FACULTY OF MECHANICAL AND POWER ENGINEERING

SUBJECT CARD

Name of subject in Polish:	**Metoda elementów skończonych**
Name of subject in English:	**Finite element analysis**
Main field of study (if applicable):	**Power Engineering**
Specialization (if applicable):	**Computer Aided Mechanical and Power Engineering**
Profile:	**academic**
Level and form of studies:	**2nd level, full-time studies**
Kind of subject:	**optional/specialization**
Subject code:	**W09ENG-SM0059**
Group of courses:	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	90		60		
Form of crediting	Examination		Crediting with grade		
For group of courses mark final course with (X)					
Number of ECTS points	3		2		
including number of ECTS points for practical (P) classes	0		2		
including number of ECTS points for direct teacher-student contact (BK) classes	1,5		1,5		

*delete as applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge and skills in the field of: mechanics, thermodynamics, basics of machine construction, strength of materials, basics of materials science
2. Solid models preparation in any CAD-software

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SUBJECT OBJECTIVES

C1 To acquaint students with the knowledge of the theory of the finite element method.
C2 To develop students skills to build an appropriate model for FEA simulations with one-, two- and three-dimensional models.
C3 To develop students skills for numerical modeling of real objects and phenomena.
C4 The acquisition of skills by students to critically analyze the results of the FEA.

SUBJECT LEARNING OUTCOMES

relating to knowledge:

PEU_W01 Has knowledge of the theory of the finite element method
PEU_W02 Has knowledge of the preparation and formulation of numerical models for FEA calculations
PEU_W03 Has knowledge about the limitations and possibilities of using FEM analysis for numerical verification of the operating conditions of individual elements and structural systems

relating to skills:

PEU_U01 The acquisition of skills by students to use the FEM-based algorithm software to perform numerical calculations
PEU_U02 Can define and apply the appropriate type of numerical model in based on FEM and depending on the problem being solved
PEU_U03 Can perform a critical analysis of the obtained results from FEA calculations

relating to social competences:
PEU_K01 Acquires the ability to take responsibility for the own work
PEU_K02 To develop of thinking and acting creatively

PROGRAM CONTENT

	Lectures	**Number of hours**
Lec 1	Introduction to mathematical modeling and numerical engineering analysis. Examples of FEA.	2
Lec 2	Fundamentals of the finite element method.	2
Lec 3	Methodology of FEM model formulation.	2
Lec 4	Types and characteristics of finite elements.	2
Lec 5	Shape function in the description of the finite element structure.	2
Lec 6	FEM model assumptions - presentation of basic relationships for one-dimensional (1D) models.	2
Lec 7	Examples of the application of the FEM algorithm in numerical strength of materials calculations.	2
Lec 8	FEA strength of materials calculations for one-dimensional (1D), two-dimensional (2D) and three-dimensional (3D) model - comparative analysis.	2
Lec 9	Nonlinearity in FEM calculations. Isotropic and anisotropic properties of materials and their influence on the construction of a discrete model.	2
Lec 10	Dynamic analysis using the FEM algorithm. Modal analysis.	2
Lec 11	FEM analysis of steady state heat flow processes.	2
Lec 12	The influence of changes of boundary conditions on the obtained solutions of selected engineering problems.	2
Lec 13	FEM analysis of structural elements under complex load state.	2
Lec 14	Analysis of factors and evaluation of their influence on the accuracy of FEA simulation and obtained results.	2
Lec 15	Implementation of the FEA algorithm in computer softwares for solving engineering problems.	2
	Total hours	30

	Laboratory	**Number of hours**
Lab 1	Presentation of the program of laboratory. Methodology of preparation and perform of numerical analysis.	2
Lab 2	Introduction to the FEA simulation software. Principles of geometrical models preparation.	2
Lab 3	Principles of numerical models preparation - discretization and boundary conditions.	2

Lab 4	Definition and implementation of material properties. Analysis of selected factors in FEA-algorithm and evaluation of their influence on the accuracy of calculations.	2
Lab 5	Definition and range of applicability of solid models. Solid models of isotropic materials - strength of materials analysis of machine elements in steady state conditions.	2
Lab 6	Definition and range of applicability of beam model. The use of beam models in the analysis of frame structures.	2
Lab 7	Definition and range of applicability of shell model. The use of shell models in the analysis of the operating conditions of frame structures.	2
Lab 8	2D models in strength of materials numerical analysis. Plane stress, plane strain and axisymmetric models.	2
Lab 9	Shell models of pressure apparatus equipment and elements.	2
Lab 10	Isotropic and anisotropic properties of materials and their influence on results of numerical strength of materials analysis.	2
Lab 11	Modal analysis – vibration characteristics (natural frequencies and mode shapes).	2
Lab 12	FEM analysis of steady state heat flow processes.	2
Lab 13	Strength of materials analysis in complex mechanical structures using contact dependencies.	2
Lab 14	Feasibility and optimization analysis of solutions within the given criteria.	2
Lab 15	Report of FEA numerical simulations - Results analysis.	2
	Total hours	30

TEACHING TOOLS USED
N1. Traditional lecture with the use of multimedia presentation, blackboard and chalk. Discussion of the problem. N2. Preparation and presentation of the project and discussion of the obtained solutions and results. N3. Individual work - models preparation for numerical simulations. N4. Individual consultations.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT - LECTURE

Evaluation (F – forming (during semester), C – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
C	PEK_W01, PEK_W02, PEK_W03	Final exam

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT - LABORATORY

Evaluation (F – forming (during semester), C – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
C	PEK_U01, PEK_U02, PEK_U03	Work evaluation during the laboratory Preparation of reports based on the conducted numerical analysis

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Zienkiewicz O. C., Taylor R. L., Zhu J.Z., The Finite Element Method: Its Basis and Fundamentals, 7th ed., McGraw-Hill / Butterworth-Heinemann (Imprint of Elsevier), 2013
[2] Reddy J. N., An introduction to the Finite Element Method, 3rd ed., McGraw Hill, New York, 2006
[3] Bathe K. J., Finite Element Procedures, 2nd ed., K. J. Bathe, Watertown, MA, 2014
[4] Thompson M. K., Thompson J. M., Ansys Mechanical APDL for Finite Element Analysis, Butterwoth-Heinemann (Imprint of Elsevier), 2017
[5] Alawadhi E. M., Finite element simulations using ANSYS, CRC Press Inc. Taylor & Francis Group, 2019

SECONDARY LITERATURE:

[1] Larson M. G., Bengzon F., The Finite Element Method: Theory, Implementation, and Applications, Springer Heidelberg, 2010
[2] Madenci E., Guven I., The Finite Element Method and Applications in Engineering Using ANSYS, Springer New York, Second Edition, 2015
[3] Chen X., Liu Y., Finite element modeling and simulation with ANSYS Workbench, CRC Press Inc. Taylor & Francis Group, 2018

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

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*delete if not necessary