COURSE DESCRIPTION CARD- SYLLABUS

Course name
Finite difference method

Course

Field of study
Mathematics in Technology
Area of study (specialization)
—
Level of study
first-cycle studies
Form of study
full-time

Year/Semester
3/6
Profile of study
general academic
Course offered in
Polish
Requirements
elective

Number of hours

Lectures
30
Laboratory classes
30
Other (e.g. online)
—
Tutorials
—
Projects/seminars
—

Number of credit points

4

Lecturers

Responsible for the course/lecturer::

mgr inż. Marcin Stasiak

Responsible for the course/lecturer::

—

Prerequisites

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

Course objective

The aim of the subject is presentation of a finite difference method for solving numerically boundary and initial-boundary problems given by differential equations.

Course-related learning outcomes

Knowledge

- has extended and in-depth general knowledge of various branches of higher mathematics;
- knows advanced numerical methods and algorithms;
- knows at least one numerical software.

Skills

- is able to construct and analyse complex mathematical models;
- 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

- is aware of the possibility of making mistakes by himself and others;
- is ready to think and act in a creative and entrepreneurial way, taking into account safety, work ergonomics and its economic aspects;
- 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

Update: 11.09.2020r.

- finite difference approximation (lecture and lab);
  - discreet grid;
  - geometrical interpretation;
  - one-dimensional mesh;
  - difference approximation of I and II order derivative;
  - non-standard approximations;
- bVP's for ODE's (lecture and lab);
  - formulation of BVP for linear ODE of II order with different types of boundary conditions;
  - types of boundary conditions: Dirichlet, Neumann, Robin;

  - norm, matrix and function norm, measuring an error;
  - thomas method for three- and pentadiagonal systems of linear equations;
  - polar and sphrerical problems;
  - nonlinear BVP;

- implicit and explicit schemes (lecture and lab);
- convergence and stability (lecture);
- bVP's and IBVP's for PDE's (lecture and lab);
  - difference approximation of I and II order partial derivative;
  - elliptic, Laplace and Poisson equations;
  - schemes for hyperbolic equations: I order scheme, Lax scheme, LElevier scheme, Lax-Wendorff scheme, leap-frog scheme;
  - discretization of two-dimensional domain, 5 and 9 points schemes;
  - polar grid;
  - iterative methods for elliptics partial equations;
  - parabolic and hyperbolic PDE's od II order, time-space grid, space discretization, difference schemes for diffusion and wave equations;
  - bendera-Schimdta scheme, Crank-Nicolson scheme, Duforta-Frankla scheme;
- stability of difference schemes, von Neumann condition (lecture).

Teaching methods

Lectures: traditional form given on the blackboard with discussion;

Laboratory classes: creating and algorithms and solving numerically problems given by differential equations.

Bibliography

Basic

- Metody Obliczeniowe Fizyki, David Potter, PWN Warszawa 1982.
- Analiza numeryczna zagadnień fizyki matematycznej, Gurij Iwanowicz Marczuk, PWN Warszawa 1983.
- Finite Difference Methods for Ordinary and Partial Differential Equations, Randall J. LeVeque, Society for Industrial and Applied Mathematics 2007.
- Numerical Partial Differential Equations: Finite Difference Methods, J. W. Thomas, Springer 1995.

- Analysis of Finite Difference Schemes for Linear Partial Differential Equations with Generalized Solutions, Boąko S. Jovanovic, Springer 2014.

Additional

- An Introduction to Partial Differential Equations with MATLAB, Matthew P. Coleman, CRC Press 2013.
- Numerical Methods and Modelling for Chemical Engineers, Mark E. Davis, John Wiley & Sons Canada 1984.
- A modern introduction to differential equations, Henry Ricardo, Elsevier Canada 2009.
- 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	70	3,0
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation)	30	1,0