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

Department of
Applied Radio
Electronics

[RE-236] DESIGN OF MICROWAVE RECEIVING DEVICES (PN-12)

Work program of the academic discipline (Syllabus)

Course details

Level of higher education	First (bachelor's)
Field of knowledge	17 - Electronics, automation, and electronic communications
Special	172 - Electronic communications and radio engineering
Educational program	172B ICR - Information and Communication Radio Engineering (EDEBO id: 49228)172B ICRI+ - Information and Communication Radio Engineering (EDEBO id: 57910)
Discipline status	Regulatory
Form of higher education	Full-time
Year of training, semester	3rd year, spring semester
Scope of the discipline	4 credits (Lectures 36 hours, Practical work 18 hours, Laboratory work 18 hours, Self-study 48 hours)
Semester control/control measures	Exam
Class schedule	https://schedule.kpi.ua
Language of instruction	Ukrainian
Information about the course director/teachers	Lecturer: Peregudov S. M., Practical classes: Peregudov S. M., Lab: Peregudov S. M., Self-study: Peregudov S. M.
Course location	https://classroom.google.com/c/NDEyNjQ0NDU4NzY5?cjc=kfejwkt

Curriculum

1. Description of the academic discipline, its purpose, subject matter, and learning outcomes

The modern development of telecommunication systems, in particular microwave band receiving devices, and the increase in their functional capabilities require the use of modern design methods, which, in addition to the use of traditional methods for calculating certain receiver components, involve the use of special software that allows modeling the operation of devices as a whole, as well as determining their technical characteristics. This reduces the development time for designing microwave receiving devices for various purposes. The discipline "Design of Microwave Receiving Devices" belongs to the cycle of professional training of students of the first (bachelor's) level of higher education under the educational program "Information and Communication Radio Engineering."

The aim of teaching this discipline is to develop knowledge about receiving devices used in the microwave range, methods of their design, principles of signal conversion in microwave receiver paths, and basic technological operations of the manufacturing process.

The subject of the discipline is the basic methods of designing microwave receiving devices, calculating their main technical characteristics, and determining operating conditions.

As a result of training, students will develop:

General competencies (GC)

GC 2 Ability to apply knowledge in practical situations.

Professional competencies (PC)

PC 21 Ability to design radio frequency printed circuit boards and microwave module structures. Studying the discipline "Design of Microwave Receiving Devices" contributes to the achievement of the following **program learning results**

Program learning results (PLR)

PLR 1 Analyze, argue, and make decisions when solving specialized problems

and practical problems in telecommunications and radio engineering, which are characterized by complexity and incomplete certainty of conditions.

PLR 25 Calculate and design low-noise receivers for information and communication radio systems.

Within the framework of the above-defined general and professional competencies and program learning results, students should:

understand the physical principles of operation of microwave receiving devices and their components

; the main technical characteristics of the most important components; the modeling and calculation methods used at the design stage;

be able to use the acquired knowledge in the design of microwave receivers, the development and operation of equipment in which they are included; analyze the conversion of signals by the components of microwave receiving devices.

Students **gain experience** working with individual components of the above-mentioned equipment and their application in the creation of telecommunications systems.

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

Interdisciplinary connections are determined by the place of the discipline "Design of Microwave Receiving Devices" in the professional educational program for training specialists in the field of electronics and telecommunications. It is based on the general training of students in physics and mathematics. The professional disciplines that precede its study are: "UHF Devices," "Antennas," "Signal Generation, Modulation, and Coding," "Antennas", "Signal Generation, Modulation and Coding".

The discipline "Design of Microwave Receiving Devices" provides for the study of the first (bachelor's) level of higher education in the degree programs "Automated Design of Antennas and Microwave Devices" and "Mobile Telecommunication Systems."

