COURSE DESCRIPTION CARD - SYLLABUS

Course name
Applied mathematics [S2Bud1-BDMiK>MS]

Course

Field of study
Civil Engineering

Year/Semester
1/1

Area of study (specialization)
Road, Bridge and Railway Engineering

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
30

Laboratory classes
0

Other
0

Tutorials
15

Projects/seminars
0

Number of credit points

3,00

Coordinators

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Lecturers

Prerequisites

KNOWLEDGE: Basic knowledge of mathematical analysis, theory of ordinary differential equations, linear algebra, matrix calculus and analytical geometry (from first cycle studies). Basic knowledge of the strength of materials and mechanics. SKILLS: Ability to formulate physical problems in the language of mathematics and to solve algebraic and differential equations that occur in the tasks of theoretical mechanics, strength of materials and structural mechanics. Operation of a computer station, basic skills in using a spreadsheet. SOCIAL COMPETENCE: Awareness about necessity of expending the theoretical knowledge in order to justify its application during the professional career. Understanding the necessity of constant education.

Course objective

The goal of the course is to teach mathematical tools (tensor and variational calculus) and methods for formulating boundary value problems in continuum mechanics and structures as well as in constitutive modeling of materials, which are necessary to solve typical tasks of static and strength analysis of basic structural elements.

Course-related learning outcomes

Knowledge:

The student knows the concept of a linear operator (tensor), the concept of eigenvalue and eigenvector of a linear operator.
The student knows the notions of the general and special solutions of a differential equation in the context of BVPs in mechanics, e.g. equations of beams (1D), plates (2D), theory of elasticity (3D).
The student has knowledge of the constitutive laws of elasticity and plasticity of materials.
The student understands the specifics and knows the Airy function method for analyzing two-dimensional problems (PSN and PSO, disks). The student understands the specifics and knows the methods of static analysis of thin plates. The student understands the specificity of the elastic-plastic behavior of materials and knows the methods of analysis of the limit load capacity of bar structures.

Skills:
Student is capable to solve problems involving tensor calculus in absolute, index and matrix notations.
Student is capable to solve 2-D boundary value problems for elastic disks (plane stress and plane strain states).
Student is capable to calculate the ultimate load capacity of bar systems (elasto-plastic beams and frames).

Social competences:
Student is capable to work individually as well as in the team.
Student is aware of the responsibility arising from the accuracy of obtained results and is able to provide the interpretation.
Student is aware of the necessity of constant education and knowledge expansion.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Learning outcomes presented above are verified as follows:
1) Lectures: written test (2 h) at the end of semester
2) Tutorials: two written tests during semester (45 mins.) and one home assignment (project).

Programme content

Elements of vector and tensor calculus. Stress state - stress tensor. Differential equilibrium equations and boundary conditions. Principal stresses and principal directions of a tensor, extremal tangential stresses. Motion description, Lagrange formulation and Euler formulation. State of deformation - deformation tensor. Deformation equations.
Constitutive equations of elasticity (Hooke"s law). Elements of calculus of variation: functional, potential, derivative of a functional, Euler-Lagrange equation. Theorem on minimum potential energy. Virtual work equation. Lame"s equations. Beltrami-Michella equations. Two-dimensional problems.
Plane stress state. Plane deformation state. Airy"s stress function. Plane problems in polar coordinates. Methods and examples of solving boundary problems. Boussinesq"s problem and Flamant"s problem.
Fundamentals of the theory of thin plates. Assumptions and derivation of equations. Internal forces in plates. Rectangular plates. Axially symmetrically loaded circular plates. Examples of calculating internal forces and displacements in plates.
Constitutive relationships of plasticity. Plasticity conditions of Treska, Huber-Mises-Hencky.
Basic assumptions, theorems and methods of the theory of ultimate load capacity. Examples of the calculation of the ultimate load capacity of beams.

Course topics

W1. Elements of vector calculus.
W2. Elements of tensor calculus.
W3. Law of transformation of vector or tensor coordinates during rotation of their coordinate axis system.
W4. Motion description, Lagrange formulation and Euler formulation.
W5. State of deformation - deformation tensors.
W6. Stress state - stress tensor.
W7. Differential equilibrium equations.
W8. Hooke's law.
W9. Elastic-plastic behaviour of materials.
W10. Plastic joint, ultimate moment of force of a cross section.

W11. Elastic-plastic analysis of ultimate bearing capacity of beams.
W12. Boussinesq"s problem and Flamant"s problem.
W13. Fundamentals of the theory of thin plates.
W14. Calculating deflection and internal forces in plates
W15. Ultimate load capacity of plates.

Teaching methods

Lecture — traditional lectures ("chalk-and-talk"), with computer-assisted presentations at times.
Tutorial — discussing and solving problems on the blackboard with plenty of student participation.

Bibliography

Basic
1. Brunarski L., Kwiecinski M.: Wstęp do teorii sprężystości i plastyczności, Wyd. PW, Warszawa 1976.
2. Brunarski L., Górecki B., Runkiewicz L.: Zbiór zadań z teorii sprężystości i plastyczności, Wyd. PW, Warszawa 1976.
3. Gawęcki A.: Mechanika materiałów i konstrukcji prętowych, Tom I+II, Wyd. PP, Poznań 1998.
4. Kącki E., Siewierski L: Wybrane działy matematyki wyższej z ćwiczeniami. PWN, Warszawa 1979.
Additional
1. Itskov M.: Tensor Algebra and Tensor Analysis for Engineers with Applications to Continuum Mechanics, Springer-Verlag, Berlin Heidelberg New York, 2007.
2. Mang H.A.: Hofstetter G.: Festigkeitslehre, Springer Vieweg 2018.
3. Mase G.E.:Theory and problems of continuum mechanics, Mc-Graw Hill , New York 1970.
4. Nowacki W.: Teoria sprężystości, PWN, Warszawa 1970.

Breakdown of average student's workload

	Hours	ECTS
Total workload	90	3,00
Classes requiring direct contact with the teacher	45	1,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	45	1,50