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

Radio Engineering Faculty
Radio Engineering Department

Automated Design of Microwave Antennas and Devices (PN-06)

Curriculum 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	*Information and Communication Radio Engineering*
Discipline status	*Compulsory professional training*
Form of study	*Full-time (day)* *Full-time (daytime) based on a junior specialist diploma*
Year of training, semester	*4th year, 8th semester (full-time)* *3rd year, 6th semester (based on a junior specialist diploma)*
Scope of the discipline	*Total: 4 ECTS credits/120 hours* *Lectures: 20 hours* *Laboratory classes: 40 hours* *Self-study by students: 60 hours.*
Semester control/control measures	*Modular test, homework test, credit* *Ongoing assessment/defense of laboratory work*
Class schedule	*Lectures (once a week starting from week 1* *Laboratory work (once a week, preferably after the lecture)*
Language of instruction	*Ukrainian*
Information about the course supervisor/teachers	*Lecturer: Ph.D., Associate Professor of the Radio Engineering Department* *Serhii Martyniuk (Martyniuk.Sergii@LLL.kpi.ua),* *+38 066 298 37 00* *Laboratory work: Assistant Professor, Radio Engineering Department* *Yevgen Saratov*
Course location	*The course is hosted on the Sikorsky distance learning platform:* *https://do.ipo.kpi.ua/course/view.php?id=8359*

Curriculum

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

The academic discipline "Automated Design of Antennas and Microwave Devices (PN-06)" is one of the compulsory disciplines of professional training, which provides theoretical knowledge and practical skills in modern methods of computer design necessary for a radio engineer. This subject is the final one in a set of bachelor's degree courses that study antennas (PN-11) and microwave devices (PN-10), allowing students to move from theory to practical design at a modern level, which is why it is studied immediately before writing a bachelor's thesis.

After mastering the discipline, students should demonstrate the following learning outcomes:

1) Knowledge:

- The main tasks and capabilities of automated design systems;
- Modern requirements for automated design systems for antennas and microwave devices;
- Universal numerical methods for solving Maxwell's equations;
- Problem formulation in the design of antennas and microwave devices;
- Principles of designing the main types of antennas and microwave devices.

2) Skills:

- Apply modern automated design systems for antennas and microwave devices;
- Create accurate three-dimensional electrodynamic models of antennas and microwave devices;
- Perform electrodynamic calculations and adjust the geometric parameters of antennas and microwave devices to achieve the required characteristics.

3) Experience: based on the acquired knowledge and skills, the specialist will be able to apply automated design systems in practice to calculate the characteristics of antennas and microwave devices, perform multi-parameter design synthesis of complex electrodynamic structures.

In accordance with the professional educational program (PEP) of the first "bachelor's" level of higher education, after mastering the academic discipline, students should acquire **the** following program **competencies**:

General competencies (GC)

GC07 – Ability to learn and master modern knowledge.

Professional competencies (PC)

PC08 – Readiness to promote the implementation of promising technologies and standards.

PC16 – Ability to calculate the basic parameters of various types of antennas and microwave devices, select the most effective antennas and microwave devices for radio engineering systems with specified operating modes and functional characteristics, experimentally study the characteristics and devices of microwave antennas of various designs and frequency ranges.

PC17 – Ability to apply modern CAD systems for the design, structural synthesis, and highly efficient multi-parameter optimization of antennas, active and passive microwave devices.

Program learning results (PLR)

According to the first "bachelor's" level of higher education, as a result of mastering the academic discipline, students must demonstrate the following **program learning results**:

PLR15 – Application of understanding of means of automation of design and technical operation of telecommunications and radio engineering systems in professional activity.

PLR24 – Perform calculations, numerical optimization, and design of antennas and microwave devices, active microwave receiving systems using modern CAD systems.

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

In the structural and logical scheme of the educational and professional training program for specialists of the first (bachelor's) level of higher education, the academic discipline "Automated Design of Antennas and Microwave Devices" is included in the list of compulsory professional disciplines aimed at forming the professional competencies of specialists.