3. Course content

Names of sections and topics	Number of hours				
	Total	including			
		Lectur	Practical	Laboratory work	SS
SECTION 1 FEATURES OF MICROWAVE RADIO RECEIVERS					
Introduction. Content and structure of the discipline "Design of microwave receiving devices"	2.5	2			0.5
Topic 1.1 Block diagrams of microwave receivers	17	4	6	3	4
Topic 1.2 Component base of microwave radio receivers	7.5	2	2	0	3.5
Total for Section 1	27	8	8	3	8
CHAPTER 2 DESIGNING THE RADIO FREQUENCY PATH OF MICROWAVE RECEIVERS					
Topic 2.1. Designing input path devices for microwave receivers	11	2	4	3	2
Topic 2.2 Frequency converters	15	4	4	3	4
Total for Section 2	26	6	8	6	6
CHAPTER 3 DESIGN OF INTERMEDIATE AND LOW FREQUENCY DEVICES					
Topic 3.1 Detectors and amplitude limiters of the IF	11	2	2	3	4
Topic 3.2 Intermediate frequency amplifiers	16	6	4	0	6
Total for Section 3	27	8	6	3	10
CHAPTER 4 AUTOMATIC CONTROL OF MICROWAVE RECEIVERS					
Topic 4.1 Automatic gain control of microwave receivers	15	4	4	3	4
Topic 4.2 Automatic frequency and phase adjustment systems	8	2	2	0	3
Topic 4.3 Sensitivity assessment of receiving microwave devices	3	2	0	0	1
Total for Section 4	25	8	6	3	8
Modular test	2	0	0	0	2
Exam	13	0	0	0	13
Total hours	120	36	18	18	48

4. Teaching materials and resources

Recommended reading

Basic

1. Design of microwave receiving devices: Lecture notes [Electronic resource]: textbook for students majoring in 172 "Electronic Communications and Radio Engineering" / Igor Sikorsky Kyiv Polytechnic Institute; compiled by: S. M. Peregudov. – Electronic text data (1 file: 8.55 MB). – Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2025. – 220 p.

2. Designing microwave receiving devices: Laboratory workshop [Electronic resource]: textbook for students majoring in 172 "Electronic Communications and Radio Engineering" / Igor Sikorsky Kyiv Polytechnic Institute; compiled by: S. M. Peregudov. – Electronic text data (1 file: 4.17 MB). – Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2023. – 65 p.

3. Designing microwave receiving devices: Coursework [Electronic resource]: textbook for students majoring in 172 "Electronic Communications and Radio Engineering"/ Igor Sikorsky Kyiv Polytechnic Institute; compiled by: S. M. Peregudov. – Electronic text data (1 file: 2.59 MB). – Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2023. – 45 p.

4. Haiduk .I. et al. Radio Telecommunications Technologies: Radio Transmitting and Receiving Devices. – Nizhyn: Aspect-Poligraf Publishing House, 2007. – 320 p.

Supplementary

5. Shokalo V.M., Pravda V.I., Usin V.A., Vuntesmeri V.S., Gretskykh D.V. Electrodynamics and Radio Wave Propagation. Part 1. Fundamentals of electromagnetic field theory: Textbook for university students / Edited by V.M. Shokalo and V.I. Pravda – Kharkiv: KNURE; Collegium, 2009 – 286 p.

6. Shokalo V.M., Pravda V.I., Usin V.A., Vuntesmeri V.S., Grechykh D.V. Electrodynamics and propagation of radio waves. Part 2. Radiation and propagation of electromagnetic waves: Textbook for university students / Edited by V.M. Shokalo and V.I. Pravda – Kharkiv: KNURE; Collegium, 2010 – 435 p.

7. Ilnytskyi L.Ya. Ultra-high frequency devices and antennas: Textbook/ Ilnytskyi L.Ya., Sibruk L.V., Shcherbina O.A. – Kyiv: NAU, 2013. – 188 p.

8. Dmitrenko V. P. Microwave Devices. Fundamentals of Theory: Monograph / Dmitrenko V. P., Bugrova T. I., Logachova L. M. – Zaporizhia: ZNTU, 2009. – 280 p.

7. Skrypnyk Yu. O. Modulation radiometric devices and systems of the microwave range: Textbook / Skrypnyk Yu. O., Manoilov V. P., Yanenko O. P. – Zhytomyr: ZHITI Publishing House, 2010. – 374 p.

9. Pozar, D.M. Microwave Engineering / David M. Pozar – 4th ed. – John Wiley & Sons, 2012. – 752 p.

10. Laverghetta, Thomas S. Microwaves and wireless simplified /Thomas S. Laverghetta. – 2nd ed. – Artech House Inc., 2005 – 288 p.

