Syllabus
Course Program

Numerical Methods

Specialty
122 – Computer Science

Institute
Institute of Computer Science and Information Technology

Educational program
Computer Science and Intelligent Systems

Department
Software Engineering and Management Intelligent Technologies (321)

Level of education
Bachelor's level

Course type
Special (professional), Mandatory

Semester
5

Language of instruction
English, Ukrainian

Lecturers and course developers

Olena Nikulina

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Doctor of Technical Sciences, Professor, Professor of the Department of Software Engineering and Information Technologies of NTU "KhPI"

Prepared and published more than 100 scientific and educational works (Google Scholar: https://scholar.google.com/citations?user=ZEe2GlcAAAAJ; ORCID https://orcid.org/0000-0003-2938-4215; Scopus: https://www.scopus.com/authid/detail.uri?authorId=57541344600).
More about the lecturer on the department's website

General information

Summary

Acquaintance of students with the main sections of computer computational mathematics, which are widely used in the design and development of mathematical and software. Objectives of the discipline: to know the basic numerical methods of finding the zeroes of a function, to know the basic numerical methods of solving a system of algebraic equations, to know the basic numerical methods of differentiation, to know the basic numerical methods of integration, to be able to work in user-level environments, to compose linear, branched and cyclic programs, to compose data processing programs.

Course objectives and goals

It involves the study of numerical methods, specification and implementation of classical methods of integration, differentiation, approximate calculation of functions, and solving a system of algebraic equations.

Format of classes

Lectures, laboratory work, coursework, independent work, consultations. The final control is an exam.

Competencies

GC1. Ability to think abstractly, analyze and synthesize.
GC2. Ability to apply knowledge in practical situations.

GC3. Knowledge and understanding of the subject area and understanding of professional activities.
GC6. Ability to learn and master modern knowledge.
SC1. Ability to mathematically formulate and study continuous and discrete mathematical models, justify the choice of methods and approaches for solving theoretical and applied problems in the field of computer science, analysis and interpretation.
SC3. Ability to think logically, build logical conclusions, use formal languages and models of algorithmic computing, design, develop and analyze algorithms, evaluate their effectiveness and complexity, solvability and intractability of algorithmic problems for adequate modeling of subject areas and creation of software and information systems.
SC4. Ability to use modern methods of mathematical modeling of objects, processes and phenomena, to develop models and algorithms for numerical solution of mathematical modeling problems, to take into account the errors of approximate numerical solution of professional problems.

Learning outcomes

PLO2. To use modern mathematical apparatus of continuous and discrete analysis, linear algebra, analytical geometry in professional activities to solve theoretical and applied problems in the design and implementation of information technology objects.
PLO5. To design, develop and analyze algorithms for solving computational and logical problems, to evaluate the effectiveness and complexity of algorithms based on the use of formal models of algorithms and computable functions.
PLO6. To use methods of numerical differentiation and integration of functions, solution of ordinary differential and integral equations, features of numerical methods and possibilities of their adaptation to engineering problems, to have skills in software implementation of numerical methods.

Student workload

The total volume of the course is 150 hours (5 ECTS credits): lectures - 32 hours, laboratory classes - 32 hours, self-study - 86 hours.

Course prerequisites

The basis for studying the course is the general mathematical training of students and the content of the disciplines "Higher Mathematics", "Algorithmization and Programming", as well as the use of mathematical packages.

Features of the course, teaching and learning methods, and technologies

Teaching and learning methods:
interactive lectures with presentations, discussions, laboratory classes, teamwork, case method, student feedback, problem-based learning.
Forms of assessment:
written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), express surveys (CAS), online tests (CAS), final/semester control in the form of a semester exam, according to the schedule of the educational process (FAS).

Program of the course

Topics of the lectures

Topic 1: Basic concepts
The subject of numerical methods.
Concept and definition of the theory of numerical methods.
Classification of methods.
Topic 2. Approximate calculation of functions
Basic theoretical provisions.
Lagrange interpolation polynomial.
Newton's interpolation polynomial.
Topic 3. Finding the values of zeros of a function

Basic theoretical concepts.
The method of half division.
The method of chords.
Newton's method.
The combined method
Topic 4. Numerical methods of linear algebra
Basic theoretical provisions.
Numerical methods for solving a system of algebraic equations (SLAE).
Kramer's method. Gauss method.
Topic 5. Numerical differentiation of a tabular given function
The main theoretical provisions.
Tabular differentiation of a given function by interpolation.
Tabular differentiation of a given function by approximation.
Topic 6: Numerical integration
Basic theoretical provisions.
The method of rectangles.
The method of trapezoid.
The method of parabolas.
Topic 7. Solving ordinary differential equations
Basic theoretical provisions.
Euler's method.
Runge-Kutta method.
Topic 8: Solving systems of ordinary differential equations
Basic theoretical provisions.
Euler's method.
Runge-Kutta method.
Parabolic partial differential equations.
Numerical methods for solving the Cauchy problem for ordinary differential equations.
Solving partial differential equations.
Topic 9: Mathematical data processing.
Basic theoretical provisions.
The method of least squares.

