COURSE DESCRIPTION CARD - SYLLABUS

Course name
Finite element method

Course

Field of study
Mathematics in technology

Year/Semester
1/2

Area of study (specialization)

Profile of study
general academic

Level of study
Second-cycle studies

Course offered in
polish

Form of study
full-time

Requirements
elective

Number of hours

Lecture
30

Laboratory classes
30

Other (e.g. online)
0

Tutorials
0

Projects/seminars
0

Number of credit points

4

Lecturers

Responsible for the course/lecturer:
M. Sc., Eng. Marcin Stasiak

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Responsible for the course/lecturer:

Prerequisites

Student should have basic knowledge from calculus, linear algebra, basics of functional analysis and numerical methods.

Course objective

The aim of the subject is presentation of a finite element method for solving numerically boundary and initial-boundary problems given by differential equations. The theory of finite elements based on functional analysis will be also presented.

Course-related learning outcomes

Knowledge

1. Has extended and in-depth general knowledge of various branches of higher mathematics
2. Knows advanced numerical methods and algorithms
3. Knows at least one numerical software

Skills

1. Is able to construct and analyse complex mathematical models

2. Can construct an algorithm for solving a complex engineering task or a simple research problem and implement and test it in a selected programming environment

Social competences

1. Is aware of the possibility of making mistakes by himself and others
2. Is ready to think and act in a creative and entrepreneurial way, taking into account safety, work ergonomics and its economic aspects
3. Is aware of the importance of intellectual honesty in own and other people's actions

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Oral exam from lecture part. Final project summary of designed algorithms.

Programme content

1. Introduction (lecture)
- normed spaces
- ODE's and PDE's, boundary and initial-boundary problems
- Hilbert spaces, L2 space
- orthogonal functions, orthogonal and orthonormal basis
2. Introduction to Finite element method (lecture and lab classes)
- linear spaces, function spaces, norms
- P1(I), Vh(I) spaces
- interpolation and approximation in Vh(I) space
- L2 projection
- definition of finite element
3. Finite element method for one-dimensional steady problems (lecture and lab classes)
- boundary problem given by linear II order ODE's
- discretization, equations for elements, assembling, implementing boundary conditions
- linear and quadratic one-dimensional elements
- local transformation
- stiffness matrix properties
4. Finite element method for one-dimensional unsteady problems (lecture and lab classes)
- one-dimensional diffusion and wave equations
- time step difference approximation
- time-space mesh implementation
5. Finite element method for two-dimensional steady problems (lecture and lab classes)
- two-dimensional mesh generation
- triangular and rectangular elements
- Lagrange and Serendip elements
6. Mathematical basics of finite elements, Riesz and Lax-Milgram theorems

Teaching methods

Lecture: traditional form given on the blackboard with discussion
Lab classes: creating and algorithms and solving numerically problems given by integral equations

Bibliography

Basic

1. The Finite Element Method: Its Basis and Fundamentals, Olek C. Zienkiewicz, Robert L. Taylor, J.Z. Zhu, Elsevier 2005
2. Wprowadzenie do Metody Elementów Skończonych, Adam Grabarski, Iwona Wróbel, Oficyna Wydawnicza Politechniki Warszawskiej 2008
3. Metody Numeryczne Zagadnienia Początkowo-Brzegowe, Radosław Grzymkowski, Adam Kapusta, Iwona Nowak, Damian Słota, Wydawnictwo Pracowni Komputerowej Jacka Skalmierskiego, Gliwice 2009
4. Zbiór Zadań z Metod Matematycznych Fizyki, W. Władimirow, PWN Warszawa 1979
5. Analiza numeryczna zagadnień fizyki matematycznej, Gurij Iwanowicz Marczuk, PWN Warszawa 1983
6. Fundamentals of the Finite Element Method for Heat and Mass Transfer, Perumal Nithiarasu, Roland W. Lewis, Kankanhalli N. Seetharamu, , John Wiley & Sons USA 2004
7. Extended Finite Element Method: Theory and Applications, Amir R. Khoei, , John Wiley & Sons USA 2015
8. The Finite Element Method in Heat Transfer and Fluid Dynamics, J. N. Reddy, D.K. Gartling, CRC Press 2010

Additional

1. An Introduction to Partial Differential Equations with MATLAB, Matthew P. Coleman, CRC Press 2013
2. Numerical Methods and Modelling for Chemical Engineers, Mark E. Davis, John Wiley & Sons Canada 1984
3. A modern introduction to differential equations, Henry Ricardo, Elsevier Canada 2009
4. Beginning Partial Differential Equations, Peter V. O?Neil, Wiley-Interscience 2008

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,0
Classes requiring direct contact with the teacher	60	3,0
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	40	1,0

[1] delete or add other activities as appropriate