Syllabus
Course Program

Numerical methods

Specialty
113 Applied mathematics

Institute
Educational and Scientific Institute of Computer Science and Information Technology

Educational program
Intelligent Data Analysis

Department
Computer Mathematics and Data Analysis

Level of education
Bachelor's level

Тип дисципліни
Special (professional), Mandatory

Semester
4

Language of instruction
Ukrainian

Lecturers and course developers

Sergii Iglin

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Candidate of technical sciences, associate professor, professor of the department of computer mathematics and data analysis.

Author of more than 120 scientific and methodical papers. Basic courses: higher mathematics, linear programming, graph theory, numerical methods.
More about the lecturer on the website
http://iglin.epizy.com

General information

Summary

The course is aimed at mastering numerical methods. Problems of linear algebra, solving nonlinear equations and their systems, interpolation and approximation, numerical differentiation and integration are considered.

Course objectives and goals

Providing students with the knowledge and skills necessary for the numerical solution of problems encountered in practice, which do not have an analytical solution, or for which finding an analytical solution is impractical.
The target of the course is to teach students the basic theoretical principles and practical methods of computational mathematics.

Format of classes

Lectures, laboratory works, self-study, calculation tasks, consultations. Final control in the form of an exam.

Competencies

SC 2. Ability to perform tasks formulated in mathematical form.
SC 4. Ability to choose and apply numerical methods for solving optimization problems.
SC 9. Ability to use modern technologies of programming and software testing.

Learning outcomes

LO 2. Master the basic principles and methods of mathematical, complex and functional analysis, linear algebra and number theory, analytic geometry, theory of differential equations, in particular partial differential equations, probability theory, mathematical statistics and random processes, numerical methods.
LO 5. Be able to develop and use in practice algorithms related to approximation of functional dependencies, numerical differentiation and integration, solution of systems of algebraic, differential and integral equations, solution of boundary value problems, search for optimal solutions.
LO 9. Build algorithms that are effective in terms of calculation accuracy, stability, speed, and consumption of system resources for numerical research of mathematical models and solving practical problems.
LO 13. To use specialized software products and software systems of computer mathematics in practical work.

Обсяг дисципліни

The total volume of the course is 120 hours (4 ECTS credits): lectures – 30 hours, laboratory classes – 30 hours, self-study – 60 hours.

Course prerequisites

"Mathematical analysis".

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

Programming skills are required. Study materials are available to students on the teacher's website.

Program of the course

Topics of the lectures

Topic 1. Basic concepts of numerical methods.
Topic 2. Solving systems of linear algebraic equations and inverting matrices.
Topic 3. Calculation of eigenvalues and eigenvectors.
Topic 4. Solving nonlinear equations.
Topic 5. Solving systems of nonlinear equations.
Topic 6. Interpolation with Lagrange and Newton polynomials.
Topic 7. Interpolation with Chebyshev polynomials and splines.
Topic 8. Approximation.
Topic 9. Numerical differentiation of a function of one variable.
Topic 10. Numerical differentiation of a function of several variables.
Topic 11. Numerical integration of a function of one variable.
Topic 12. Numerical integration of a function of several variables.
Topic 13. Numerical integration of ordinary differential equations – initial task, single-point methods.
Topic 14. Numerical integration of ordinary differential equations – initial task, multipoint methods.
Topic 15. Numerical integration of ordinary differential equations – a boundary task.
Topic 16. Numerical integration of partial differential equations.

Topics of the workshops

Workshops are not provided within the discipline.

Topics of the laboratory classes

Topic 1. Installing the software and familiarizing with it.
Topic 2. Solving systems of linear algebraic equations and inverting matrices.
Topic 3. Calculation of eigenvalues and eigenvectors.
Topic 4. Solving nonlinear equations.
Topic 5. Solving systems of nonlinear equations.
Topic 6. Interpolation with Lagrange and Newton polynomials.
Topic 7. Interpolation with Chebyshev polynomials and splines.

Topic 8. Approximation.
Topic 9. Numerical differentiation of a function of one variable.
Topic 10. Numerical differentiation of a function of several variables.
Topic 11. Numerical integration of a function of one variable.
Topic 12. Numerical integration of a function of several variables.
Topic 13. Numerical integration of ordinary differential equations – initial task, single-point methods.
Topic 14. Numerical integration of ordinary differential equations – initial task, multipoint methods.
Topic 15. Numerical integration of ordinary differential equations – a boundary task.
Topic 16. Numerical integration of partial differential equations.