11. Hong Jia-Sheng. Microstrip filters for RF/microwave applications / Jia-Sheng Hong : 2nd ed. – Hoboken: John Wiley & Sons, Inc., 2011. – 655 p.

Information resources

I. Microwaves101.com (Microwave Encyclopedia) [Electronic resource] – Access mode:

https://www.microwaves101.com.

II. Microwave Journal [Electronic resource] – Access mode: http://www.microwavejournal.com.

Educational content

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

Lectures

No.	Lecture topic and list of main questions
	SECTION 1 FEATURES OF RADIO RECEIVING DEVICES MICROWAVE
1	Introduction
	Content and structure of the discipline "Design of microwave receiving devices" Content and structure of the discipline module. Scope and features of the design of radio engineering devices and systems in the microwave range. The concept of the microwave path of a radio engineering system. Its main elements and devices, their classification and graphical designation.
	Topic 1.1 **Block diagrams of microwave receivers**
2	**Features of microwave signal reception** Wireless communication. Main characteristics of the receiver. Frequency ranges of electromagnetic radiation. Features of the microwave range and its use. Classification of radio receiving devices. Self-study assignment: review the lecture material and study the literature sources – analyze the features of long transmission lines.
3	**Selection and development of a structural diagram of the receiver** Linear path diagram. Features of structural diagrams of different types of receivers. Self-study assignment: review the lecture material and study the literature sources, paying attention to the dependence of the electrical parameters of transmission line segments on their geometric dimensions.
	Topic 1.2. **Component base of microwave radio receiving devices**
4	**Active devices and passive devices of the microwave range** Active devices of the microwave range (bipolar and field-effect transistors, generator diodes, diodes for converters). Passive elements, features of the use of concentrated and distributed elements, resonators, methods and means of matching microwave path devices. Microwave integrated circuits. Self-study assignment: review the lecture material, study the literature sources, and learn the formulas for calculating the parameters of the main transmission lines in the microwave range.
	SECTION 2 **DESIGNING THE RADIO FREQUENCY PATH OF MICROWAVE RECEIVERS**
	Topic 2.1 **Designing devices for the input path of microwave receivers**
5	**The input path of an SHF receiver, features of its structure** The structure of the input circuit of a microwave receiver, design features, and component selection. Connection of devices and line segments with different active and wave impedances. Transformation of the active component of the input and output impedance of devices and the wave impedance of the transmission line to the nominal value. Calculation of the parameters and characteristics of the input path. Self-study assignment: review the lecture material, master the basic methods of matching microwave path components, learn how to use the Smith chart.

6	**Frequency-selective devices of the microwave range** Properties of transmission line segments. Microwave resonators. Main characteristics of a resonator. Equivalent circuit of a volumetric resonator with one coupling element. Resonators with distributed parameters on a transmission line segment. Resonator designs and parameters. Pass-through resonator with two coupling elements. Cascade connection of resonators. Methods for calculating and implementing microwave filters. Self-study assignment: review the lecture material, memorize the main types of transitions for transmission lines, and master the basic methods for calculating them.
7	**Ultra-high frequency amplifiers** Classification of microwave amplifiers. Component base. Features of calculating their main characteristics and design development. Special software for designing and modeling the operation of microwave amplifiers. Matching microwave amplifiers to the load. Non-reciprocal devices of the microwave path and their use. Designs of microwave band microstrip amplifiers. Self-study assignment: review the lecture material.
	Topic 2.2. **Frequency converters**
8	**Ultra-high frequency diode mixers** Types of microwave converters. General theoretical information. Methods and means of frequency conversion, element base, circuitry, and designs of microwave mixers. Self-study assignment: review the lecture material.
9	**Transistor frequency converters** Operation of field-effect and bipolar transistors in nonlinear mode, calculation of transistor operating modes, design of matching circuits and power supply circuits. Design features of transmission lines. Self-study assignment: review the lecture material.
10	**Heterodyne receivers for microwave devices** General information about radio receiver heterodyne receivers, basic requirements for devices of this class. Centimeter and millimeter wavelength heterodyne receivers, their active elements. Designing microwave generators. Methods for matching heterodyne receivers with input loads, use of non-reciprocal elements. Self-study assignment: review the lecture material, compare methods for designing different types of heterodyne receivers.
	SECTION 3 **DESIGN OF INTERMEDIATE FREQUENCY AND LOW FREQUENCY DEVICES**
	Topic 3.1 **Intermediate frequency amplifiers**
11	**Intermediate frequency path structure** Features of IF circuit design. General information about intermediate frequency amplifiers, requirements for IF selection. Component base and basic circuit solutions. Methods for calculating the main parameters of IF amplifiers. The concept of distributed selectivity of amplifiers. Self-study assignment: review the lecture material.
12	**Designing IF amplifiers with focused selectivity** Principles of designing IF amplifiers with focused selectivity. Methods for calculating LC filters with focused selectivity, computer-aided design methods, special software. Use of piezoelectric, piezoelectromechanical, and acoustoelectric filters. Self-study assignment: review the lecture material, explain the principles of operation of piezoelectric and acoustoelectric filters.

