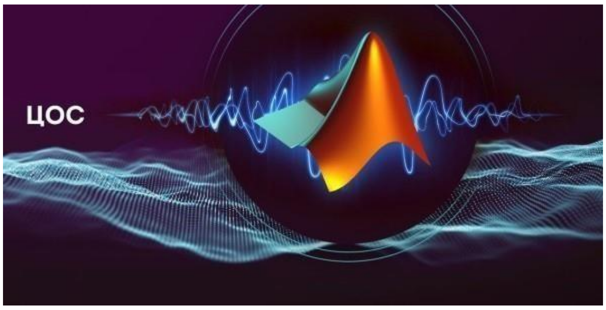
Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Department of Applied Radio Electronics

[RE-114] DIGITAL SIGNAL PROCESSING



Curriculum of the academic discipline (Syllabus)

Course details

Level of higher education	First (bachelor's)
Field of knowledge	G Engineering, Manufacturing and Construction
Specialization	G5 Electronics, Electronic Communications, Instrument
Educational program	Intelligent Radio Electronics Technologies Information and Communication Radio Engineering Radio Engineering Computerized Systems Radio Electronic Warfare Technologies
Discipline status	Regulatory
Form of higher education	Full-time
Year of training, semester	3rd year, fall semester
Scope of the discipline	5 credits (Lectures 30 hours, Practical classes 30 hours, Laboratory classes 16 hours, Independent work 74 hours)
Semester control/control measures	Exam

Class schedule	https://schedule.kpi.ua
Language of instruction	Ukrainian

Information about the course leader/teachers

Lecturer: R. V. Antypenko, Practical classes: I. O. Prykhodko,

Laboratory classes: I. O. Prykhodko, Independent work: R. V. Antypenko

Course placement https://do.ipo.kpi.ua/course/view.php?id=450

Curriculum

1. Description of the course, its purpose, subject matter, and learning outcomes The purpose of the credit module is to develop students' abilities to:

- Analyze discrete systems and their structures;
- Design linear digital filters;
- Determine the main characteristics of discrete signals;
- Use the basic methods of spectral analysis of discrete signals;
- Design discrete systems with signal processing at multiple speeds.

After completing the credit module, students should demonstrate the following learning outcomes:

knowledge:

properties of discrete systems and their main characteristics in the time, frequency, and z-domain; methods of designing digital linear filters; basic methods of spectral analysis of discrete signals; matched digital filtering; processing of discrete signals at multiple speeds.

skills:

analyze and design linear discrete systems (digital filters); use the basic methods of spectral analysis of discrete signals; use matched filtering of discrete signals, process discrete signals using multirate systems.

Experience:

designing linear digital filters; spectral analysis of discrete signals; using Matlab tools and other software products for digital signal processing.

General competencies provided by studying the discipline:

GC2. Ability to apply knowledge in practical situations

GC4. Knowledge and understanding of the subject area and understanding of professional activity.

GC7. Ability to learn and acquire modern knowledge

GC8. Ability to identify, pose, and solve problems

Professional competencies:

- **PC3.** Ability to use basic methods, techniques, and means of obtaining, transmitting, processing, and storing information
- **PC4.** Ability to perform computer modeling of devices, systems, and processes using universal application software packages.

Program learning outcomes:

- **PLO1.** Analyze and make informed decisions when solving specialized tasks and practical problems in telecommunications and radio engineering, which are characterized by complexity and incomplete certainty of conditions;
- **PLO 2.** Apply the results of personal research and analysis of information to solve qualitative and quantitative problems of a similar nature in information and communication networks, telecommunications, and radio engineering systems;
- **PLO 3.** Competently apply the terminology of the telecommunications and radio engineering industry;
- **PLO 8.** Describe the principles and procedures used in telecommunications systems, information and telecommunications networks, and radio engineering;

- **PLO 13.** Apply fundamental and applied sciences to analyze and develop processes occurring in telecommunications and radio engineering systems;
- **PLO 18.** Find, evaluate, and use information from various sources necessary for solving professional tasks, including reproducing information through electronic search.
- **PLO 20.** Explain the principles of construction and operation of hardware and software complexes of control and maintenance systems for the development, analysis, and operation of information and telecommunications networks, telecommunications, and radio engineering systems.