Prerequisites: the academic discipline is specialized and is taught in the 8th semester of the 4th year of the first (bachelor's) level of higher education programs. To master this discipline, knowledge of the following disciplines is required: "Antennas," "Microwave Devices."

Post-requisites: – the knowledge gained in this discipline will enable students to complete a bachelor's thesis related to antennas and microwave devices.

It is an integral part of the first (bachelor's) level of higher education.

3. Contents of the academic discipline

Section 1. Basic principles of engineering design

Topic 1.1. RSA

Topic 1.2. Basic principles of modern design. The concept of innovation.

Section 2. Basic stages of design. Product life cycle.

Topic 2.1. Basic definitions.

Topic 2.2. Marketing research in the industry. The main goal of the marketing research stage

Topic 2.3. Development of technical specifications. Structure of technical specifications. Main tasks in forming technical specifications.

Topic 2.4. Technical proposal.

Topic 2.5. Preliminary design.

Topic 2.6. Technical project.

Topic 2.7. Prototype. Design documentation. Manufacturing. Testing.

Topic 2.8. Preparation for serial production.

Topic 2.9. Serial manufacturing.

Topic 2.10. Product support.

Topic 2.11. Disposal and recycling.

Section 3. Basic design methods.

Topic 3.1. Manual design of antennas and microwave devices. Main advantages and disadvantages.

Topic 3.2. Automatic design of antennas and microwave devices. Prospects and problems of automatic design.

Topic 3.3. Automated design of antennas and microwave devices. Main advantages, disadvantages, and directions for development.

Section 4. Main methods for solving problems in electrodynamics.

Topic 4.1. Formulation of problems in electrodynamics. Internal and external problems.

Topic 4.2. Approximate methods for solving problems in electrodynamics.

Topic 4.3. Directivity diagram of a symmetrical vibrator.

Topic 4.4. Physical optics method for calculating mirror antennas.

Topic 4.5. Universal methods for solving electrodynamic problems used to create modern automated design systems. Finite difference method in the time domain.

Section 6. Overview of the capabilities of modern automated design systems for antennas and microwave devices.

Section 7. Automated design of microwave devices.

Topic 7.1. Types of microwave transmission lines.

Topic 7.2. Content of generalized scattering matrix coefficients.

Topic 7.3. Microstrip transmission line. Fundamentals of automated design.

Topic 7.4. Waveguides. Fundamentals of automated design.

Topic 7.5. Design of a Wilkinson power divider.

Topic 7.6. Design of a coaxial-waveguide transition.

Modular test (MT1).

Section 8. Automated antenna design.

Topic 8.1. Basic antenna parameters.

Topic 8.2. Designing microstrip antennas and antenna arrays.

Topic 8.3. Design of wave channel type vibrator antennas.

Topic 8.4. Design of horn antennas.

Topic 8.5. Design of circularly polarized vibrator turnstile antennas.

Topic 8.6. Designing a biconical antenna.

Topic 8.7. Designing Vivaldi ultra-wideband antennas.

Final Test

4. Teaching materials and resources

Basic and additional literature (hereinafter referred to as literature) is used to prepare for lectures, laboratory classes, modular tests, homework, and self-study. The literature required for mastering the

discipline is studied by students independently using Internet resources, on the Sikorsky distance learning platform using the Moodle platform. In the context of distance learning, students can use literature available in electronic form on university and external media.

Basic literature

1. Vasilenko, D. O. Ultra-high frequency devices. Lecture notes [Electronic resource]: textbook for bachelor's degree students in the educational program "Information and Communication Radio Engineering" in the specialty 172 "Electronic Communications and Radio Engineering" / D. O. Vasilenko; Igor Sikorsky KPI. – Electronic text data (1 file: 5.67 MB). – Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2023. – 182 p. – Title from the screen.
2. Kupriy O.M. Antennas. Lecture notes, 2025 250 p.