13	**Signal distortion in the IF path** Distortion of AM signals in the FM path. Distortion of FM signals in the FM path. Sources of noise in radio receiving devices. Noise characteristics of amplifiers. Basic principles of low-noise amplifier design. Self-study assignment: review the lecture material, explain the principle of low-noise amplifier design.
	Topic 3.2 **Detectors and amplitude limiters of the IF path**
14	**Amplitude detectors and amplitude limiters** Principles of amplitude detection, basic circuits of amplitude detectors, their application. Linear and quadratic detectors, their principle of operation, selection of active elements, and calculation of matching circuits. Amplitude limiters, their application and implementation. Self-study assignment: review the lecture material, explain the principle of operation of diode detectors and limiters, give examples of their application
15	**FM signal detectors and phase detectors** General information about frequency and phase detection methods, basic circuits of these types of detectors, features of use, advantages and disadvantages of the most common circuit solutions. Self-study assignment: review the lecture material, explain the principle of operation of frequency and phase modulators, and provide examples of their application.
	SECTION 4 **AUTOMATIC CONTROL OF MICROWAVE RECEIVERS**
	Topic 4.1 **Automatic gain control of microwave receivers**
16	**Designing an ARP system for microwave receiving devices** General information about ARP for radio receivers, manual and automatic gain control, calculation of steady-state and dynamic modes of the ARP system, types of ARP systems, selection and calculation of ARP circuit elements. Self-study assignment: review the lecture material, explain the principle of ARP operation.
	Topic 4.2 **Automatic frequency tuning systems**
17	**Designing automatic frequency tuning systems for microwave receivers** General information about AFC systems, calculation of continuous frequency systems, features of designing AFC heterodyne systems. Self-study assignment: review the lecture material, explain the principles of operation of automatic frequency tuning systems.
	Topic 4.3 **Sensitivity assessment of microwave receiving devices**
18	**Assessment of the effect of electromagnetic interference and noise on receiver sensitivity** General characteristics of interference and its classification. Electromagnetic noise and methods of its description. Noise from active and passive radio elements in the receiving path. Radio path noise factor. Receiver sensitivity assessment Self-study assignment: review the lecture material.

Practical classes

The main objectives of the practical classes are:

- to deepen and consolidate theoretical knowledge;

- mastering the principles of designing systems with distributed parameters;
- mastering methods for calculating the parameters of basic elements of the microwave path of telecommunications systems;
- acquiring skills in preparing graphic and text documentation accompanying microwave range products.

