



STATISTICAL RADIO ENGINEERING (PN-09)

Curriculum of the academic discipline (Syllabus)

Course details

Level of higher education	<i>First (bachelor's)</i>
Field of knowledge	<i>17 Electronics, Automation, and Electronic Communications</i>
Special	<i>172 Electronic Communications and Radio Engineering</i>
Educational program	<i>Information and Communication Radioengineering</i>
Status of discipline	<i>Compulsory for professional training</i>
Form of study	<i>Full-time (day)</i>
Year of training, semester	<i>3rd year, 5th semester</i>
Scope of the discipline	<i>Total: 4 ECTS credits / 120 hours Lectures: 18 hours Laboratory classes: 18 hours Practical classes: 18 hours Self-study by students (SS): 66 hours.</i>
Semester control/control measures	<i>Modular test, home test, credit Ongoing assessment/defense of laboratory work</i>
Class schedule	<i>Lectures (once every two weeks starting from week 1 Laboratory work (once every two weeks, preferably after the lecture)</i>
Language of instruction	<i>Ukrainian</i>
Information about the course supervisor/teachers	<i>Lecturer: Ph.D., Associate Professor of the Radioengineering Department Sergii Litvintsev (Litvintsev.Sergii@LLL.kpi.ua), +38 094 821 37 72 Laboratory work: Ph.D., Associate Professor, Radioengineering Department Sergii Litvintsev Ph.D., Associate Professor, Radioengineering Department Elena Guseva Practical classes: Ph.D., Associate Professor, Radioengineering Department Elena Guseva</i>
Course location	<i>The course is available on the Sikorsky distance learning platform: https://do.ipu.kpi.ua/course/view.php?id=2529</i>

Curriculum

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

The academic discipline "Statistical Radio Engineering" is one of the basic disciplines that any radio engineer needs to know. This subject is the foundation on which all subsequent knowledge and skills necessary for working with random signals and the results of any measurements are built.

After completing the course, students should demonstrate the following learning outcomes:

1) *Knowledge*: random event, random variable, integral distribution function, probability density, moments, mathematical expectation, variance, random process, moment functions, characteristic function, covariance and correlation functions, spectral power density, white noise, Gaussian normal process, internal noise, optimal filtering.

2) *Skills*: perform statistical processing of measurement results, determine the parameters of a random process, perform correlation analysis of signals and spectral analysis of random signals, take into account the effect of various internal noises on the useful signal, be able to determine a random signal at the output of linear and nonlinear circuits, and create an optimal filter in the presence of noise of various nature.

3) *Experience*: freely use statistical tools to process measurement results and the theory of statistical processing when calculating random signals against a background of various noises.

In accordance with the professional educational programs (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)

GC-2 – Ability to apply knowledge in practical situations.

GC-7 – Ability to learn and master modern knowledge.

GC-8 – Ability to identify, pose, and solve problems.

Professional competencies (PC)

PC-3 – Ability to use basic methods, techniques, and means of obtaining, transmitting, processing, and storing information.

PC-4 – Ability to perform computer modeling of devices, systems, and processes using universal application software packages.

PC-6 – Ability to perform instrumental measurements in information and telecommunications networks, telecommunications and radio engineering systems.

PC-15 – Ability to perform calculations in the process of designing structures and means of information and telecommunication networks, telecommunication and radio engineering systems, in accordance with technical specifications using both standard and independently developed methods, techniques, and software tools for design automation.

Program learning results (PLR)

According to the first bachelor's degree level higher education program, upon completion of the course, students should demonstrate **the following program learning results**:

PRL1 – analyze, argue, and make decisions when solving specialized tasks and practical problems of statistical radio engineering, which are characterized by complexity and incomplete certainty of conditions;

- PRL4 – explain the results obtained as a result of radio engineering measurements in terms of their significance and relate them to the relevant theory;
- PLR7 – competently apply the terminology of the field of statistical radio engineering;
- PLR8 – describe the principles and procedures used in telecommunications systems, information and telecommunications networks, and radio engineering;
- PLR9 – analyze and evaluate the effectiveness of methods for designing information and telecommunications networks, telecommunications and radio engineering systems;
- PLR13 – apply fundamental and applied sciences to analyze and develop processes occurring in telecommunications and radio engineering systems;
- PLR15 – apply understanding of automation tools for the design and technical operation of telecommunications and radio engineering systems in professional activities;
- PLR16 – apply understanding of the basics of metrology and standardization in the field of telecommunications and radio engineering in professional activities;
- PLR18 – find, evaluate, and use information from various sources necessary for solving professional tasks, including reproducing information through electronic search;
- PLR20 – 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)

