tensors, strain tensors in material and spatial description. Geometric linearizaton, small strain and small rotation tensors. Interpretation of components of strain tensor and of small strain tensor. Change of length of a material fiber, area of a material surface and volume of a body after deformation.	6
W3	Mass, mass density, conservation of mass. Body forces, surface tractions and stress. Stress vector. Tetrahedron conditions. Tensorial measures of stress state. Laws of motion for deformable solids, equations of motion in material and spatial description.	5
W4	Constitutive relations and postulates concerning formulation of those relations. Elastic material, hyperelastic material. Isotropy, anisotropy, homogeneity, inhomogeneity. Isotropic hyperelastic material. Hooke's material.	2
W5	Linear theory of elasticity. Lame displacement equations, Beltrami-Michell stress compatibility equations. Plane stress and plane strain states. Plane stress and plane strain states. Airy stress function. Levy theorem.	5
W6	Examples of solution of chosen boundary value problems of linear theory of elasticity.	4
W7	Variational methods in theory of elasticity. Principle of Virtual Displacements, Lagrange theorem, Principle of Virtual Forces, Castigliano theorem. Betti-Maxwell reciprocal theorem. Galerkin method in application to variational formulation - Finite Element Method.	3
W8	Chosen features of plastic deformation. Chosen propositions of a yield condition. Yield surface. Active and passive processes, Hencky-Ilyushin theory. Prandtl-Reuss and Levy-Mises theory.	3

7 Narzędzia dydaktyczne

N4 Lectures

N5 Design classes

N6 Office hours

8 Obciążenie pracą studenta

Forma aktywności	Średnia liczba godzin na zrealizowanie aktywności
Godziny kontaktowe z nauczycielem akademickim, w tym:	
Godziny wynikające z planu studiów	45
Konsultacje przedmiotowe	6
Egzaminy i zaliczenia w sesji	4
Godziny bez udziału nauczyciela akademickiego wynikające z nakładu pracy studenta, w tym:	
Przygotowanie się do zajęć, w tym studiowanie zalecanej literatury	6
Opracowanie wyników	4
Przygotowanie raportu, projektu, prezentacji, dyskusji	10
Sumaryczna liczba godzin dla przedmiotu wynikająca z całego nakładu pracy studenta	**75**
Sumaryczna liczba punktów ECTS dla przedmiotu	3.00

9 Sposoby oceny

Ocena formująca

F1 Individual project

F2 Oral answers

Ocena podsumowująca

P1 Written test

Warunki zaliczenia przedmiotu

W1 All learning outcomes must be marked positive

W2 All given projects must be completed - its content must be done in a correct way and student must answer correctly few questions concerning the project.

Kryteria oceny

Efekt kształcenia 1	
Na ocenę 3.0	Student formulates the boundary value problem of non-linear theory of elasticity both in material and in spatial description, defines and explains the physical sense of physical quantities used and formulates the conditions for linearization of the theory.
Na ocenę 4.0	Student meets the requirements for mark 3,0 and, additionally: names and explains known postulates and theorems concerning kinematics, dynamics and theory of constitutive relations in Continuum Mechanics.
Na ocenę 5.0	Student meets the requirements for mark 4,0 and, additionally: shown general concepts of proofs of fundamental theorems of Continuum Mechanics and derivations of known relations, explains the physical meaning of such notions as material derivative, polar decomposition of deformation gradient, difference between true stress, nominal stress and material stress vectors and tensors.
Efekt kształcenia 2	
Na ocenę 3.0	For given equations student determines the deformation gradient and performs its polar decomposition, determines deformation tensors, strain tensors and displacement vector in both material and spatial description.
Na ocenę 4.0	Student meets the requirements for mark 3,0 and, additionally: for given deformation and constitutive relations determines the Cauchy stress tensor as well as Piola-Kirchhoff stress tensor of the 1st and 2nd kind, determines body forces vector and surface tractions.
Na ocenę 5.0	Student meets the requirements for mark 4,0 and, additionally: for a given deformation finds the change of volume, area of surface element and length of a material curve after deformation.
Efekt kształcenia 3	
Na ocenę 3.0	Student formulates the boundary value problem of linear theory of elasticity, understands the mathematical structure of obtained system of equations and presents the boundary value problem in a two-dimensional case (plane stress and plane strain state)
Na ocenę 4.0	Student meets the requirements for mark 3,0 and, additionally: defines kinematically admissible displacement field and statically admissible stress field, explains known semi-inverse methods of solution of a boundary value problem in linear theory of elasticity, knows the concept of solution of the problem with the use of Lame displacement equations and Beltrami-Michell stress compatibility equations.
Na ocenę 5.0	Student meets the requirements for mark 4,0 and, additionally: presents known variational principles and energy theorems on linear theory of elasticity and their relation with the Finite Element Method, explains the sense of Green influence function with the example of solution of the Kelvin problem or Flamant problem.
Efekt kształcenia 4	