No.	Name of the lesson topic and list of main questions (list of teaching aids, references to literature, and assignments for independent study)
1	**Evaluation of receiver parameters** Self-study assignment: review the material from the practical lesson, master the methodology for evaluating the main parameters of a microwave range receiving device.
2	**Calculation of S-parameters of microwave devices** Self-study assignment: review the material from the practical class, learn how to calculate the main S-parameters of microwave receiver radio frequency path devices.
3	**Purpose and objectives of the preliminary design of a microwave receiving device** Self-study assignment: review the material from the practical class; develop technical specifications for the linear path of the microwave receiving device.
4	**Calculation of the preselector filter** Self-study assignment: review the material from the practical class; calculate the input circuit based on the output data of the
5	**Determination of the parameters of the microwave amplifier** Self-study assignment: review the material from the practical class, perform estimated calculations of the main characteristics of the MSHP in accordance with the assignment for the course work.
6	**Determination of the characteristics of the microwave frequency converter** Self-study assignment: review the material from the practical class; review the material from the practical class, perform evaluation calculations of the main characteristics of the frequency converter
7	**Methodology for calculating FZS on LC elements** Self-study assignment: review the material from the practical class and the main theoretical principles, learn how to calculate the main parameters of a concentrated selection filter.
8	**Method for calculating an intermediate frequency amplifier with FZS** Self-study assignment: review the material from the practical class, learn how to calculate an IF amplifier with a focused selection filter.
9	**Determining the distribution of gain and noise factor between radio receiver blocks** Self-study assignment: review the material from the practical class, learn to evaluate the distribution of the gain coefficient and noise coefficient in the linear path of a microwave receiver.

Laboratory classes

The main purpose of the laboratory classes:

- to test acquired theoretical knowledge in practice;
- acquiring skills in working with measuring instruments and equipment;
- mastering methods for measuring parameters and experimentally determining the main characteristics of microwave devices;
- acquiring skills in evaluating experimental data and drawing conclusions.

No. No	Name of laboratory work	Number of lecture hours
1	**Determination of the characteristics of a double frequency conversion receiver** Self-study assignment: prepare for the laboratory work using the material from the methodological recommendations and lectures 2 and 3; complete the experimental part of the work; write a report and prepare answers to the control questions.	3
2	**Investigation of irregularities in the input microwave path of a radio receiving device** Self-study assignment: prepare for the lab work using the material from the methodological recommendations and lecture 5; complete the experimental part of the work; write a report and prepare answers to the control questions.	3
3	**Determination of parameters of ferrite devices in the microwave path** Self-study assignment: prepare for the laboratory work using the material from the methodological recommendations and lecture 8; complete the experimental part of the work; write a report and prepare answers to the control questions.	3
4	**Investigation of the characteristics of a *pin* attenuator** Self-study assignment: prepare for the lab work using the material from the methodological recommendations and lecture 11; complete the experimental part of the work; write a report and prepare answers to the control questions.	3
5	**Investigation of the characteristics of a synchronous detector** Self-study assignment: prepare for the laboratory work using the material from the methodological recommendations and lecture 16; complete the experimental part of the work; write a report and prepare answers to the control questions.	3
6	**Analysis** of **the characteristics** of **a selective receiving device** Self-study assignment: prepare for the lab work using the material from the methodological recommendations and lectures 20; complete the experimental part of the work; write a report and prepare answers to the control questions.	3

6. Self-study by the student

Students complete the self-study assignments listed in section 5, as well as in the methodological recommendations for practical and laboratory classes in accordance with the academic calendar.

The approximate amount of self-study for students is given in the table in section 3 of the syllabus.

Policy and control

7. Academic discipline (educational component) policy

Rules for attending classes

Laboratory classes are compulsory to attend and complete assignments. If they are missed, they must be made up either during consultation hours or with other groups by prior agreement with the teacher.

If a student misses a lecture or practical class, they must complete the assigned tasks and attend an interview with the lecturer on the material covered in the missed class. The interview is conducted during scheduled consultation hours. Lecture and practical class materials with assignments are posted on Google Classroom, which students will have access to at the beginning of the semester.

Admission to laboratory classes and defense of the report on the work performed

Before laboratory work, students undergo an interview with the teacher, based on the results of which a decision is made on their admission to the work.

The defense of the report on the laboratory work is held during the next scheduled laboratory class. The grade that the student receives for the laboratory class consists of the points received during admission and defense. The number of points is indicated in the rating system (item 8).

Incentive and penalty points and academic integrity policy The most active students, especially those who perform excellently on assignments based on class materials, can receive 1 to 10 points toward their semester grade.

Penalty points are applied if a student submits someone else's work as their own. In this case, they must redo the assignment.

Deadline and retake policy

The dates for taking the exam and retakes are determined by the schedule approved by the dean of the faculty.