In the structural-logical scheme of the professional educational program for training specialists of the first (bachelor's) level of higher education, the academic discipline "Statistical Radio Engineering" is included in the list of compulsory disciplines aimed at forming the professional competencies of a specialist.

Prerequisites: the academic discipline is specialized and is taught in the 3rd year, 5th semester of the educational program "Information and Communication Radio Engineering" of the first (bachelor's) level of higher education. To master this discipline, knowledge of the following disciplines is required: "Mathematical Analysis," "Fundamentals of Circuit Theory," "Fundamentals of Electronic Communications and Radio Engineering. Part 2. Signals and Processes in Radio Engineering," "Processes in Linear Electronic Circuits."

Post-requisites: – knowledge gained in this discipline will ensure mastery of the following disciplines: "Digital Signal Processing," "Electromagnetic Compatibility," "Signal Generation, Modulation, and Coding."

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

3. Content of the academic discipline

Chapter 1. Random events and magnitudes

- Topic 1.1. RSA
- Topic 1.2. Random events
- Topic 1.3. Terminology
- Topic 1.4. Four probability theorems
- Topic 1.5. Random variable
- Topic 1.6. Integral distribution function
- Topic 1.7. Probability density
- Topic 1.8. Moments, mathematical expectation, and variance

Section 2. Random Process and Its Parameters

- Topic 2.1. Random process
- Topic 2.2. One-dimensional distribution function
- Topic 2.3. One-dimensional probability density
- Topic 2.4. Moment functions and their properties
- Topic 2.5. Characteristic function and its properties

Section 3. Multidimensionality, correlation, ergodicity

- Topic 3.1. Two-dimensional and multidimensional probability density
- Topic 3.2. The concept of correlation
- Topic 3.3. Stationarity
- Topic 3.4. Ergodicity
- Topic 3.5. Physical meaning of moments of ergodic random processes

Modular test on sections 1-3

Section 4. Correlation analysis

- Topic 4.1. ACF of a deterministic signal
- Topic 4.2. VCF of a deterministic signal
- Topic 4.3. Mutual energy spectrum of signals
- Topic 4.4. Covariance and correlation functions
- Topic 4.5. VCF of random processes
- Topic 4.6. Correlation coefficient
- Topic 4.7. Correlation interval
- Topic 4.8. Energy spectrum
- Topic 4.9. Spectral power density
- Topic 4.10. Effective spectrum width

Section 5. Spectral Analysis

- Topic 5.1. Wiener-Khinchin formulas
- Topic 5.2. White noise
- Topic 5.3. Experimental determination of statistical characteristics m_1 , m_2 , dispersion
- Topic 5.4. Characteristics of harmonic voltage with random phase
- Topic 5.5. Experimental determination of statistical characteristics W
- Topic 5.6. VCF of signals
- Topic 5.7. Mutual energy spectrum of signals and its properties
- Topic 5.8. Correlation receiver
- Topic 5.9. Coherent receiver

Section 6. Gaussian process and internal noise

- Topic 6.1. Gaussian normal process and its properties
- Topic 6.2. Thermal noise
- Topic 6.3. Nyquist's theorem
- Topic 6.4. Generalized Nyquist theorem
- Topic 6.5. Thermal noise of an oscillating circuit
- Topic 6.6. Fractional noise
- Topic 6.7. Flicker noise
- Topic 6.8. Methods of equivalent representation of noise

Modular test on sections 4-6

Section 7. Random signals and linear circuits

- Topic 7.1. Passage of random signals through linear circuits. Normalization effect
- Topic 7.2. The stability property of the normal law
- Topic 7.3. Lyapunov's central limit theorem
- Topic 7.4. Spectral correlation characteristics of a random signal at the output of a linear circuit
- Topic 7.5. Spectral method
- Topic 7.6. Time method
- Topic 7.7. Differentiation of a random signal
- Topic 7.8. Integration of a random signal