Additional literature

1. Pozar D.M. Microwave engineering.4thedition. Wiley, 2021, 656 p.
2. Balanis C.A. Antenna Theory: Analysis and Design.4thedition, Wiley, 2016, 1104 p.

Educational content

5. Methods of mastering the academic discipline (educational component)

Ten lectures and ten laboratory classes are planned for the study of the academic discipline, during which students must complete modular tests and defend their laboratory work after completion.

Lectures

No.	Lecture topic and list of key questions
1	RSD. Basic principles of modern design. The concept of innovation.
2	Main stages of design (part 1). Product life cycle. Key definitions. Marketing research in the industry. Development of technical specifications. Structure of technical specifications. Key tasks in developing technical specifications.
3	Main stages of design (part 2). Technical proposal. Preliminary design. Technical project. Prototype. Design documentation. Manufacturing. Testing. Preparation for serial production. Serial manufacturing. Product support. Disposal and recycling.
4	Basic design methods. Manual design of antennas and microwave devices. Main advantages and disadvantages. Automatic design of antennas and microwave devices. Prospects and problems of automatic design. Automated design of antennas and microwave devices. Main advantages, disadvantages, and areas for development.
5	Basic methods of solving problems in electrodynamics. Problem formulation in electrodynamics. Internal and external problems. Approximate methods for solving problems in electrodynamics.

	Directionality diagram of a symmetrical vibrator. Physical optics method for calculating mirror antennas.
6	Universal methods for solving electrodynamic problems used to create modern automated design systems. Finite difference method in the time domain.
7	Overview of the capabilities of modern automated antenna and microwave device design systems.
8	Automated design of microwave devices. Types of microwave transmission lines. Contents of generalized scattering matrix coefficients. Microstrip transmission line. Fundamentals of automated design.
9	Automated antenna design (part 1). Basic antenna parameters. Design of microstrip radiators.
10	Automated antenna design (part 2). Design of horn antennas. Design of vibrator antennas.

Laboratory classes (offline)

No	Name of the class topic and list of main questions
1	**Laboratory work No. 1.** **Overview of the software package.** Installation of the student version of the software package. Overview of the main menus and interfaces.
2	**Laboratory work No. 2.** **Designing a coaxial-waveguide transition.** Creating three-dimensional models of coaxial-wave guide transitions. Calculating the results of the scattering matrix.
3	**Laboratory work No. 3.** **Designing a horn antenna.** Creation of three-dimensional models of horn antennas. Calculation of matching and radiation results.
4	**Laboratory work No. 4.** Designing a Wilkinson power divider. Creating a three-dimensional model of a Wilkinson microstrip power divider. Optimizing geometric dimensions. Calculating the results of the scattering matrix
5	**Laboratory work No. 5** **Designing microstrip radiators.** Creation of a three-dimensional model of microstrip radiators and antenna arrays based on them. Optimization of geometric dimensions. Calculation of matching and radiation

	characteristics.
6	**Laboratory work No. 6.** **Designing a wave channel type vibrator antenna.** Creation of a three-dimensional model of a wave channel type vibrator antenna. Optimization of geometric dimensions. Calculation of matching and radiation characteristics.
7	**Laboratory work No. 7.** **Designing a circularly polarized vibrator turnstile antenna.** Creation of a three-dimensional model of a vibrator turnstile antenna with circular polarization. Optimization of geometric dimensions. Calculation of matching and radiation characteristics.
8	**Laboratory work No. 8.** **Designing a biconical antenna.** Creation of a three-dimensional model of a biconical antenna. Optimization of geometric dimensions. Calculation of matching and radiation characteristics.
9	**Laboratory work No. 9.** **Designing a Vivaldi ultra-wideband antenna.** Creation of a three-dimensional model of a Vivaldi ultra-wideband antenna. Optimization of geometric dimensions. Calculation of matching and radiation characteristics.
10	**Laboratory work No. 10. (summarizing)** Review (demonstration) of the extended capabilities of the software package. Defense of previous laboratory work. Working off debts, etc.

