COURSE DESCRIPTION CARD - SYLLABUS

Course name

Numerical analysis

Course

Field of study	Year/Semester
Civil Engineering	1/2
Area of study (specialization)	Profile of study
Structural Engineering	general academic
Level of study	Course offered in
Second-cycle studies	English
Form of study	Requirements
full-time	compulsory

Number of hours

Lecture	Laboratory classes	Other (e.g. online)
30	30	0
Tutorials	Projects/seminars	
0	0	

Number of credit points

3

Lecturers

Responsible for the course/lecturer:

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Responsible for the course/lecturer:

Prerequisites

Knowledge: knowledge of methods of solving differential equations, linear and non-linear systems of equations, knowledge of approximation and interpolation methods, including numerical methods; knowledge of nonlinear structure mechanics methods, finite element methods for PSO, PSN, 3d, shells including geometric nonlinearities, buckling in static and dynamic cases; understanding how the choice of the advancement and complexity of the computer model affects the results obtained with it; knowledge acquired in the subjects Mathematics, Computational Methods, KWP, Structural Mechanics, Strength of Materials and Theory of Elasticity at the NQF level 6 and on the subject of Computer Methods.

Skills acquired during classes and laboratories and projects in the subjects: Mathematics, Computational Methods, KWP, Structural Mechanics, Strength of Materials and Theory of Elasticity at the level of KRK 6 and on the subject: Computer Methods; solving problems of statics and dynamics of structures in the linear and non-linear range using the finite element method; is able to create a construction model of different advancement and complexity; knows how to use selected computer tools for structure analysis and design, including the Abaqus program;

Social competences: Is aware of the purposefulness of continuous training in disciplines related to the field of study and related disciplines; is inquisitive and curious about the challenges posed to him;

Course objective

Provide students with basic knowledge on modeling building materials used in modern structures, which are used in programs for structure analysis. Presentation of methods by which elements of modern building structures are combined. Presentation of computer methods used in coupled mechanics with particular emphasis on the temperature field. Developing the designer's personal responsibility for the results of computer analyzes - a critical evaluation of the quality of these results. Gaining knowledge and skills related to the use of advanced numerical methods to solve complex engineering tasks supporting the design process in construction.

Course-related learning outcomes

Knowledge

1. has an extended and deepened knowledge of mathematics, physics and chemistry, creating theoretical foundations useful for formulating and solving construction-related tasks

2. knows the key issues of continuum mechanics; knows the principles of analysis of statics, stability and dynamics

3. has advanced detailed knowledge of the issues of material strength, material and structure modeling; has knowledge of the theoretical basis of the Finite Element Method and general principles of nonlinear calculations of engineering structures

4. knows in depth the currently used building materials and products, their properties and test methods, as well as the technologies of their production and assembly

5. has in-depth knowledge of the algorithms of operation of selected computer programs supporting the analysis and design of building objects and useful for planning and managing construction projects, including BIM (Building Information Modeling) technology

6. has advanced detailed knowledge of the theoretical foundations of structure analysis and optimization and design of selected building objects

Skills

1. is able to perform classical static and dynamic analysis and stability analysis of rod structures (trusses, frames and tendons) statically determinate and indeterminate and surface structures (shields, plates, membranes and shells)

2. uses advanced specialist tools to search for useful information, communication and obtaining software supporting the work of a designer and organizer of construction processes

3. is able to correctly define a computer computational model and conduct an advanced linear analysis of complex buildings, their elements and connections, and apply basic techniques of nonlinear calculations with a critical evaluation of the results of numerical analysis

4. is able to plan and carry out laboratory experiments leading to the assessment of the quality of the materials used and the assessment of the strength of the elements of selected buildings, using appropriate methods and tools

4. using the possessed knowledge, is able to choose appropriate methods and tools (analytical, numerical, simulation, experimental) to solve technical problems

5. is able to formulate and test hypotheses related to simple research problems, leading to the solution of engineering, technological and organizational problems appearing in construction, in accordance with scientific principles, using a scientific workshop; is able to prepare studies preparing him to start scientific work

Social competences

1. is responsible for the reliability of the results of his work and the work of his team

2. is responsible for the safety of his own and team work

3. is aware of the need to improve professional and personal competences, is ready to critically evaluate the knowledge and content received

4. is aware of the need to care for their own health and physical fitness

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Completion of the lecture is based on a written answer to 4 questions (tasks, derivation of dependencies or in the form of a procedure description) conducted during the last lecture. Passing threshold: 50% of points.