Section 8. Random signals and nonlinear circuits

- Topic 8.1. What is a nonlinear inertia-free transducer (NIT)?
- Topic 8.2. One-dimensional W at the output of the NIT
- Topic 8.3. Linear detector as an example
- Topic 8.4. Moments and characteristic function at the output of the NIT
- Topic 8.5. Two-dimensional W at the output of the NIT
- Topic 8.6. Spectral correlation characteristics of a random signal at the output of an NIT
- Topic 8.7. Direct method for determining the ACF
- Topic 8.8. Characteristic function method (Reiss method)
- Topic 8.9. Derivative method (Price method)

Section 9. Optimal filtering

- Topic 9.1. Amplitude detection of Gaussian narrowband noise
- Topic 9.2. Linear detector
- Topic 9.3. Quadratic detector
- Topic 9.4. Frequency detector
- Topic 9.5. Optimal filtering
- Topic 9.6. Optimal filter against white noise
- Topic 9.7. Optimal filter against non-white noise

Home control work

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, self-study, etc. 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 recommended literature

1. Vasilyev V. M. Probability Theory in Radio Engineering: Textbook / V. M. Vasilyev, S. Ya. Zhuk. — Kyiv: Igor Sikorsky KPI, 2023. — 352 p.
2. Kostenko, P. Yu. Fundamentals of Statistical Theory of Information and Measurement Radio Engineering Systems: Textbook / P. Yu. Kostenko, S. Ya. Falkovich. — Kharkiv: KNUPS, 2021. — 612 p.
3. Voloshchuk V. I. Signals and Processes in Radio Engineering. — Vol. 1 / V. I. Voloshchuk. — Kharkiv: SMIT Company, 2003. — 580 p.
4. Statistical Radio Engineering: Lecture Notes / Compiled by O. S. Makarenko, S. M. Litvintsev. — Kyiv: Igor Sikorsky KPI, 2023. — 89 p.
5. Methodological guidelines for laboratory work in the discipline "Radio Engineering Circuits and Signals" for students majoring in "Radio Engineering." Part III // Compiled by F. D. Lyubich, Yu. G. Kuleshov, O. S. Makarenko. — Kyiv: KPI, 1993. — 36 p.

Recommended supplementary reading

1. Filippsky Yu. K. Random processes in radio engineering circuits: textbook for students of higher educational institutions / Yu. K. Filippsky. — Odessa: AO BAKHVA, 2012. — 176 p.
2. Koval, Yu. O. Fundamentals of circuit theory: textbook for students of higher educational institutions. Part 1 / Yu. O. Koval, L. V. Grinchenko, I. O. Milyutchenko. — Kharkiv: KNURE; Collegium, 2004. — 436 p.

Educational content

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

To study the academic discipline, nine lectures, nine practical classes, and three laboratory classes are planned, during which students must complete modular tests and defend their laboratory work after completion.

Lectures

No.	Lecture topic and list of main questions
1	RSA, random event, terminology, four probability theorems, random variable, integral distribution function, probability density
2	Random process, one-dimensional distribution function, one-dimensional probability density, moment functions and their properties, characteristic function and its properties
3	Multidimensionality, correlation, ergodicity, two-dimensional and multidimensional probability density, concept of correlation, stationarity, ergodicity, physical meaning of moments of ergodic random processes
4	ACF of a deterministic signal, AFC of a deterministic signal, mutual energy spectrum of signals, covariance and correlation functions, AFC of random processes, correlation coefficient, correlation interval, energy spectrum, spectral power density, effective spectrum width
5	Wiener-Khinchin formulas, white noise, experimental determination of statistical characteristics m_1 , m_2 , dispersion, characteristics of harmonic voltage with random phase, experimental determination of statistical characteristics W , autocorrelation function of signals, mutual energy spectrum of signals and its properties, correlation receiver, coherent receiver
6	Gaussian normal process and its properties, thermal noise, Nyquist theorem, generalized Nyquist theorem, thermal noise of an oscillating circuit, fractional noise, flicker noise, methods of equivalent representation of noises
7	Passage of random signals through linear circuits, normalization effect, stability property of the normal law, Lyapunov's central limit theorem, spectral-correlation characteristics of a random signal at the output of a linear circuit, spectral method, time method, differentiation of a random signal, integration of a random signal
8	What is a nonlinear inertia-free transducer (NIT), one-dimensional W at the output of the NIT, a linear detector as an example, moments and characteristic function at the output of the NIT, two-dimensional W at the output of the NIT, spectral correlation characteristics of a random signal at the output of an NIT, direct method for determining the ACF, method of characteristic functions (Reiss method), method of derivatives (Price method)
9	Amplitude detection of Gaussian narrowband noise, linear detector, quadratic detector, frequency detector, optimal filtering, optimal filter against white noise, optimal filter against non-white noise