Distance learning platform

For better assimilation of the material of the academic discipline during the period of distance learning, e-mail, the Sikorsky distance learning platform using the Moodle platform, and the Google Meet and ZOOM platforms for online meetings are used, with the help of which:

- simplify the placement of methodological recommendations, teaching materials, literature, etc.;
- feedback is provided to students on educational tasks and the content of the academic discipline;
- completed assignments are checked and evaluated;
- keeping track of students' progress in the course, adherence to the schedule for submitting educational/individual assignments, and their assessment.

6. Self-study of the student (SS)

Self-study includes: preparation for laboratory classes; self-assessment of acquired knowledge; study of recommended sources and literature; preparation for modular tests; preparation for exams, etc. ISW involves working through certain theoretical issues, which are set during lectures.

Preparation for lectures

To prepare for lectures, students must study the planned basic and supplementary literature and recommended sources. Before lectures, students must review the theoretical material that was presented

in previous lectures or assigned in advance. Students are allocated approximately 1 hour for each topic of the discipline.

Preparation for laboratory classes

Students must prepare for laboratory classes in advance. Homework assignments for laboratory classes are provided in the relevant methodological guide. Homework must be completed before the start of the relevant laboratory class.

Modular test (MT)

Up to 2 hours are allocated for preparation for the MT. A list of questions for preparation for the MT is provided in Appendix B.

Home control work (HCW)

In order to better assimilate the course material, a homework assignment is planned, which is presented in the form of an analysis and calculation of a real microwave structure. To prepare for the homework assignment, students should use the recommended literature, lecture notes, and methodological guidelines. Individual assignments for the homework assignment are given by the instructor, who also sets deadlines for its completion. The homework assignment includes:

1. Approximate engineering calculation of the geometry of the Wilkinson microstrip power divider.

Test

The test is conducted during the semester control period (test week), at the end of the academic semester after students have written their modular tests and home control work, based on the results of the rating points earned during the semester or by decision of the teacher, who writes the test work. Six hours of independent study are allocated for preparation for the credit. A list of questions for preparation for the credit is provided in Appendix A. During the period of distance learning, the credit can be taken according to the class schedule using Moodle and the Google Meet and ZOOM online meeting platforms.

Policy and control

7. Academic discipline (educational component) policy

Class attendance

Attendance at lectures and laboratory classes is in accordance with the Regulations on the Organization of the Educational Process at Igor Sikorsky KPI. At least once every two weeks, the instructor holds consultations on various issues related to the credit module. During consultations, the instructor can provide assistance in studying the material of classes that students have missed for various reasons and must master on their own.

In any case, students are encouraged to attend all types of classes, as they cover theoretical material and develop the skills necessary to complete homework assignments and module tests.

Rules for completing assignments

When studying the material of the course "Automated Design of Antennas and Microwave Devices," students:

1) during lectures:

- complete modular tests using the Sikorsky platform;

2) in laboratory classes:

- prepare homework assignments based on their own tasks using sources and literature;
- save the results obtained for further preparation of reports on the results of laboratory work.

Tasks and materials for express tests/creative assignments are developed by the teacher based on the course material and submitted in Google Classroom or in another form.

Rules of conduct in class

When studying the material of the academic discipline "Automated Design of Antennas and Microwave Devices," students listen attentively to the lecturer during lectures and, if necessary, write down important information, periodically complete express tests in written form (within 5–10 minutes) and modular tests (MTR) using the Sikorsky platform. Dialogue between students and the teacher in the form of questions and answers is allowed.

During laboratory classes, students complete mandatory assignments. Student work involves participation in interactive forms of teaching (answering questions posed by the lecturer or students). Each student is expected to be prepared for all questions in the laboratory class, supplement the answers of other students, and express their own opinion during discussions of issues that arise while completing tasks. Students are allowed to use their own written notes and summaries. The use of laptops, tablets, and phones for educational purposes is permitted. At the same time, students should try to express their own opinions rather than read out other people's texts. The teacher critically analyzes the presentations, comments on mistakes, and moderates discussions between students.