2. Prerequisites and post-requisites of the discipline (place in the structural-logical scheme of training under the relevant educational program)

Digital signal processing is based on the disciplines: "Signals and processes in radio engineering." Post-requisites of the discipline – "Communication methods in intelligent systems."

3. Contents of the discipline Topic

1. Basic concepts.

Development of DSP systems. Classical directions of DSP: spectral analysis and digital filtering. Areas of application of DSP, advantages and disadvantages. Mathematical apparatus. Generalized diagram of the DSP system. Ways of implementing DSP systems.

Basic types of signals. Discrete signal. Digital signal. Typical discrete signals.
Digital unit impulse. Digital unit step. Discrete real exponent. Discrete harmonic signal. Discrete complex harmonic signal. Combination of standard sequences.

Discrete systems. Basic definitions. Classification of discrete systems. Linear discrete system. Stationary discrete system. Deterministic discrete system. System memory. Stability.

Topic 2. Fundamentals of discrete transformations.

Discrete transformations (overview).

Discrete Laplace transform. Difference from analog signal transformation. Basic properties.

Fourier transform of a discrete sequence. Main properties of the Fourier transform. Continuity. Periodicity. Fourier transform of a real signal. Linearity.
Frequency shift. Time shift (delay). Parseval's theorem. Convolution theorem. Periodic convolution theorem (modulation). Frequency differentiation.

Z-transform. Connection with the discrete Laplace transform. Connection with the Fourier transform.

s region of convergence. Z-transform. Properties of the region of convergence.

Properties of z-transformation. Linearity. Delay theorem. Convolution theorem. Multiplication by an exponential sequence. Differentiation.

Inverse z-transform. Methods for finding the inverse z-transform. Correspondence tables. Decomposition of z-images into simple fractions. Decomposition into power series.

Topic 3. Spectral analysis.

Spectrum of a discrete signal. Properties of discrete signal spectra. Superposition of discrete signal spectra. Connection with the spectrum of an analog signal, multiplication of the spectrum of an analog signal.

Discrete Fourier transform (DFT). Forward transform. Analysis range. Frequency resolution. Absolute frequency count. Number of time and frequency counts. Frequency periodicity of DFT. DFT matrix.

Properties of the DFT. Periodicity. Linearity. Offset. Delay. Parseval's theorem. Symmetry. Calculation using the DFT of circular (periodic) convolution. DFT of the product of periodic sequences.

Fast Fourier transform algorithms. Computational complexity of the DFT.

FFT algorithm with temporal thinning. Initial conditions (bit reversal). Example of an 8-point FFT sequence. The basis of the FFT algorithm. FFT algorithm with frequency thinning.
of an 8-point sequence. Basis of the FFT algorithm. FFT algorithm with frequency thinning. Finding the

inverse DFT using the FFT algorithm. Generalization of FFT. Hertzel's algorithm.e spread of the

spectrum. Discrete filtering using DFT. Spectrogram. Features of using DFT for spectral analysis.

Topic 4. Linear discrete systems (LDS).

Linear discrete systems, definition.

Description of LDS in the time domain. Impulse response (IR). Transient response. Relationship between the input and output of LDS. Discrete linear convolution formula. Difference equation. Recursive and non-recursive LDS. Systems with finite and infinite IC. LDS memory. LDS stability. Assessment of LDS stability by IC.

Description of LDS in the z-domain. Transfer function. Properties of PF. Map of zeros and poles of PF. Relationship between PF and IH. PF of recursive and non-recursive LDS. Assessment of LDS stability by PF.

Description of LDS in the frequency domain. Frequency response. KCH, ACH, and FCH. Relationship between KCH and PF. Properties of KCH.

Structures of LDS, basic operations.

Structures of recursive LDS. Direct structure I. Direct structure II (canonical direct structure). Cascade structure. Parallel structure.

Structures of non-recursive LDS. Direct structure. Cascade structure. Selection of LDS structure.

Topic 5. Digital linear filters (DLF). Calculation methods.

Digital filters. Requirements for DF. DF as LDS. Impulse response of DF of different orders. Cases of real and complex poles. Geometric interpretation of AFC and FCH. Zero-pole map of DF. Influence of zeros and poles on CH.

DFs of different orders. 1st order DF. Schematic diagram, characteristics. 2nd order DF. Direct and canonical forms of implementation. Block diagrams. Algorithm for calculating impulse response and frequency response.methods for calculating of NICH filters.

Method of invariant transformation of impulse response. Advantages and disadvantages of the method. Calculation examples.