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

A student's rating consists of points (on a 100-point scale) that they receive for:

1. ongoing assessment of lecture material mastery (an average of 7 answers per student);
2. answers in practical classes (an average of 7 answers per student);
3. completion and defense of laboratory work;
4. modular test (MT);
5. answers on the exam.

The number of points and assessment criteria are determined as follows.

Rating (weighted) point system and assessment criteria

1. Monitoring of lecture material mastery

Weighting score – 2. The maximum number of points is equal to:

2 points x 5 = 10 points.

2. Work in practical classes

Weighting score – 2. The maximum number of points for all classes is:

2 points x 6 = 12 points. Assessment criteria:

– complete answer 2 points;

– satisfactory answer 1 point;

– unsatisfactory answer 0 points.

3. Laboratory work

Weighting – 5 points.

The maximum number of points for all laboratory work is 30 points.

5 points x 6 = 30 points.

For each laboratory assignment, the following are assessed:

a) preparedness for work:

– free command of theoretical material,

– availability of a prepared protocol;

(if unprepared, the student is not allowed to work and performs it by agreement with the teacher at another time);

b) completion of the laboratory work and preparation of the report in accordance with the requirements;

c) defense of the work.

4. Modular test (MT)

Weighting score – 8. Assessment criteria:

– complete answers to all test questions 8 points;

– correct answers to most of the test questions 4 … 7 points;

– incorrect answers to most of the test questions 0 … 3 points.

5. Penalty points for:

– not being admitted to laboratory work (unsatisfactory entrance test) -1 point;

– absence from laboratory class without a valid reason -1 point;

– late completion (more than a week late) of the MT -2 points. The total number of penalty points must not exceed RS = 10 points.

Conditions for a positive interim assessment

– To receive a "pass" on the first interim assessment (week 8), students must earn at least 8 points ("perfect" students earn 15 points).

– To receive a "pass" on the second interim assessment (week 14), students must earn at least 30 points ("perfect" students earn 60 points).

Calculation of the semester rating scale (R)

The size of the R scale is formed as the sum of the weighted scores of the control measures (R_C) during the semester and the weighted score of the exam (R_E): $R = R_C + R_E$.

The size of the starting scale is ..... R_C = 60 points. The size of the exam scale..... R_E = 40 points. The size of the rating scale..... R = 100 points.

The starting scale is determined by the sum of the maximum possible points for control measures (items 1-5) carried out during the semester: $R_C = 10 + 12 + 30 + 8 = 60$ points. Conditions for admission to the exam: you must have a rating of at least 30 points and all laboratory work must be completed.

Exam grade

For each question, the student can receive points according to the grading system:

– "excellent", complete answer (90% of the required information) 9-10 points;

– "Good," a fairly complete answer (75% of the required information) 7-8 points;

– "Satisfactory," incomplete answer (60% of the required information) 5-6 points;

– "sufficient," incomplete answer (50% of the required information) 3-4 points;

– "unsatisfactory," unsatisfactory answer (< 50% of the required information) 0-2 points.

Table of correspondence between rating points and university scale grades

Number of points	Grade
100-95	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)

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

Practical classes involving the use of software are held in computer classrooms (402-17, 404-17) with 18 workstations equipped with programs. Computers with the following minimum requirements: 32-bit (x86) or 64-bit (x64) processor with a clock speed of 1 GHz or faster*; 1 gigabyte (GB) of RAM (for 32-bit version) or 2 GB (for 64-bit version); 16 GB (for 32-bit version) or 20 GB (for 64-bit version) of available hard disk space; Graphics device with DirectX 9 support and WDDM 1.0 or later driver. Software:

– Smith V4.1 (conditionally free software, demo version available): https://www.fritz.dellsperger.net/smith.html;

– Cadence AWR Design Environment (PTF license, Igor Sikorsky KPI).

Methodological recommendations have been developed for practical training tasks and are available on Google Classroom.

Laboratory classes are held in the training laboratory (301-17) with models for performing the tasks specified in paragraph 5. Methodological recommendations for the tasks are posted on Google Classroom.

Work program for the academic discipline (syllabus):

Compiled by S. M. Peregudov;

Approved by the PRE Department (Minutes No. 06/2024 dated June 27, 2024).

Approved by the REF Methodological Commission (protocol No. 06/2024 dated 28.06.2024).