During the laboratory exercises, students are assessed on the basis of a semester project and a test held during the last class, in which they independently build computational models and read the required results using the Abaqus program. Passing threshold: 50% of points.

Programme content

Lecture program:

Presentation of the basics of experimental research aimed at determining the mechanical properties of building materials (steel, other metals, concrete, glass and others) in a complex state of stress, a wide range of deformation rates and temperatures

Presentation of the measures of deformation, deformation velocity and stress used in nonlinear constitutive relationships used for modeling building materials.

Discussion of nonlinear physical relationships that are used in modeling materials that make up building structures: plasticity, plasticity depending on the deformation rate, taking into account thermal effects in 3D, damage and destruction of materials, hyperelastic materials Introduction to nonlinear thermomechanics (linear thermomechanics, steady and transient heat flow).

Review of methods of analyzing thermomechanical processes using the finite element method: sequential and coupled problems.

Modeling of interactions and connections of building structure elements (contact, bolts, welds)

Review of other computer methods in construction mechanics: SPH (Smoothed Particle Hydrodynamics), Multimaterial Finite Element Method, XFEM, MED (Discrete Element Method) and others.

Summary of lectures

Passing

Laboratory program:

Dynamic calculations of a cantilever loaded with a concentrated force at the end: statics, the problem of natural vibrations, linear dynamics: in the time and frequency domain, non-linear dynamics. Compare and interpret the results. (Abaqus)

Dynamic calculations using the explicit method of integrating the interaction of the projectile and two members. Analysis of wave phenomena that occur in the system.

Comparison with analytical solutions (Abaqus, Scilab) Numerical analysis of the HMH plasticity surface in a plane stress state for different Sigma 11 and Sigma 22 stress ratios for a given material with elastic-plastic properties. Comparison of simulation results with the analytical solution (Scilab, Abaqus)

Analysis of a tensile sample with an elastic-plastic material. Comparison of the results: stresses, global and local strains with the input data.

Analysis of the results and their interpretation (Abaqus)

Analysis of a stretched sample with hyper-elastic material (curve from task 4) - loading and unloading.

Analysis of the results and their interpretation (Abaqus) Calculation of stresses and deformation of a steel frame during a fire: sequential and coupled (thermal displacement) analysis.

Analysis of the finite elements used, temperature-dependent material properties (elastic-plastic model), thermal and mechanical loads (Abaqus)

An individual project carried out in pairs, concerning the analyzed issues and its presentation in front of the whole group. (Abaqus)

Consultation and implementation of an individual task - PASS

Teaching methods

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

2. Laboratory: multimedia presentation, illustrated with examples given on the blackboard, and carrying out the tasks given by the teacher

Bibliography

Basic

1. O.C.Zienkiewicz, (R.Taylor), The finite element method, wyd. 1 - 6, 1972 - 2007

2. T. Belytschko, W. K. Liu, B. Moran, Nonlinear Finite Elements for Continua and Structures, John Wiley and Sons, 2000

3. T. Jankowiak, Kryteria zniszczenia betonu poddanego obciążeniom quasi-statycznym i dynamicznym, Monografia, Wydawnictwo Politechniki Poznańskiej, 2011, p. 138

4 T. Jankowiak, Wykorzystanie metod eksperymentalnych I symulacji komputerowych do określania właściwości materiałów przy dużej prędkości deformacji, Monografia, Wydawnictwo Politechniki Poznańskiej, 2016, p. 161

Additional

1. T.J.R.Hughes, The finite element method. Linear static and dynamics, Prentice-Hall Eds., 1987

Breakdown of average student's workload

	Hours	ECTS
Total workload	90	3,0
Classes requiring direct contact with the teacher	60	2,0
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	30	1,0

[1] delete or add other activities as appropriate