The topics of lectures and laboratory classes are covered in the course syllabus, which is available on the Electronic Campus, the website of the Radio Engineering Department, and the Sikorsky platform (Moodle, Google Classroom).

Incentive and penalty points

Bonus points. Students are encouraged to independently study topics that are not included as mandatory in the course of this subject (use of such technology when performing laboratory work +5 points maximum).

Student participation in solving problems that many students encounter when performing laboratory tasks is encouraged (+1 point for solving one problem).

Students are encouraged to create new teaching materials (new test questions, suggestions for improvement, etc.) and to find errors in existing teaching materials (+1 point for each suggestion/error found).

Missed tests

The result for a student who did not attend the assessment is zero. If a student misses an assessment for a valid reason, they are given the opportunity to complete it (do the lab work) in the presence of the instructor. If the absence was without a valid reason, the issue of making up the assessment is decided with the instructor in consultation with the department management. A missed test is not counted regardless of the reason for the absence; in this case, the student receives a "did not show up" mark, and if they are eligible to take the test, they must take it during an additional session.

Announcement of test results

The defense of the completed section of the HCW takes the form of an interview with the teacher. During the defense, the student must be able to explain the results obtained and answer the main theoretical questions on the topics of the sections. The results of the defense are announced to the student in their presence or remotely, accompanied by specific comments and remarks regarding errors (remote communication via Discord, Zoom, or Telegram with video and audio).

The results for the completed laboratory work are posted after its completion and defense.

Academic integrity

The policy and principles of academic integrity are defined in Section 3 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute." For more details, see: https://kpi.ua/code.

Standards of ethical behavior

The standards of ethical conduct for students and employees are defined in Section 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute." For more details, please visit: https://kpi.ua/code.

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

Ongoing assessment

Ongoing assessment is carried out during classes and aims to check the level of student preparation for classes. During laboratory classes, students are surveyed on topics related to the subject. Modular tests are conducted once per semester to assess residual knowledge of the most important sections of the academic discipline. Express control in the form of tests is conducted after each lecture.

Calendar control

Calendar control is carried out twice per semester to monitor the current status of syllabus requirements. There are two possible results of calendar control: certified (c) and not certified (n/c). The result depends on the number of points scored at the time of calendar control in accordance with the requirements of Igor Sikorsky KPI.

Semester control

Semester control is considered a credit.

Assessment and control measures

A student's grade for a course consists of points earned for:

1) assessment of residual knowledge by completing express test tasks based on lecture materials from using tests on the Sikorsky platform;

2) work in 10 laboratory classes;

3) a modular test

4) home control work

Information on the above points is summarized in the table

No.	Assessment	Maximum score	**Number**	**Total**
2	Work in laboratory classes	10	8	80
3.	Modular test (MT)	10	1	10
4.	Home control work (HCW)	10	1	10
5	Bonuses	5	1	5
6.	Credit (if you did not score 60)	20	1	20
	Total maximum without bonuses			10
	Total maximum with bonuses			105

In order to receive the highest rating, students must actively participate in laboratory classes, actively supplement the answers of other students, clearly and logically express their own position on discussion issues, and complete MT and express controls in a timely manner. Students are given a one-time opportunity to complete MT and express controls.

The following factors lead to a decrease in a student's rating: failure to complete coursework and quick tests; inadequate preparation and poor quality of laboratory work; inaccuracies, incompleteness, errors in answers, or reliance on unreliable sources.

The instructor evaluates the student's work in each laboratory class and assigns grades for the work and results of the MT and express controls to the "Current Control" module of the Electronic Campus. The results of the first and second calendar controls depend on the student's current rating and are entered by the teacher into the "Calendar Control" module of the Electronic Campus in the eighth and sixteenth weeks of study, respectively (see Appendix C).

