Finite element analysis

Faculty of	**Mechanical and Power Engineering**
Name in English	**Finite element analysis**
Name in Polish	**Metoda elementów skończonych**
Main field of study	**Power Engineering**
Specialization	**Computer Aided Mechanical and Power Engineering; Renewable Sources of Energy; Refrigeration and Cryogenics**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**obligatory**
Language	**English**
Education cycle from	**2023/2024**
Subject code	**W09ENG-SM2339**
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	3		2		
including number of ECTS points for direct teacher-student contact (BU) classes	1,5		1,5		

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

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

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Introduction to mathematical modeling and numerical engineering analysis. Examples of FEA.	2
Wy2	Fundamentals of the finite element method.	2
Wy3	Methodology of FEM model formulation.	2
Wy4	Types and characteristics of finite elements.	2
Wy5	Shape function in the description of the finite element structure.	2
Wy6	FEM model assumptions - presentation of basic relationships for one-dimensional (1D) models.	2
Wy7	Examples of the application of the FEM algorithm in numerical strength of materials calculations.	2
Wy8	FEA strength of materials calculations for one-dimensional (1D), two-dimensional (2D) and three-dimensional (3D) model - comparative analysis.	2
Wy9	Nonlinearity in FEM calculations. Isotropic and anisotropic properties of materials and their influence on the construction of a discrete model.	2
Wy10	Dynamic analysis using the FEM algorithm. Modal analysis.	2
Wy11	FEM analysis of steady state heat flow processes.	2
Wy12	The influence of changes of boundary conditions on the obtained solutions of selected engineering problems.	2
Wy13	FEM analysis of structural elements under complex load state.	2
Wy14	Analysis of factors and evaluation of their influence on the accuracy of FEA simulation and obtained results.	2
Wy15	Implementation of the FEA algorithm in computer softwares for solving engineering problems.	2
Total hours		30

laboratory		Number of hours
La1	Presentation of the program of laboratory. Methodology of preparation and perform of numerical analysis.	2
La2	Introduction to the FEA simulation software. Principles of geometrical models preparation.	2
La3	Principles of numerical models preparation - discretization and boundary conditions.	2
La4	Definition and implementation of material properties. Analysis of selected factors in FEA-algorithm and evaluation of their influence on the accuracy of calculations.	2
La5	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
La6	Definition and range of applicability of beam model. The use of beam models in the analysis of frame structures.	2
La7	Definition and range of applicability of shell model. The use of shell models in the analysis of the operating conditions of frame structures.	2
La8	2D models in strength of materials numerical analysis. Plane stress, plane strain and axisymmetric models.	2
La9	Shell models of pressure apparatus equipment and elements.	2
La10	Isotropic and anisotropic properties of materials and their influence on results of numerical strength of materials analysis.	2
La11	Modal analysis - vibration characteristics (natural frequencies and mode shapes).	2

La12	FEM analysis of steady state heat flow processes.	2
La13	Strength of materials analysis in complex mechanical structures using contact dependencies.	2
La14	Feasibility and optimization analysis of solutions within the given criteria.	2
La15	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 EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
C1	PEU_W01, PEU_W02, PEU_W03, PEU_K02	Final exam
C2	PEU_U01, PEU_U02, PEU_U03, PEU_K01	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)

Imię i nazwisko:	Konrad Babul
E-mail:	konrad.babul@pwr.edu.pl