COURSE SPECIFICATION

Course code	full-time programme:	**M#2-S2-ME-103**
	part-time programme:	
Course title in Polish	**Zaawansowane metody elementów skończonych**	
Course title in English	**Advanced Finite Element Method**	
Valid from (academic year)	**2024/2025**	

GENERAL INFORMATION

Programme of study	**MECHANICAL ENGINEERING**
Level of qualification	**second-cycle**
Type of education	**academic**
Mode of study	**full-time programme**
Specialism	**all**
Department responsible	**Department of Machine Design and Machining**
Course leader	**dr hab. inż. Sławomir Błasiak, prof. PŚk**
Approved by	**dr hab. Jakub Takosoglu, prof. PŚk, Dean of the Faculty of Mechatronics and Mechanical Engineering**

COURSE OVERVIEW

Course type		**programme-specific**
Course status		**compulsory**
Language of instruction		**English**
Semester of delivery	full-time programme	**Semester I**
	part-time programme	**Semester I**
Pre-requisites		
Examination required (YES/NO)		**NO**
ECTS value		**2**

Mode of instruction		**lecture**	**class**	**laboratory**	**project**	**seminar**
No. of hours per semester	full-time programme	**15**		**15**	**15**	
	part-time programme					

LEARNING OUTCOMES

Category of outcome	Outcome code	Course learning outcomes	Corresponding programme outcome code
Knowledge	W01	Has an in-depth knowledge of mathematics, including integration, differentiation and interpolation used in numerical methods necessary for solving complex engineering tasks in the field of mechanics and mechanical engineering, especially in the development of computational algorithms.	MiBM2_W01
	W02	Has the in-depth and structured knowledge necessary to understand physical phenomena and the complex relationships between them in relation to their analysis and simulation using FEM.	MiBM2_W02 MiBM2_W10
Skills	U01	Be able to use and consciously select numerical methods and tools, including advanced computer software for complex problems related to the analysis and simulation of physical phenomena using numerical methods including FEA.	MiBM2_U02
	U02	Able to carry out complex engineering tasks with the help of information and communication tools, able to select and use appropriate numerical methods necessary for solving mathematical models using FEM to describe basic physical phenomena.	MiBM2_U05
Competence	K01	Ma świadomość potrzeby samodzielnego uzupełniania i poszerzania wiedzy z zakresu analizy i symulacji zjawisk fizycznych z użyciem metod numerycznych oraz MES.	MiBM2_K01

COURSE CONTENT

Mode of instruction	Topics covered
lecture	The lecture covers the analysis of rod and beam elements, including shape functions and the creation of stiffness matrices in a global system using transformation examples. Generalised forces and displacements and relationships describing the behaviour of elements and systems will be discussed. In terms of two-dimensional elements, disc and plate elements will be presented, with emphasis on shape functions satisfying geometrical conditions and stiffness matrices for real and generalised forces and displacements. Basic issues of three-dimensional elements will also be introduced, including the concept of super element and natural coordinates. Lagrange and Hermite interpolations will also be touched upon, as well as the concept of the isoparametric element as a universal approach in the finite element method. Special attention will be given to the general task of numerical integration.
laboratory	Principles and characteristics of the use of beam, shell and mixed models in FEM. Applications in numerical calculations of material models for linear-elastic and plastic ranges. Analysis of simulation results for physical problems: linear and non-linear. Interpretation of magnitude distributions of mechanical fields in front of a fracture front. Principles of contact definition in numerical simulations. Strength analyses of basic engineering components and systems. Fatigue calculations.
project	Load analysis of engineering components using the finite element method. Procedure for preparing a material model for use in FEA. Principles of definition of complex boundary conditions in a numerical model. Conducting simulations taking into account the destruction criterion. Stress criteria. Principles of validation of numerical simulation results.

