COURSE DESCRIPTION CARD - SYLLABUS

Course name
Numerical methods [S1Eltech1>MN]

Course

Field of study
Electrical Engineering

Year/Semester
1/2

Area of study (specialization)
–

Profile of study
practical

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
15

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

3,00

Coordinators

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Lecturers

Prerequisites

The student should have knowledge of mathematics (linear algebra, differential and integral calculus) and computer science (basic data structures and programming). The student should be aware of the need to expand their competences, understand the need for further education, and be ready to cooperate within the team.

Course objective

1. Familiarizing students with topics related to numerical methods, e.g. with the differences between real and computer arithmetic, numerical errors, discretization, and basic numerical algorithms. 2. Application of learned algorithms to solve selected mathematical problems and simple engineering tasks in the field of electrical engineering. 3. Supporting calculations with appropriate IT tools. 4. Verification of the obtained solutions.

Course-related learning outcomes

Knowledge:
1. The student has basic knowledge of numerical methods for solving simple engineering tasks.
2. The student knows at least one computer package supporting numerical calculations.

Skills:
1. The student is able to formulate correct algorithm and describe its implementation; He knows at least one programming language.
2. The student is able to choose and apply the correct numerical method to solve simple engineering tasks of a practical nature.
3. The student has the skills of self-education; can perform measurements and computer tests, interpret the results and draw conclusions

Social competences:
1. The student knows the limitations of their knowledge and understands the need for further education.
2. The student is aware of the validity of the effects of engineering calculations.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The knowledge acquired during the lectures is verified by a colloquium consisting of differently scored questions. Passing threshold: 50% of points. Assessment issues on the basis of which the questions are developed will be provided to students during the lecture preceding the colloquium and/or posted via e-courses.

The skills acquired during laboratory classes are verified by obtaining a Matlab certificate and completing two projects. Additionally, points are scored: student's preparation for laboratory classes, implementation of laboratory exercises, and assessment of teamwork skills. Passing threshold: 50% of points.

Programme content

1. Floating point arithmetic, round-off errors.
2. Numerically stable and unstable algorithms, 'well-conditioned' and 'ill-conditioned' problems.
3. Polynomial approximation (Interpolation, Taylor polynomials).
4. Numerical integration.
5. Numerical solutions of nonlinear equations.

Course topics

The lecture program covers the following topics:
1. Floating-point arithmetic.
Real number – various forms of notation.
Factoring numbers.
Converting numbers between decimal and binary systems and related problems.
Rounding and error measures.
Floating-point representations of real numbers.
Real numbers and machine numbers.
Machine accuracy.
Arithmetic operations with floating-point numbers.
Characteristics of floating-point arithmetic on a selected example.
Numerical errors.
Stable and unstable algorithms.
Task conditioning.

2. Function approximation.
Power series (Taylor series).
Polynomial interpolation.
Interpolation assumptions.
Continuous and discrete case.
Interpolation task.
An example of "reverse engineering".
Uniqueness of interpolation.
Matrix, Lagrange and Newton methods. Divided differences.

Node selection problem. Equidistant and Chebyshev nodes.
Convergence of interpolation processes, Runge phenomenon.
Interpolation of polynomials - special cases.
Estimation of the error of the interpolation formula.

3. Numerical solution of nonlinear equations of functions of one variable.
Selected iterative methods: The method of tangents (Newton-Raphson), bisection, secants and regula-falsi.
Graphical interpretation of methods.
Derivation of method formulas.
Conditions for convergence of methods. Local and global convergence.
Examples of method divergence.
Computational complexity of methods.
Termination conditions.
Verification of the correctness of the solution.
Newton's method for multiple roots.
Introduction of the concepts: attractor, repeller, attraction pool and their relationship with solving nonlinear equations.

4. Numerical integration.
Interpolation in numerical integration.
Simple and complex Newton-Cotes quadratics.
Trapezoidal and Simpson's formulas.
Derivation of formulas.
Graphical interpretation of methods.
Numerical integration errors (quadratures).
Estimating errors.
Derivation of formulas determining the number of integration intervals depending on the given accuracy of the solution using complex methods.

The laboratory program covers the following topics:
1. Introduction to Matlab.

2. Floating-point arithmetic.
Rounding error representations of activities.
Machine accuracy.
Investigating the properties of floating-point arithmetic.
Floating point overflow and underflow.
Single and double precision real types.
Examples of unstable algorithms and ill-conditioned tasks.

3. Function approximation.
Power series (Taylor series).
Polynomial interpolation.
Lagrange or Newton's method.
Study of the approximation of the selected function for equidistant and Chebyshev nodes - the problem of optimal selection of nodes.
Runge phenomenon.

4. Numerical solution of nonlinear equations of functions of one variable.
Selected iterative methods: The method of tangents (Newton-Raphson), bisection, secants and regula-falsi.
Exploring the relationship between the data and the obtained solution.
Exploring the relationship between termination conditions and solution accuracy.
Verification of the correctness of the solution.
Examples of method divergence.
Researching solutions for tasks that do not meet the required assumptions.

5. Numerical integration.
Simple and complex trapezoidal and Simpson methods.

Testing the accuracy of solutions.

Teaching methods

Lectures:
1.Lecture with multimedia presentation supplemented by examples given
on the blackboard.
2.Lecture conducted in an interactive way of formulating questions to students.
3.Student activity is taken into account during the course of the assessment.
4.Theory presented in connection with practice.
5.Theory presented in connection with the current knowledge of students,
6.Taking into consideration various aspects of the presented issues,
7. introducing a new topic, preceded by a reminder of related content, known to students from other subjects.

Laboratories:
1. computational experiments,
2. reviewing reports by the laboratory"s leader,
3. work in teams,

Bibliography

Basic
1. Fortuna, Macukow, Wąsowski, Metody numeryczne, WNT: PWN, 2017
2. Kincaid, Cheney, Analiza numeryczna, WNT 2006,

Additional
1. Burden, Faires, Numerical analysis, Prindle, Weber&Schmidt, Boston,
2. D.Spałek, Metody numeryczne w elektrotechnice, Wyd.Politechniki Śląskiej2020.
3. E. Kącki, A. Małolepszy, A. Romanowicz, Metody numeryczne dla inżynierów, Wyd. Politechniki Łódzkiej 2000
4. Magnucka-Blandzi, Dondajewski, Gleska, Szyszka, Metody numeryczne w MatLabie. Wybrane zagadnienia, Wyd. Politechniki Poznańskiej 2013,

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,00
Classes requiring direct contact with the teacher	45	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	30	1,00