Na ocenę 3.0	Student expresses the stress state components in terms of the Airy stress function and writes down the static boundary conditions expressed in terms of the Airy stress function.
Na ocenę 4.0	Student meets the requirements for mark 3,0 and, additionally: solves the problem of plane elastic structures with the use of Finite Difference Method.
Na ocenę 5.0	Student meets the requirements for mark 4,0 and, additionally: formulates the classical problems of linear theory of elasticity, which were introduced during the lecture.
Efekt kształcenia 5	
Na ocenę 3.0	Student defines basic yield criteria, makes a sketch of a yield surface for them, knows characteristic features of plastic deformation such as: permanent strain, elastic unloading and subsequent loading, plastic flow, hardening.
Na ocenę 4.0	Student meets the requirements for mark 3,0 and, additionally: explains the notions of active and passive processes, presents the distribution of stress in partially and fully yielding cross-section subjected to basic load cases.
Na ocenę 5.0	Student meets the requirements for mark 4,0 and, additionally: presents mathematical formalism of description of plastic deformation.

10 Macierz realizacji przedmiotu

Efekt kształcenia	Odniesienie danego efektu do szczegółowych efektów zdefiniowanych dla programu	Cele przedmiotu	Treści programowe	Narzędzia dydaktyczne	Sposoby oceny
EK1	K_W01 K_W03 K_W04	Cel 1 Cel 5	w1 w2 w3 w4	N4 N5 N6	F1 F2 P1
EK2	K_W01 K_W03 K_W04 K_U13 K_U17 K_U18 K_K01 K_K02	Cel 1	p1 p2 p3 p4 w1 w2 w3 w4	N4 N5 N6	F1 F2
EK3	K_W01 K_W03 K_W04	Cel 2 Cel 5	w1 w2 w3 w4 w5 w6 w7	N4 N5 N6	F1 F2 P1
EK4	K_W01 K_W03 K_W04 K_U13 K_U17 K_U18 K_K01 K_K02	Cel 3 Cel 5	p5 w5 w6	N4 N5 N6	F1 F2

Efekt kształcenia	Odniesienie danego efektu do szczegółowych efektów zdefiniowanych dla programu	Cele przedmiotu	Treści programowe	Narzędzia dydaktyczne	Sposoby oceny
EK5	K_W01 K_W03 K_W04	Cel 4 Cel 5	p6 p7 w8	N4 N5 N6	P1

11 Wykaz literatury

Literatura podstawowa

[1] **Love E.A.H.** — *A treatise on the mathematical theory of elasticity*, Cambridge, 1906, Cambridge University Press

[2] **Hill R.** — *The Mathematical Theory of Plasticity*, Oxford, 1950, Oxford University Press

[3] **Chen W. F., Han J. D.** — *Plasticity for Structural Engineers*, New York, 1988, Springer

[4] **Gere J.M., Timoshenko S.P.** — *Mechanics of Materials ,2nd Ed.*, Boston, 1984, PWS-Kent

Literatura uzupełniająca

[1] **Życzkowski M.** — *Combined loadings in the theory of plasticity*, Warsaw, 1981, PWN

[2] **Bower A.F.** — *Applied Mechanics of Solids*, -, 0, -

[3] **Szeptyński P.** — *Theory of Elasticity - lecture notes*, -, 0, -

[4] **Szeptyński** — *A Short Introduction to the Theory of Plasticity - lecture notes*, -, 0, -

12 Informacje o nauczycielach akademickich

Osoba odpowiedzialna za kartę

dr inż. Paweł Szeptyński (kontakt: `pszeptynski@pk.edu.pl`)

Osoby prowadzące przedmiot

1 dr inż. Paweł Szeptyński (kontakt: `pszeptynski@pk.edu.pl`)

13 Zatwierdzenie karty przedmiotu do realizacji

(miejscowość, data) (odpowiedzialny za przedmiot) (dziekan)

Przyjmuję do realizacji (data i podpisy osób prowadzących przedmiot)

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