ASSESSMENT METHODS

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Outcome code	Methods of assessment					
	Oral examination	Written examination	Test	Project	Report	Other
W01			X			
W02			X			
U01				X	X	
U02				X	X	
K01						X

ASSESSMENT TYPE AND CRITERIA

Mode of instruction	Assessment type	Assessment criteria
lecture	non-examination assessment	Successful completion of the lecture, i.e. obtaining at least 50% of the marks.
laboratory	non-examination assessment	Final assessment based on reports produced. Achievement of at least 50% of the points.
project	non-examination assessment	Final assessment based on the developed project. Achievement of at least 50% marks.

OVERALL STUDENT WORKLOAD

ECTS weighting												
No.	Activity type	Student workload										Unit
		full-time programme					part-time programme					
		L	C	Lb	P	S	L	C	Lb	P	S	
1.	Scheduled contact hours	**15**		**15**	**15**							h
2.	Other contact hours (office hours, examination)	**2**		**2**	**2**							h
3.	**Total number of contact hours**	**51**										h
4.	**Number of ECTS credits for contact hours**	**1,7**										ECTS
5.	**Number of independent study hours**	**9**										h
6.	**Number of ECTS credits for independent study hours**	**0,3**										ECTS
7.	**Number of practical hours**	**40**										h
8.	**Number of ECTS credits for practical hours**	**1,3**										ECTS
9.	**Total study time**	**60**										h
10.	**ECTS credits for the course** *1 ECTS credit = 25-30 hours of study time*	**2**										ECTS

READING LIST

1. Bielski, J., 2010. Wprowadzenie do inżynierskich zastosowań metody elementów skończonych : pomoc dydaktyczna. Wydaw. PK.
2. Bull, J.W., 2012. Numerical Analysis and Modelling of Composite Materials. Springer Science & Business Media.

Politechnika Świętokrzyska Kielce University of Technology
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WMiBM Wydział Mechatroniki i Budowy Maszyn

3. Chróścielewski, J., Burzyński, S., Daszkiewicz, K., Sobczyk, B., Witkowski, W., 2014. Wprowadzenie do modelowania MES w programie ABAQUS : materiały pomocnicze do laboratorium z Metody Elementów Skończonych. Wydawnictwo Politechniki Gdańskiej.
4. Domański, J., 2022. SolidWorks 2022. Projektowanie maszyn i konstrukcji. Helion.
5. Miśkiewicz, M., 2016. Nieliniowa analiza MES i monitoring konstrukcji prętowo-cięgnowych. Wydawnictwo Politechniki Gdańskiej.
6. Neimitz, A., 2016. Elementy mechaniki ośrodków ciągłych i ciała stałego. Wydawnictwo Politechniki Świętokrzyskiej.
7. Rakowski, G., Kacprzyk, Z., 2005. Metoda elementów skończonych w mechanice konstrukcji. Oficyna Wydawnicza Politechniki Warszawskiej.
8. Szturomski, B., 2013. Inżynierskie zastosowanie MES w problemach mechaniki ciała stałego: na przykładzie programu Abaqus. Wydawnictwo Akademickie AMW, Gdynia.
9. Werkle, H., 2021. Finite Elements in Structural Analysis: Theoretical Concepts and Modeling Procedures in Statics and Dynamics of Structures, Springer Tracts in Civil Engineering. Springer International Publishing, Cham. https://doi.org/10.1007/978-3-030-49840-5
10. Zagrajek, T., Krzesiński, G., Marek, P., 2005. Metoda elementów skończonych w mechanice konstrukcji: ćwiczenia z zastosowaniem systemu ANSYS. Oficyna Wydawnicza Politechniki Warszawskiej.
11. Zienkiewicz, O.C., Taylor, R.L., Zhu, J.Z. (Eds.), 2013. The Finite Element Method: Its Basis and Fundamentals, in: The Finite Element Method: Its Basis and Fundamentals (Seventh Edition). Butterworth-Heinemann, Oxford, p. i. https://doi.org/10.1016/B978-1-85617-633-0.00019-8