COURSE DESCRIPTION CARD - SYLLABUS

Course name
Computational mechanics [S2Bud1E-KB>MO]

Course

Field of study
Civil Engineering

Year/Semester
1/1

Area of study (specialization)
Structural Engineering

Profile of study
general academic

Level of study
second-cycle

Course offered in
English

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
30

Laboratory classes
30

Other (e.g. online)
0

Tutorials
0

Projects/seminars
0

Number of credit points

4,00

Coordinators

prof. dr hab. inż. Wojciech Sumelka
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Lecturers

Prerequisites

Knowledge: Mathematics: foundations of differenctial, integral and matrices calculuses; Structural Mechanics, Strength of Materials and Theory of Elsticity on the level of 6 according to KRK system; Numerical Methods and Information Technology on the level of 6 according to KRK system; Skills: The Student is able to follow through the static analysis of beam structures; Uses the displacement method for solving beam systems; The Student uses the selected software tools of computer analysis and design of structures; Social competencies: Understand the role of continuous education in teh direction of the study but also other technical sciences;

Course objective

To be familiar with the basics and applications of numerical methods and computational analysis of structures for linear and nonlinear cases; also to be responsible for proper modeling and the results of computations;

Course-related learning outcomes

Knowledge:
1. have extended and detailed knowledge of mathematics, physics and chemistry, forming theoretical

principles appropriate to formulate and solve tasks related to building engineering.
2. know key issues of continuous medium mechanics; principles of analysing the issues of statics, stability and dynamics.
3. have extended and detailed knowledge of material strength, modelling and constructing;
have knowledge of theoretical principles of the finite element method as well as general rules of non-linear calculations of engineering structures.
4. have detailed knowledge in the field of operation algorithms of selected software supporting the analysis and design of building facilities, which are also useful to plan and manage construction projects, including Building Information Modelling (BIM).
5. have advanced and detailed knowledge of the theoretical principles of structure analysis and optimization as well as design of selected building units.

Skills:
1. can perform a classical static and dynamic analysis and stability analysis of statically determinate and non-determinate bar structures (trusses, frames and strands); as well as surface construction (discs, plates, membranes and shells).
2. use advanced specialized tools in order to search for useful information, communication and in order to obtain software supporting the designer and organizer of building engineering works.
3. are able to correctly define a computational model and carry out an advanced linear analysis of complex building units, their elements and connections; are able to apply basic nonlinear computational techniques together with a critical evaluation of numerical analysis results.
4. utilizing the obtained knowledge, they can select appropriate (analytical, numerical, simulation, experimental) methods and tools to solve technical problems.
5. applying scientific rules and skills, are able to formulate and test hypotheses related to simple research problems, in order to solve engineering, technological and organisational problems in construction engineering; can prepare studies preparing for research work.

Social competences:
1. take responsibility for the reliability of working results and their interpretation.
2. are responsible for the safety of own work and team work.
3. can realise that it is necessary to improve professional and personal competence; are ready to critically evaluate the knowledge and received content.
4. can realise how important it is to take care of health and physical fitness.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

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The lectures are finished with final assessment in the form of written exam and if
necessary oral one. In the written part the Students answer to 4-6 questions (problems) or if test was chosen on 20 questions. After reviewing
the oral part is only for those who are the best in the group. It is necessary to obtain 50% points.
During the labs the progres in the work of Students is evaluated. The marks are offered for every problem that has to be solved. It is necessary to obtain 50% points.

Programme content

Lecture Schedule:
Mathematical modelling in Civil Engineering
Fundamentals of continuum mechanics for Civil Engineering
Introduction to advanced Finite Element Method (FEM) with applications in Civil Engineering
Introduction to FEM - cont.
Modeling of building constructions as three-dimensional bodies (constructions of an arbitrary shape)
Modeling of building constructions as two-dimensional bodies (walls, retaining walls, dams)
Modeling of plate structures
Advanced linear/nonlinear statics of building constructions (introduction - 1D formulation)
Advanced nonlinear statics of building constructions (FEM) (3D formulation)
Advanced nonlinear statics of building constructions (FEM) (linear buckling analysis, load/displacement control and Riks methods)
Dynamics of building constructions - linear analysis (natural frequencies extraction, steady-state

analysis - harmonic excitation)
Dynamics of building constructions - linear / non-linear analysis (modal superposition, implicit/explicit integration, arbitrary excitation)
Dynamics of building constructions - non-linear analysis (implicit/explicit integration, , arbitrary excitation)
Dynamics of building constructions - non-linear analysis - cont.
Summary
Laboratory Schedule:
Introduction to Abaqus – cantilever beam (Getting Started with Abaqus: Interactive Edition Appendix B).
Introduction to Abaqus - hinge model (Getting Started with Abaqus: Interactive Edition: Appendix C).
Linear statics – comparative analysis of the influence of the finite element mesh density and element type (type of shape functions, integration, etc.) / comparative analysis of the continual and structural (plate, beam) models - linear elastic isotropic material. (PDF)
Non-linear statics - understanding the incremental process. (PDF)
Linear / non-linear statics - orthotropic elastic material vs. isotropic elastic material / elasto-plastic material vs. elastic material. (PDF)
Linear dynamics - eigenproblem / forced vibrations. (PDF)
Consultation and realisation of individual tasks.
Consultation and realisation of individual tasks – Assessment.

Course topics

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Mathematical modelling in Civil Engineering
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Introduction to advanced Finite Element Method (FEM) with applications in Civil Engineering
Introduction to FEM - cont.
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Dynamics of building constructions - non-linear analysis (implicit/explicit integration, , arbitrary excitation)
Dynamics of building constructions - non-linear analysis - cont.
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Consultation and realisation of individual tasks – Assessment.

Teaching methods

1. Lecture: multimedia presentation, illustrated with examples on the board.

2. Laboratory: multimedia presentation, illustrated with examples given on a board, and performance of tasks given by the teacher.

Bibliography

Basic
O.C. Zienkiewicz, R.L. Taylor, The Finite Element Method, V1-3, 2000
O.A. Bauchau, J.I. Craig, Structural Analysis, With Applications to Aerospace Structures, Springer, 2009
T. Belytschko, W. Kam Liu, B. Moran, Nonlinear finite elements for continua and structures, Wiley, 2000
René de Borst, Mike A. Crisfield, Joris J. C. Remmers, Clemens V. Verhoosel, Non-Linear Finite Element Analysis of Solids and Structures, Second Edition, Wiley, 2012
Additional
P. Haupt, Continuum Mechanics and Theory of Materials, Springer, 2000
J.N.Reddy, Energy principles and variational methods in applied mechanics, Willey 1984
J.N.Reddy, An introduction to the Finite Element Method, McGraw-Hill, 2006
J.C. Simo, T.J.R. Hughes, Computational inelasticity, Springer, 1997
EA de Souza Neto, D Peric, DRJ Owen, Computational methods for plasticity – theory and applications, Wiley, 2008
P. Wriggers, Nonlinear Finite Element Methods, Springer, 2008
G.A. Holzapfel, Nonlinear solid mechanics – A continuum approach for engineering, Willey 2000

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,00
Classes requiring direct contact with the teacher	60	2,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	40	1,50