Self-study

During self-stury, students study lecture material, perform individual homework (IHW), prepare for tests and colloquiums. Correctly performed IHW are counted, incorrect ones are returned for revision. IHW are evaluated as completed after correcting errors.

In non-formal education according to the relevant Regulation (http://surl.li/pxssv), the educational component or its individual topics can be taken into account in case of independent completion of professional courses/trainings, obtaining civic education, online education, professional internship, etc. In particular, individual topics of this component may be taken into account upon successful completion of the following courses:

Topic 4. Solving nonlinear equations.
https://www.coursera.org/learn/numerical-methods-engineers#modules
module 2 (root search)

Topic 2. Solving systems of linear algebraic equations and inverting matrices.
Topic 3. Calculation of eigenvalues and eigenvectors.
https://www.coursera.org/learn/numerical-methods-engineers#modules
module 3 (matrix algebra)

Topic 6. Interpolation with Lagrange and Newton polynomials.
Topic 7. Interpolation with Chebyshev polynomials and splines.
Topic 11. Numerical integration of a function of one variable.
https://www.coursera.org/learn/numerical-methods-engineers#modules
module 4 (quadrature interpolation)

Topic 13. Numerical integration of ordinary differential equations – initial task, single-point methods.
Topic 14. Numerical integration of ordinary differential equations – initial task, multipoint methods.
https://www.coursera.org/learn/numerical-methods-engineers#modules
module 5 (ordinary differential equations)

Topic 16. Numerical integration of partial differential equations.
https://www.coursera.org/learn/numerical-methods-engineers#modules
module 6 (partial differential equations)

Course materials and recommended reading

Main literature

1. Volontir L. O. Numerical methods. Tutorial / L. O. Volontir, L. V. Zelinska, N. A. Potapova, I. A. Chikov. – Vinnycia: VNAU, 2020. – 322 p. (in Ukrainian)
https://r.donnu.edu.ua/bitstream/123456789/1805/1/%D0%A7%D0%B8%D1%81%D0%B5%D0%BB%D1%8C%D0%BD%D1%96%20%D0%BC%D0%B5%D1%82%D0%BE%D0%B4%D0%B8%20%D0%BD%D0%B0%D0%B2%D1%87%D0%B0%D0%BB%D1%8C%D0%BD%D0%B8%D0%B9%20%D0%BF%D0%BE%D1%81%D1%96%D0%B1%D0%BD%D0%B8%D0%BA.pdf

2. Goncharov O. A. Numerical methods of solving applied tasks. Tutorial / O. A. Goncharov, L. V. Vasilieva, A. M. Yunda. – Sumy: SDU, 2020. – 142 p. (in Ukrainian)
https://essuir.sumdu.edu.ua/bitstream-download/123456789/79378/3/Honcharov_chyselni_metody.pdf;jsessionid=5D2E2EB7BC18B0BF8EC0DFC6A785C680
3. Remez N. S. Numerical methods of solving technical tasks / N. S. Remez, V. B. Kiseliov, A. O. Dichko, Yu. Yu. Minaeva. – Helvetica, 2022. – 186 p. (in Ukrainian)
https://knushop.com.ua/index.php?route=product/product&product_id=3632&gclid=Cj0KCQiAh8OtBhCQARIsAIkWb6958QIEgAslxNx4VwlYc8wTGmTabeOStWbXj7hdvjYx33iSY8Ao_vEaAhI7EALw_wcB
4. Humpherys J. Foundations of Applied Mathematics Volume 2: Algorithms, Approximation, Optimization / J. Humpherys, T. J. Jarvis. – SIAM, 2020. – 789 p.
https://epubs.siam.org/doi/book/10.1137/1.9781611976069
5. Lange K. Algorithms from THE BOOK / K. Lange. – SIAM, 2020. – 214 p.
https://epubs.siam.org/doi/book/10.1137/1.9781611976175

Additional literature

6. Trubaiev O. I. Performing mathematical calculations in the MATLAB system. Tutorial / Trubaiev O. I., Mietielov V. O., Iglin S. P. – Kharkiv : NTU "KhPI" , 2023. – 53 p. (in Ukrainian)
https://repository.kpi.kharkov.ua/server/api/core/bitstreams/605f7c3e-098e-467e-b403-163bafb536ef/content

Assessment and grading

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

A necessary condition for passing the test or exam is the fulfillment of all individual home tasks.
60 points are awarded for writing control papers.
Passing colloquiums — 40 points.

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	Date, signature 29.08.2024		Head of the department Olena AKHIIEZER
	Date, signature 29.08.2024		Guarantor of the educational program Olena AKHIIEZER