Method of bilinear transformation. Essence of the method. Requirements for the analog frequency transformation function. Basic relationships. Disadvantages of the method.

Calculation of CF coefficients by placing zeros and poles. Calculation of CF coefficients by matched z-transform.

Methods for calculating SIH filters.

Method of weighting impulse response. Use of LPF and bandpass ideal analog filters as prototypes of CF. Basic relationships. Gibbs phenomenon. Types of weighting windows: rectangular, Hamming, Hann, Kaiser. Comparison of their effectiveness.
Selection of windows based on guaranteed decay and transition frequency band. Advantages and disadvantages of the method.

Frequency sampling method. Basic relationships. Deviations of the frequency response of the digital filter from the prototype at frequency sampling points. Methods for optimizing frequency sampling. Linear programming method. Various forms of implementation of the interpolating CIF filter. Use of non-recursive and recursive structures.

CF with linear frequency response. Conditions for ensuring ideal linear frequency response, types of CF. Frequency response of filters with finite impulse response. Problem statement. Solution results. Type of impulse response of a SIH filter with ideal frequency response. Ensuring constant phase and group delay.

All-pass filters (APF). First-order APF. Higher-order APF. Structural diagrams of first-order APF. Recursive formula for APF PF.

Minimum phase LDS. Matched CF.

4. Teaching materials and resources

1. Distance learning course Digital Signal Processing on the Sikorsky distance learning platform.
2. Alan V. Oppenheim. Digital Signal Processing / Alan V. Oppenheim, Ronald W. Schafer — Access mode : https://ocw.mit.edu/courses/res-6-008-digital-signal-processing-spring-2011/ — Title from the screen.
3. Bortnik G.G. Digital Signal Processing in Telecommunications Systems: Textbook. G.G. Bortnik / 2014. — Vinnytsia: VNTU 2014.— 231 p.
4. Usenko Yu.O. Fundamentals and methods of digital signal processing: from theory to practice, textbook. Yu.O. Usenko, V.V. Drozhak, M.S. Gavrilyak, M.V. Talakh / 2021. — Chernivtsi: Yuriy Fedkovych Chernivtsi National University 2021. — 307 p.
5. Digital Signal Processing. Principles, Algorithms, and Applications. Third Edition. John G. Proakis, Dmitris G. Manolakis. 1996, Prentice Hall, New Jersey, USA.
6. Signal Processing Toolbox — Access mode: https://uk.mathworks.com/help/signal/index.html?s_tid=hc_product_card— Title from screen.

Educational content

5. Methodology for mastering the academic discipline (educational component)

Lectures

No.	Lecture topic and list of main questions
1	**Topic 1. Basic concepts.** [1], [2], [3], History of DSP development. Classical DSP directions: spectral analysis and digital filtering. DSP applications - advantages and disadvantages. ***Assignments for independent study:*** Mathematical apparatus. Generalized diagram of a DSP system. Ways to implement DSP systems. [3, pp. 7, 20] **Topic 2. Fundamentals of discrete transformations.** [1] Discrete Laplace transform. Differences from analog signal transformation. Main properties.
No.	**Lecture topic and list of main questions**
2	**Topic 2. Fundamentals of discrete transforms (continued).** Fourier transform of a discrete sequence. Condition of existence. Main properties. Z-transform is direct. Justification of the transition from the complex p-plane to the Z-plane. Convergence of the Z-transform. Relationship between the complex p-plane and the Z-plane. Properties. Examples of transforms. Inverse Z-transform. Methods of finding. Examples. ***Assignment for independent study:*** Other discrete transformations (overview): orthogonal transformations, discrete Hilbert transform, Hadamard transform, Haar transform, Walsh transform, cosine and sine transforms, Karhunen-Loewy transform. [2]

