COMPUTER METHODS IN MECHANICS

Subject code: **11.9-WILŚ- BUD- MKOM- RB02**

Subject type: Obligatory

Language of instruction: English

Responsible for the subject: Person currently conducting lectures

Providing education: Department of Building Mechanics

Type of class	Number of classes per semester	Number of classes per week	Semester	Type of credit	ECTS points
Full time studies					3
Lecture	15	1	I	credit with a grade	
Laboratory	30	2		credit with a grade	
Part time studies					
Lecture	9	1	I	credit with a grade	
Laboratory	18	2		credit with a grade	

SUBJECT OBJECTIVE:

The objective of the course is to teach advanced computer methods based on the finite element method that are used in solving problems occurring in construction.

INITIAL REQUIREMENTS:

Mathematics. Computational methods. Strength of materials. Building mechanics.

SUBJECT SCOPE:

Lecture

The extreme energy function and virtual work equation in problems of mechanics. Appropriate approximation properties of finite element (FEM) methods for formulation of weak boundary problems in mechanics - approximation error, convergence issue and MES adaptive methods. Numerical analysis of slabs and shells using the finite element method - customized and unadjusted finite elements. Numerical direct and iterative methods for individual problems of buckling and dynamics of construction. Geometrically and physically nonlinear problems in mechanics. Linearization of non-linear problems. The Newton-Raphson method and its application to geometrically non-linear problems as well as elastic-plastic problems. The finite difference method. Numerical methods of integration of motion equations. Conditional and unconditional stability of integration methods over time.

Laboratory
Project exercises:

1. Analysis of slabs using the finite element method.
2. Disc analysis in the elastic-plastic range using the finite element method.

Educational methods**:**

Lecture - conventional lecture,

Laboratory - exercises in a computer laboratory, individual and team work on projects.

EDUCATION RESULTS:

Results after completion of the course	Symbol	Verification method	Type of class
Knowledge			
The student acquires basic knowledge of understanding and application of approximation rules and MES modelling for systems of any geometry; understanding and application of MES algorithms for advanced problems of structural mechanics.	**K_W01**	test	L
The student acquires knowledge of the basics of the finite element method and its application in the analysis of bars, beams and discs	**K_W01**	test	L
Abilities			
The student acquires basic skills in the use of computer methods in engineering practice and the use of advanced computer software for engineering calculations MES (Abaqus).	**K_U07**	Project and a test	Lab
Social competences			
The student can think and act in a creative and entrepreneurial way	**K_K01**	conversation during lectures initiated by the teacher; checking competences during the introduction to classes	L, Lab

REQUIREMENTS TO OBTAIN A CREDIT:

Lecture — A credit for a test with points:

56% - 65% correct answers	satisfactory,
66% - 75%	satisfactory plus,
76% - 85%	good
86% - 93%	good plus
94% - 100%	very good.

Laboratory — The condition for a credit is a positive grade for all projects (2 projects)) and for written tests with points proving the student's knowledge and individual work on tasks.

Credit for the subject:

The final grade is the average of the grades : G = (L+Lab)/2

STUDENT WORK:

Interaction with the teacher	15W+30L+10K, total	55 h
Preparation for the lecture test		15 h
Preparation for the laboratory		10 h
Projects – individual work	2proj x 20h	40 h
Total	55+15+10+40	120 h
ECTS for the subject	120/30=4	4 ECTS.

BASIC LITERATURE:

1. Szmelter J., *Metody komputerowe w mechanice*. PWN, Warszw 1980.
2. Zienkiewicz O.C., *Metoda elementów skończonych*. Arkady, Warsaw 1972.
3. Ciesielski R. et al., *Mechanika budowli: ujęcie komputerowe*, t. 2. Arkady, Warsaw 1992.
4. Borkowski A. et al., *Mechanika budowli: ujęcie komputerowe*, t. 3. Arkady, Warsaw 1995.
5. Rakowski G., Kacprzyk Z., *Metoda elementów skończonych w mechanice konstrukcji.* Wyd. Politechniki Warszawskiej. Warsaw 2005.
6. Łodygowski T., Kąkol W., *Metoda elementów skończonych*. Politechnika Poznańska. Poznań 1994.
7. Rajche J., Pryputniewicz S., Bryś G., *Projektowanie wspomagane komputerem. Cz. II: Metoda elementów skończonych*. Wyd. WSInż., Zielona Góra 1991.
8. Piecha J.R., *Programowanie w języku Fortran 90 i 95*. Wyd. Politechniki Warszawskiej, Warszawa 2000.
9. Dahlquist G., Bjoerck A., *Numerical Methods in Scientific Computing*. vol. I, SIAM, Philadelphia 2008.
10. Sobieski W., *Edi 3.1 - zintegrowane środowisko programistyczne dla programujących w języku Fortran*. Olsztyn 2008. (darmowy program do ściągnięcia pod zakładką Projekty na stronie http://www.uwm.edu.pl/edu/sobieski/)

COMPLEMENTARY LITERATURE:

1. Findeisen W., Szymanowski J., Wierzbicki A., *Teoria i metody obliczeniowe optymalizacji*. PWN, Warsaw 1980.
2. Kleiber M. (red.), *Komputerowe metody mechaniki ciał stałych*. PWN, Warsaw 1995.
3. Kuczma M., *Podstawy mechaniki konstrukcji z pamięcią kształtu. Modelowanie i numeryka*. Uniwersytet Zielonogórski, Zielona Góra 2010.
4. Oden J.T., Carey G. F., *Finite Elements: Special Problems in Solid Mechanics.* The Texas Finite Element Series, vol. V. Prentice-Hall Inc., Englewood Cliffs, New Jersey 1984.
5. Piechna J.R., *Programowanie w języku Fortran 90 i 95.* Politechnika Warszawska, Warsaw 2000.
6. Stein E. (eds.), *Adaptive Finite Elements in Linear and Nonlinear Solid and Structural Mechanics.* Springer, Wien 2005.
7. Wriggers P., *Nichtlineare Finite-Element-Methoden.* Springer, Berlin 2001.

SYLLABUS PREPARED BY

Krzysztof Kula, Ph.D. Eng.