Syllabus
Course Program

Signal Processing 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
Master's level

Course type
Special (professional), Selective

Semester
1

Language of instruction
English

Lecturers and course developers

Oleksii Haluza

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Doctor of Science (Physics&Mathematics), Full Professor, Professor of Computer Mathematics and Data Analysis Department

Work experience - more than 20 years. The author of many scientific, educational, and methodological works. Leading lecturer in the courses: "Algorithmization and Programming", "Optimization Methods", "Machine Learning", etc.

More about the lecturer on the department's website

General information

Summary

Problems, theoretical approaches and methods of solving the main types of signal processing problems are considered.

Course objectives and goals

The discipline is aimed at acquiring the necessary competencies in the field of signal processing.

Format of classes

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

Competencies

GC 3. Ability for continuous learning, acquiring new knowledge and skills, including in areas other than professional ones.
GC 4. Ability to identify, pose, and solve problems in professional activities.
GC 7. Ability to work with information, find and use information from various sources necessary for solving professional tasks.
SC 1. Ability to formulate a mathematical problem, relying on the language of the subject area, verifying the correctness of the formulation, including under conditions of uncertainty.

SC 2. Ability to choose, develop, and investigate mathematical, analytical, or numerical methods for solving practical problems that ensure the required accuracy and reliability of the result.
SC 5. Ability to conduct mathematical and computer modeling and computational experiments, collect, visualize, analyze, and process obtained data, solve formalized problems using specialized software tools.
SC 7. Ability to search, study, and analyze scientific and technical information, domestic and foreign experience related to the application of mathematical methods for the study of processes and systems.
SC 12. Ability to develop and operate specialized software tools for intelligent data analysis of texts, signals, and images.
SC 14. Ability to use modern information technologies for intelligent data analysis, forecasting, decision-making, information retrieval, and knowledge extraction.

Learning outcomes

LO 1. Demonstrate knowledge and understanding of the fundamental and applied mathematics concepts, principles, and theories and apply them in practice.
LO 2. Ability to formalize problems formulated in the language of a specific subject area, choose a rational method for solving them, solve problems using analytical or numerical methods, assess the accuracy and reliability of the results, and interpret them.
LO 5. Develop algorithms that are efficient in terms of accuracy, stability, speed, and resource consumption for numerical investigation of mathematical models and data analysis, decision-making.
LO 7. Apply modern programming technologies and software development, implement numerical and symbolic algorithms.
LO 12. Know and understand modern methods for solving mathematical problems of statistical and intelligent data analysis, forecasting, etc.
LO 14. Ability to apply existing and develop new algorithms and software tools for statistical and intelligent analysis of uncertain data.

Student workload

The total volume of the course is 180 hours (6 ECTS credits): lectures - 32 hours, laboratory classes - 48 hours, self-study - 100 hours.

Course prerequisites

"Programming", "Mathematical analysis", "Linear algebra", "Probability theory", "Mathematical statistics", "Functional analysis".

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

When teaching this discipline, such teaching and learning methods as gamification and peer-to-peer are used. LMS (learning management systems) systems are used in the learning process.

Program of the course

Topics of the lectures

Topic 1. Introduction. Basic concepts of digital signal processing.
Topic 2. Correlation analysis of signals
Topic 3. Transition from continuous to digital signals
Topic 4. Basic types of discrete digital signal processing algorithms
Topic 5. Discrete orthogonal transformations
Topic 6. Wavelet transformation
Topic 7. Fast algorithms of orthogonal transformations
Topic 8. Algorithms for nonlinear signal processing

Topics of the workshops

Workshops are not provided within the discipline.

Topics of the laboratory classes

Topic 1. Python tools for working with signals
Topic 2. Generation and transformation of periodic signals
Topic 3. Aperiodic signals and their spectra
Topic 4. Generation and analysis of noise-like signals
Topic 5. Determination of the fundamental frequency of periodic signals by the autocorrelation method
Topic 6. Use of discrete cosine transformation for signal compression
Topic 7. Fast Fourier transform
Topic 8. Convolution and filtering of signals
Topic 9. Integration and differentiation of signals
Topic 10. Modulation of signals

Self-study

The course involves the completion of individual tasks, the results of which are monitored and assessed by teachers. Students are also recommended additional materials (videos, articles) for self-study.

Course materials and recommended reading

1. A.B. Downey. Think DSP: Digital Signal Processing in Python. - Cambridge: O'Reilly Media, 2016. - 165 p. ISBN 978-149-193-845-4
2. V. Madisetti, D.B. Williams. The Digital Signal Processing Handbook. - CRC Press, 2017. - 904 p. ISBN 084-938-572-5
3. P.M. Embree, D. Danieli. C++ Algorithms for Digital Signal Processing. - Hoboken: Prentice Hall, 1998. - 579 p. ISBN 0-13-179144-3
4. https://www.coursera.org/specializations/digital-signal-processing

Assessment and grading

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

Description of the final score structure, course requirements, and necessary steps to earn points, especially paying attention to self-study and individual assignments.

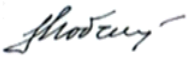
Grading scale

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 31.08.2023		Head of the department Olena AKHIIEZER
	Date, signature 31.08.2023		Guarantor of the educational program Leonid LYUBCHYK