Topics of the workshops

Workshops are not provided within the discipline.

Topics of the laboratory classes

Topic 1: Basics of working in mathematical packages.
Topic 2. Approximate calculation of functions
Topic 3. Finding the values of zeros of a function.
Topic 4. Solving a system of algebraic equations.
Topic 5. Numerical differentiation of a tabularly defined function.
Topic 6: Numerical integration.
Topic 7. Solving ordinary differential equations.
Topic 8: Solving systems of ordinary differential equations.
Topic 9: Numerical finding of the derivative of a function.

Self-study

The plan includes a course work.
During the course work, you need to design and implement a graphical user interface program that allows you to solve a specific data processing task. It is necessary to implement data entry from a file, editing and saving data in another file, as well as generating a report on the results of the program.
The topic of the course work is the development of a graphical user interface application program for numerical roots of an equation using various numerical methods.
The evaluation is based on the following criteria:

1) understanding, degree of mastery of the theory and methodology of the problems under consideration;
2) the degree of mastery of the work material;
3) implementation of a software product on the topic of the course work;
4) testing and demonstration of a graphical user interface program that allows you to solve a specific data processing task;
5) logic, structure, style of presentation of material in written works and in classroom presentations, ability to justify one's position, generalize information and draw conclusions.
The grade of "excellent" is assigned if the student's completed assignment or oral response meets all five of these criteria.
The absence of a particular component reduces the grade by the corresponding number of points.
The assessment pays attention to the quality and independence of the student's work, as well as the timeliness of submitting the completed assignments to the teacher (according to the schedule of the educational process). If any of the requirements are not met, the grade will be lowered.

Course materials and recommended reading

Key literature

1. Numerical methods: Study guide. / Volontyr L.O., Zelinska O.V., Potapova N.A., Chikov I.A., Vinnytsia National Agrarian University - Vinnytsia: VNAU, 2020 - 322 p.
2. Andrunyk V.A., Vysotska V.A., Pasichnyk V.V., Chirun L.B., Chirun L.V. Numerical methods in computer science: a textbook - Lviv: New World 2000 Publishing House, 2020. 470 p.
3. Methods of computation: Part 1. Numerical methods of algebra [Electronic resource]: a textbook for students majoring in 113 "Applied Mathematics", specializing in "Data Science" and mathematical modeling / Igor Sikorsky Kyiv Polytechnic Institute; compiled by V. V. Tretnyk, N. D. Liubashenko - Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2019. - 138 p.
4. Chapra St. C., Canale R. P. Numerical methods for engineers. Seventh edition. 2015. - 987 p.

Additional literature

5. Mazmanishvili O.S., Shvarko Y.V. Workshop on Numerical Methods - K.: SHSDO, 1994. 160 p.
6. Numerical methods. https://www.studysmarter.co.uk/explanations/math/pure-maths/numerical-methods/.
7. Lazarev Y. F. MATLAB Handbook / Electronic textbook for course and diploma design. - K.: NTUU "KPI", 2013. - 132 p.
8. Oosterlee C. W., Grzelak L. A. Mathematical Modeling and Computation in Finance: With Exercises and Python and MATLAB Computer Codes. 2017. - 540 p.

Assessment and grading

Criteria for assessment of student performance, and the final score structure

The final grade in the course is calculated as an average of several components, taking into account the grades of each type of control (grades for laboratory work, grades for coursework and exam grades).
100% final assessment in the form of an exam (18%) and a current assessment (82%).
18% exam
82% current assessment:
Coursework (10%)
Laboratory works (72%)
Laboratory work №1-2 (9%)
Laboratory work №3 (9%)
Laboratory work №4 (9%)
Laboratory work №5 (9%)
Laboratory work №6 (9%)
Laboratory work №7 (9%)
Laboratory work №8 (9%)
Laboratory work №9 (9%)

Grading scale

Total points	National	ECTS
90–100	Excellent	A
82–89	Good	B
75–81	Good	C
64–74	Satisfactory	D
60–63	Satisfactory	E
35–59	Unsatisfactory (requires additional learning)	FX
1–34	Unsatisfactory (requires repetition of the course)	F

Norms of academic integrity and course policy

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": to demonstrate discipline, good manners, kindness, honesty, and responsibility. Conflict situations should be openly discussed in academic groups with a lecturer, and if it is impossible to resolve the conflict, they should be brought to the attention of the Institute's management.
Regulatory and legal documents related to the implementation of the principles of academic integrity at NTU "KhPI" are available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Approval

Approved by	08.06.2023	Head of the department Ihor HAMAIUN
	08.06.2023	Guarantor of the educational program Andrii KOPP