The student may appeal the teacher's assessment by submitting a complaint to the teacher no later than the day after the student has been informed of the assessment given by the teacher. The complaint will be considered in accordance with the procedures established by the university.

Conditions for admission to semester control

A minimum of 40 points and a grade of at least "sufficient" on the coursework.

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

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)

The recommended list of tasks for semester control (test) is provided in Appendix A to the syllabus.

Recommendations for students

During lectures, students should write down key terms and concepts, note the main events of the topic, and summarize the generalizations and conclusions made by the instructor. This material will be useful when preparing for laboratory classes, MT, HCW, and express tests.

When preparing for a laboratory class, students must study the lecture material on a specific topic and, preferably, familiarize themselves with additional resources on the Internet. If questions arise or unclear points are identified, they should be discussed with the lecturer. During the lab session, each student should try to master the practical skills that can be mastered on their own. Students should not refuse to answer the instructor's questions. Even if a student does not know the answer, it is advisable to try to answer, express their opinion based on their own knowledge, experience, the logic of the question, etc.

However, it is important to remember that not knowing the subject matter is a significant shortcoming in a student's work and will negatively affect their overall grade. A responsible attitude toward preparing for each lab session allows students not only to properly master the material, but also to save effort when taking semester exams.

Students may be credited for a course topic if they have certificates of completion of distance or online courses on the relevant subject.

Distance learning

Synchronous and asynchronous distance learning is possible using video conferencing platforms (Google Meet, Zoom, etc.) and the Sikorsky distance learning educational platform (Moodle).

Inclusive learning

Inclusive learning is permitted.

Work program for the academic discipline (syllabus):

Prepared by: Associate Professor of the RED, Serhii Martyniuk.

Approved by: RED (Minutes No. 06/2025 dated 06/17/2025).

Approved by: REF Methodological Council (Minutes No. 06/2025 dated 26.06.2025).

10. Appendix A

Semester control is carried out by means of a final test. The test consists of answering three questions, which are included in the test ticket and approved at a meeting of the department. Two questions are theoretical, the third question is practical and requires the configuration of real equipment to provide a complete answer.

A sample test paper is provided below.

Sample exam ticket

NATIONAL TECHNICAL UNIVERSITY OF UKRAINE
"KYIV POLYTECHNIC INSTITUTE NAMED AFTER IGOR SIKORSKY"

Level of higher education **first (bachelor's)**
(degree name)

Specialty *G5 Electronics, electronic communications, instrument engineering, and radio engineering*
(code and name of the field of study)

Educational program ***Information and Communication Radio Engineering***
(code and name of specialty)

Academic discipline ***Automated Design of Antennas and Microwave Devices***
(name)

TEST SHEET No. ____

1 *Assignment to create a three-dimensional electrodynamic model of an antenna or microwave device in a software package*

Approved at a meeting of the Department ***of Radio Engineering***
(name of department)

Minutes No. _____ dated " " 202

Head of the Radio Engineering Department
(signature) (First name LAST NAME)

The final test includes tasks on the practical design of an antenna or microwave device.

Practical task

The practical assignment requires students to demonstrate their skills in using the software package for electrodynamic analysis of antennas or microwave devices studied during the semester.

- A working, correct three-dimensional electrodynamic model of an SHF device or antenna — 15–20 points;
- a working model obtained contains minor errors that may slightly affect the accuracy of calculations — 9–14 points;
- a partially working model with significant errors — 2–8 points;
- task not completed — 0 points.

Types of antennas and microwave devices for forming exam questions

1. Microstrip antennas with rectangular or circular radiating resonators, where the operating frequency range or type of microstrip substrate may vary depending on the variant.
2. Coaxial-waveguide transition.
3. Pyramidal horn.
4. Conical horn.
5. Microstrip line.
6. Symmetrical vibrator.
7. Four-element vibrator antenna array.