3	**Topic 3. Spectral analysis.** [1-4] Complex spectrum of a discrete signal. Amplitude and energy spectrum. Basic properties and theorems: linearity, digital convolution, shift theorem, frequency periodicity, connection with the spectrum of an analog signal, multiplication of the spectrum of an analog signal, possibility of restoring the spectrum of an analog signal. Superposition of spectra. ***Assignment for independent study:*** Representation of DFT as discrete filtering (Hertzel's algorithm). [3]
4	**Topic 3. Spectral analysis (continued).** Discrete Fourier transform (DFT). Forward transform. Analysis range. Frequency resolution. Absolute frequency count. Number of time and frequency counts. Periodicity of the DFT by frequency. Superposition of spectra. Algorithm speed. Complex symmetry property. Methods for improving frequency resolution. frequency resolution. Inverse Fourier transform, its properties.
5	**Topic 3. Spectral analysis (continued).** Fast Fourier transform (FFT) algorithms. Variety of FFT algorithms. Time sampling thinning procedure. Binary inversion algorithm (bit reverse). Directed graph of the FFT. Advantages of the FFT algorithm: speed, memory usage. FFT acceleration factor. Inverse FFT (IFFT). Finding the IFFT using the FFT. ***Homework assignment:*** Spectrum shift and inversion. Formation of a digital signal with a single sideband. Representation of DFT as discrete filtering (Hertzel's algorithm). [1], [3]
6	**Topic 4. Discrete convolution and correlation.** [3-4 Mutual correlation and autocorrelation. Use of correlation. Fast correlation. Discrete convolution. Use of convolution in DSP as a basic operation. Calculation example. Aperiodic (linear) convolution. Calculation examples.
7	**Topic 4. Discrete convolution and correlation (continued).** Discrete filtering using DFT. Circular (periodic) convolution. Fast convolution. Use of the FFT algorithm. ***Assignment for independent study:*** Calculation of convolution of long sequences, their sectioning (block convolution). Methods for joining individual blocks. Representation of DFT as discrete filtering (Hertzel's algorithm). [5]
8	**Topic 5. Linear discrete systems (LDS).** [1], [3] Basic concepts and properties of LDS. Description of LDS in the time domain. The main characteristic in the time domain is the impulse response. Linear convolution. Difference equation. Recursive and non-recursive LDS. Stability analysis. Description of LDS in the z-domain. The main characteristic of LDS in the z-domain is the transfer function (TF). Definition of TF. Relationship between TF and impulse response.
9	**Topic 5. Linear discrete systems (LDS) (continued).** Zero and pole map of TF. Factorization of TF. Stability analysis of LDS in the z-domain. Description of LDS in the frequency domain. The main characteristic in the frequency domain is the complex frequency response (CFR). Relationship between CFR and TF. ***Assignment for independent work:*** Express analysis of FCR. [3]
No .	**Lecture topic and list of main questions**
10	**Topic 6. LDS structures.** [1 Structures of recursive LDAs, their properties and differences. Direct structure. Canonical direct structure. Cascade structure. Parallel structure. Structures of non-recursive LDAs, their properties and differences. Direct structure. Cascade structure.

11	**Topic 7. Digital linear filters (DLF).** [1] DF as an LDS. Impulse response of DFs of different orders. Cases of real and complex poles. Geometric interpretation of frequency response and phase response. Zero-pole map of DF. DFs of different orders. First-order DF. Schematic diagram, characteristics. Second-order DF. Algorithm for calculating impulse response and frequency response. Recursive CFs. Filters with infinite impulse response (IIR filters). Features of IIR filters: implementation forms, impulse response, zero-pole map, need for stability checking, implementation algorithms. ***Assignment for independent study:*** Features of NIH filters: effect on pole frequency response, order. [3]
12	**Topic 7. Digital linear filters (DLF) (continued).** Non-recursive LF. Filters with finite impulse response (FIR filters). Impulse response. Forms of implementation. Zero-pole map. Stability of non-recursive LF. Implementation and fast convolution algorithm. Effect of zeros and poles on frequency response. Advantages and disadvantages of CFs. Choosing between NII and SIH filters.
13	**Topic 8. Methods for calculating FTs.** [1-5]. calculation of NII filters. Method of invariant transformation of impulse response. Advantages and disadvantages of the method. Calculation examples. Bilinear transformation method. Essence of the method. Requirements for the analog frequency transformation function. Basic relationships. Disadvantages of the method. ***Assignment for independent study:*** Other methods of designing NICH filters. [1-5]
14	**Topic 8. Methods for calculating CF (continued).** calculation of SIH filters. Impulse response weighting method. Use of LPF and bandpass ideal analog filters as prototypes of CF. Basic relationships. Gibbs phenomenon. Types of window functions: rectangular, Hamming, Hann, Kaiser. ***Assignment for independent study:*** Comparison of the effectiveness of window functions. Selection of windows based on guaranteed decay and transition frequency band. Advantages and disadvantages of the method. [1.5]
15	**Topic 8. Methods for calculating the center frequency (continued).** Frequency sampling method. Basic relationships. Deviations of the frequency response of the CF from the prototype at frequency sampling points. Methods for optimizing frequency sampling. Linear programming method. Various forms of implementation of the interpolating SIH filter. Recursive implementation of the SIH filter. ***'s assignment at SRC:*** Optimization methods for designing SIH filters. [1-3,5]
16	**Topic 9. Examples of COS systems and their features.** [1] SIH systems with linear frequency response. Conditions for ensuring ideal linear frequency response. Type of impulse response of an SIH filter with ideal frequency response. Ensuring constant phase and group delay. Structure of systems with linear frequency response. All-pass filters (all-pass filter). PF, KCH. Structure of all-pass filters. ***Assignment for SRC:*** Minimum phase systems. [3] Matched digital filter [4]
17	**Topic 10. Changing the sampling frequency of a digital signal.** [3] The need for signal processing at multiple speeds. Decimation (reduction of the sampling frequency of a digital signal). Principle of operation of decimation systems. Decimation using optimal DFs. Spectrum shift during decimation.
No.	**Lecture topic and list of key questions**
18	**Topic 10. Changing the sampling frequency of a digital signal (continued).** Interpolation (increasing the sampling frequency of a digital signal). How interpolation systems work, their block diagrams. Digital filtering in polynomial (linear) interpolation. Interpolation using optimal CFs. Spectrum shift during interpolation. Discrete frequency conversion with non-integer step (prediscretization). ***Assignment for independent work:*** Multistage sampling frequency conversion. Sampling frequency conversion using a multiphase structure. [3]

