SYLLABUS

Name: ***Numerical methods (MakAu>SI4NM19)***
Name in Polish:
Name in English: ***Numerical methods***

Information on course:

Course offered by department: Faculty of Automatic Control, Electronics and Computer Science
Course for department: Silesian University of Technology

Default type of course examination report:
ZAL
Language:
English
Course homepage:
https://platforma2.polsl.pl/rau1/course/view.php?id=93
Short description:
It is assumed that before starting to study this subject, the student has a background in linear algebra, mathematical analysis, and linear differential equations.
The assumption of the course is the acquisition by the student of knowledge and skills in the field of numerical analysis and numerical methods used for approximate solving of basic engineering problems. As part of the lecture, the student will learn the basic numerical methods used in engineering practice in order to determine the approximate solution of basic engineering problems. The presented methods are analyzed during the lectures in terms of their computational complexity, stability and speed of convergence. As part of the laboratory classes, the student acquires practical skills in the implementation of selected numerical algorithms as well as in assessing the effectiveness of implemented methods and the quality of obtained results.
Description:
ECTS: 4
Total workload: 120 hours (90 contact hours,/30 students’ own work hours)
Forms of contact hours:
Lecture: 30h
Laboratory: 30h
Other: (e.g. test and reports revision and discussion) 30h
Students' own work: Preparation for laboratory classes, processing results together with their interpretation and preparation of reports 30h

The aim of the lecture is to provide students with knowledge in the field of numerical methods used for approximate solving of basic engineering problems.
Lecture
1. Basic information on the theory of errors. Sources of errors. Relative and absolute error. Errors in arithmetic operations and their estimation.
2. Number representation in computer systems: two's complement code, floating point representation. Elements of floating point arithmetic. Consequences of using the floating-point representation of real numbers.
3. Calculating the value of a function. Calculating the value of polynomials - Hörner scheme and its properties. Calculating the value of the analytical function. Calculating the value of the implicit function.
4. Continued fractions and their application in determinig approximate values of irrational numbers and function values.
5. Systems of linear equations. Gauss elimination method and its modifications. LU factorization and its applications. Choleski's method. Iterative methods of approximate solving of systems of linear equations.
6. Interpolation. Formulation of the interpolation problem. Lagrange interpolation formula. Newton's interpolation formula. Difference operators. Calculation schemas for difference operators. Expansion of the difference operators into the Taylor power series. Newton's interpolation formulas using difference operators. Comparison of interpolation formulas. Optimal choice of interpolation nodes.
7. Numerical differentiation. Statement of the numerical differentiation problem. Formulas of numerical differentiation with the use of difference operators. Determinig higher order derivatives.
8. Numerical integration. Statement of the numerical integration problem. Newton-Cotes formula for numerical integration. Rectangles, trapezoids and Simpson formulas. Chebyshev's method of numerical integration. Gauss method of numerical integration. Composite Quadratures . Monte Carlo method. Comparison of numerical integration methods.
9. Approximation. Statement of the approximation problem. Different types of approximation. The space of square integrable functions. Systems of linearly independent, orthogonal and orthonormal functions. Fourier series. Quadratic approximation. Approximation in the space of continuous functions. Weierstrass theorem. Chebyshev polynomials and their application to approximation of continuous functions. Point approximation - least squares method. Pade approximation.
10. Eigenvalues and eigenvectors of matrices. Basic definitions and concept. Iterative methods of determining eigenvalues and eigenvectors.
11. Approximate solving of nonlinear equations. Bisection method. Fixed point method. Regula falsi method. Secant method. Newton's method and its modifications. Bernoulli method.
12. Approximate solving of ordinary differential equations. Taylor series method. Piccard method of successive approximations. Euler's method. Runge-Kutta method and its modifications.

The aim of the laboratory exercises is to acquire by students skills in the analysis of algorithms, enabling the selection of an appropriate numerical method and its effective application to solve the engineering problem under consideration as well as to acquire the ability to assess the quality and properly interpret the obtained results.

Topics of laboratory exercises
1. Calculation of function values / continued fractions.
2. Interpolation.
3. Numerical differentiation.
4. Numerical integration.
5. Approximation.
6. Systems of linear equations.

7. Eigenvalues and eigenvectors of matrices.
8. Approximate solving of nonlinear equations.
9. Approximate solving of ordinary differential equations.

Bibliography:

David Kincaid, Ward Cheney, Analiza numeryczna ; w przekł. i pod red. Stefana Paszkowskiego. - Warszawa : Wydawnictwa Naukowo-Techniczne, cop. 2006
Klamka Jerzy, Pawełczyk Marek, and Wyrwał Janusz, „Numerical Methods”, Wydawnictwa Politechniki Śląskiej, Gliwice, 2001.
Åke Björck, Germund Dahlquist, Metody numeryczne ; przeł. Stefan Paszkowski. - Wyd. 2. - Warszawa : Państwowe Wydawnictwo Naukowe, 1987.
Demidowicz B.P., Maron I.A., "Metody numeryczne", tom I, PWN, Warszawa 1965.
Demidowicz B.P., Maron I.A., Szuwałowa E.J., "Metody numeryczne", tom II, PWN, Warszawa 1965.
Ralston A., "Wstęp do analizy numerycznej", PWN, Warszawa 1965.

Learning outcomes:

After completing the course, the student:
knows the basic numerical methods used for approximate solving of engineering problems (K1A_W02, K1A_U08),
is able to independently implement the numerical methods of solving engineering problems learned during the course (K1A_W08, K1A_W11, K1A_U09),
is able to assess the quality of the obtained numerical results and interpret these results appropriately (K1A_W011, K1A_U10).

Assessment methods and assessment criteria:

Credit of the course is carried out on the basis of reports from the laboratory exercises performed. The deadline for submitting reports to the Remote Education Platform is 1 week from the date of the given laboratory exercise.
Passing criteria
Reports may be in paper or electronic form and are prepared according to the guidelines and requirements formulated by the person conducting the laboratory exercise. Each report is scored on a point scale of 0-5 points. The student’s final grade is determined on the basis of the point scale specified in the course crediting requirements, available on the course home page on the Distance Education Platform.
The syllabus is valid from academic year 2024/25 and its content cannot be changed during the semester.

Element of course groups in various terms:

Course group description	First term	Last term
missing group description in English (MakAu>SI4-19)	2020/2021-L	
Automation, electronics and informatics sem. 4 (AEIAu>SI_4)	2024/2025-Z	

Course credits in various terms:

<without a specific program>

Type of credits	Number	First term	Last term
European Credit Transfer System (ECTS)	4	2020/2021-L	