The sum of points is converted into a grade according to the table:

Semester or credit points	**Credit grade**
95–100	Excellent
85–94	Very good
75–84	good
65–74	satisfactory
60–64	sufficient
less than 60	unsatisfactory
Not counted HCW, not defended all laboratory work	Not admitted

11. Appendix B

MODULAR CONTROL WORK

in the academic discipline
AUTOMATED DESIGN OF ANTENNAS AND MICROWAVE DEVICES
first (bachelor's) level of higher education, bachelor's degree

form of study ***full-time***

After completing the course of lectures, students are given a one-time opportunity to write a midterm exam, which consists of test questions. There is one midterm exam per semester. The midterm exam is graded on a scale of 1 to 10 points.

Assignments for the MT

The test tasks for the MT are formed from the following blocks:

1. Selecting the waveguide size for a given frequency range.
2. Types of losses in a microstrip line.
3. Basic types of coaxial-waveguide transitions.
4. Determination of the main parameters of antennas (directivity pattern, gain coefficient, standing wave ratio).
5. Contents of the scattering matrix coefficients.

12. Appendix C

RATING SYSTEM FOR ASSESSING LEARNING OUTCOMES

in the academic discipline
AUTOMATED DESIGN OF ANTENNAS AND MICROWAVE DEVICES
first (bachelor's) level of higher education, bachelor's degree

form of study ***full-time***

1. The student's grade for the academic discipline consists of points awarded for:

- work in 10 laboratory classes;
- modular test (MT);
- home control work (HCW).

Distribution of study time by type of class and assignment from the credit module according to the working curriculum:

Semester	Teaching time		Distribution of teaching hours			Control measures		
	Credits	academic hours	Lectures	Lab work	SS	MT	HCW	Semester assessment
4	4	60	20	40	60	1	1	Credit

The student's rating for the credit module consists of points awarded for:

1) Completion and defense of 8 laboratory works, maximum number of points — 80.

3) Completion of a module control work (MCW), maximum number of points — 10.

4) Completion and defense of a home control work (HCW), maximum number of points — 10.

5) Bonus points — maximum number of points — 5.

Rating point system

1. Laboratory work

1.1. Completion of homework on laboratory work — 2 points (availability of a homework file or its presence in the report when performing offline).

2.2. Completion of laboratory work.

— When performing the work in person: 4 points for all completed and working tasks. Confirmation of completion is provided by screenshots in the report.

2.3. Defense of laboratory work (there is an option to defend through testing):

— complete mastery of the material during defense (at least 90% of the required information) — 4 points;

— partial mastery of the material (at least 80%) — 3 points;

– partial mastery of the material (at least 70%) — 2 points;

– satisfactory mastery of the material (at least 60%) — 1 point;

– unsatisfactory mastery of the material (less than 60%) — 0 points;

The laboratory work is considered successfully defended if the student scores 6 points out of a possible 10. If the student scores less than 6 points, the work must be defended again.

3. Modular test (MT)

The MT is conducted after seven lectures by means of testing in the Moodle system. For more details, see Appendix B. The maximum number of points for the MT is 10 points.

3. Home control work (HCW)

The correctness of the calculations, the presentation of the work, and the mastery of the material during the defense are evaluated. The maximum score is 10 points.

5. Bonus and penalty points

Penalty points (not taken into account during wartime):

– late defense of laboratory work — −1 point for each;

– late submission of HCW for review — up to −10 points (−1 point for each day of delay).

The maximum number of points is 100. The acceptance of the final coursework and the defense of all laboratory work are mandatory conditions for admission to the exam.

Students who have earned more than 60 points during the semester are entitled to receive an "automatic" grade; points are converted into grades according to the table.

Students who have not earned 40 points during the semester are considered to have failed to complete the course load and are not admitted to the final exam.

Students who have earned less than 60 points but more than 40, as well as those who want to improve their grade, take the exam. In this case, points for passing the exam are added to the HCW points, and this rating is final.