Practical classes

Practical classes are held for better assimilation and in-depth study of the lecture material. The topic of the practical class is communicated to students in advance, at the previous class or lecture.

At the end of the class, each student may receive an individual assignment to be completed independently on the topic of the practical class in order to assess the quality of their understanding of the material.

No.	Name of the lesson topic and list of key questions (list of teaching aids, references to literature, and assignments for independent study)
1	Discrete signals and discrete systems, classification [1]
2	Spectrum of a discrete signal, properties [1].
3	Discrete Fourier transform [1].
4	Discrete convolution [2].
5	Analysis of linear discrete systems. Use of Z-transform [2-3].
6	Structures of linear discrete systems [1-3]
7	Design of CCI filters. [3-5]
8	-coordinated digital filter. [4-5]
9	Processing of discrete signals by multirate systems. [3-4].

Laboratory classes

The main objectives of the laboratory session cycle are to develop the relevant skills and experience in students.

Laboratory work No. 1 Discrete Fourier transform

Laboratory work No. 2 Designing digital filters

Laboratory work No. 3 Designing digital filters in Filter Design and Analysis Tool

Laboratory work No. 4 Signal filtering

Individual assignments

The program includes a calculation and graphic assignment as an individual task. Students are asked to calculate digital filters of various types with specified characteristics. The results obtained are input data for performing laboratory work.

Control works

For the credit module of the CCS, the curriculum provides for modular control, which is carried out by means of tests. Their purpose is to check the quality of the knowledge acquired and the quality of independent work. Tests are conducted as independent work by students.

List of test tasks:

1. Classify a discrete system if its impulse response (or transfer function, or difference equation, or frequency response, or block diagram, or set of coefficients, etc.) is known. Justify your answer.
2. Find the transfer function of a discrete system if the impulse response (or block diagram, or input and output signals, etc.) is given.
3. Find the impulse response if the transfer function (or block diagram, or input and output signals, or set of coefficients, etc.) is known.
4. The input discrete signal is given. Find the response of the system if its impulse response (or transfer function, or difference equation, or BPP, or block diagram, or set of coefficients...) is known.
5. The response of a discrete system is known. Find the action if the impulse response of the discrete system is known (or the transfer function, or the difference equation, or the frequency response, or the block diagram, or the set of coefficients...).
6. Find spectrum of a given discrete signal .
7. Find the frequency response of a discrete system if its impulse response (or transfer function, or difference equation, or frequency response, or block diagram, or set of coefficients, or input and

output signals...) is known.

8. Draw a block diagram (of a given type) of a discrete system. The difference equation is given (or transfer function, or frequency response, or set of coefficients...).

6. Independent work of the student

No.	Title of the topic for independent study	Number of hours of independent work
1	**Topic 1. Basic concepts.** *Independent study assignment:* Mathematical apparatus. Generalized diagram of the COS system. Ways to implement COS systems. [1]	3
2	**Topic 2. Fundamentals of discrete transformations.** *Homework assignment:* Other discrete transforms (overview): orthogonal transforms, discrete Hilbert transform, Hadamard transform, Haar transform, Walsh transform, cosine and sine transforms, Karhunen-Loewy transform. [1-3]	4
3	**Topic 3. Spectral analysis.** *Assignment for independent study:* Representation of DFT as discrete filtering (Hertzel's algorithm). [1, p. 629] Spectrum shift and inversion. Formation of a digital signal with a single sideband. Representation of DFT as discrete filtering (Hertzel's algorithm). [1-3].	4
4	**Topic 4. Discrete convolution and correlation.** *Assignment for independent work:* Calculation of convolution of long sequences, their sectioning (block convolution). Methods of joining individual blocks. Representation of DFT as discrete filtering (Hertzel algorithm). [3-5]	4
5	**Topic 5. Linear discrete systems (LDS).** *Assignment for independent study:* Express analysis of KCH. [1]	2
6	**Topic 7. Digital linear filters (DLF).** *Assignment for independent study:* Features of NICH filters: influence on the frequency response of poles, order. [4]	4
7	**Topic 8. Methods for calculating CF.** *Assignment for independent study:* Other methods for designing NICH filters. [3-5] Comparison of the effectiveness of window functions. Selection of windows based on guaranteed attenuation and transition frequency band. Advantages and disadvantages of the method. Optimization methods for designing CII filters.	4
No	**Title of the topic for independent study**	**Number of hours of independent study**
8	**Topic 9. Examples of CMS systems and their features.** *Independent study assignment:* Minimum phase systems. [3] Matched digital filter [4]	4
9	**Topic 10. Changing the sampling frequency of a digital signal.** *Independent study assignment:* Multistage sampling frequency conversion. Sampling frequency conversion using a multiphase structure. [3-4]	4

Policy and control

7. Policy of the academic discipline (educational component)

- A prerequisite for admission to the exam is the absence of outstanding debts for the course, as well as a starting rating of at least 30 *points*.
- A student who scores less than 10 points on the exam (or scores *zero* on one of the three questions) is considered to have received a final grade of "unsatisfactory" regardless of their semester rating.
- The student's calendar assessment is based on their current rating at the time of assessment. If this rating is at least 50% of the maximum possible at the time of assessment, the student is considered to have passed.

8. Types of control and rating system for assessing learning outcomes (RSO)

A student's rating in a discipline consists of points that they receive for:

1. Attendance and independent work in practical classes.
2. 's completion of computational and graphical work.
3. Completion and defense of laboratory work.
4. Completion of a modular test.
5. Taking the exam.

RATING POINT SYSTEM AND EVALUATION CRITERIA

1. Attendance and answers in practical classes.

Students can receive 20 points for their work in practical classes.

2. Completion of calculation work.

Maximum number of points for completing the calculation work: 5 points.

3. Laboratory work.

Maximum number of points for all laboratory work: 20 points.

Students who have not completed the calculation work are not allowed to perform laboratory work (the work is considered not completed and not defended on time).

4. Modular control work.

Weighting of the modular control work: 15 points.

BONUS POINTS

Creative approach and high level of knowledge: additional +10 points.

RATING SCALE CALCULATION

Total weighted points for control measures during the semester: 60 points. Exam: 40

points (theoretical questions and task).

Table of correspondence between rating points and grades on the university scale

Number of points	Grade
10	Excellent
94	Very good
84	Good
74-65	Satisfactory
64-60	Sufficient
Less than 60	Unsatisfactory
Admission requirements not met	Not admitted

9. Additional information on the discipline (educational component)

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Description of material, technical, and informational support for the discipline

Equipment for laboratory work: Computer classroom with 12 Intel Celeron G540 computers, 2.5 GHz, RAM: 4 GB, HDD: 500 GB Software: MatLAB (Online)

Work program for the academic discipline (syllabus):

Compiled by Antypenko R. V.; Prykhodko I. O.;

Approved by the PRE Department (Minutes No. 06/2025 dated 06/25/2025)

Approved by the methodological commission of the faculty/research institute (protocol No. 06/2025 dated 26.06.2025)