Practical classes

No	Name of the topic and list of main questions
1	Basic concepts and theorems of probability theory
2	Random process and its statistical characteristics

3	Correlation and spectral analysis of signals
4	MT-1. Correlation functions and energy spectra. Correlation time. Effective spectrum width
5	Passage of random signals through linear circuits
6	MT-2. Noise
7	Passage of random signals through inertia-free nonlinear circuits
8	Optimal filter
9	Solving problems identical to HCW

Laboratory classes

No.	Name of the class topic and list of main questions
1	Experimental measurement of signal probability density
2	Study of the passage of a modulated random signal through a linear circuit
3	Study of changes in the signal-to-noise ratio when a random signal passes through a radio engineering system

Distance learning platform

For better assimilation of the subject matter during the period of remote work, 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, training materials, literature, etc.;
- feedback is provided to students on learning 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 students (SS)

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

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

Preparation for practical classes

To prepare for practical classes, students must study the planned basic and supplementary literature and recommended sources on the topic covered in the current practical class. Homework assignments given in practical classes must be completed before the next class.

Preparation for laboratory classes

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

Modular test (MT)

Up to 2 hours are allocated for preparation for the MT. The MT is conducted during the current practical class, following the completion of all topics covered in the planned 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 home control work is planned, which is presented in the form of an analysis and calculation of the parameters of a random signal and its passage through a radio engineering system. To prepare for the HCW, students should use the recommended literature, lecture notes, and methodological guidelines. Individual assignments for the HCW are given by the instructor, who also sets deadlines for their submission.

Final test

The test is held during the test week at the end of the academic semester. After students have completed their modular tests and homework assignments, they write a test based on their semester grades or at the instructor's discretion. Six hours of class time are allocated for preparation for the test. A list of questions for test preparation is provided in Appendix A. During the distance learning period, the test may be conducted according to the session 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, practical classes, 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 for completing homework, tests, and calculations.

Rules for completing assignments

When studying the material of the course "Statistical Radio Engineering," students:

- 1) during lectures:
 - take periodic quick tests of residual knowledge from sections of the course, which may include creative tasks on topics not covered in lectures, or quick test tasks (lasting 5–10 minutes using tests on the Sikorsky platform);
- 1) during practical classes:
 - complete modular tests either in person or using the Sikorsky platform;
 - solve practical problems and save the solutions obtained to prepare for the test;
- 2) in laboratory classes:
 - prepare homework assignments based on their own tasks based on the study of sources and literature;

- complete the tasks set for mandatory completion in accordance with the methodological guide;
- save the results obtained for further preparation of reports on the results of laboratory work.

Tasks and materials for quick tests/creative assignments are developed by the instructor 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 "Statistical Radio Engineering," students listen attentively to the lecturer during lectures and, if necessary, record important information, periodically perform express tests in written form (within 5–10 minutes) and modular tests (MTR) using the Sikorsky platform or in person. Dialogue between students and the teacher in the form of questions and answers is allowed.

During practical classes, students and the teacher discuss practical tasks and try to find the best solution through discussion.

During laboratory classes, students complete mandatory tasks. Student work involves participation in interactive forms of class organization (answering questions posed by the teacher or students). Each student is expected to be prepared for all questions in the laboratory class, supplement the reports of other students, and express their own opinion during the discussion of issues that arose during the performance of 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, practical 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).

Bonus 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 practical and/or 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 an assessment is zero. If a student misses an assessment for a valid reason, they are given the opportunity to complete it (write an MT, complete laboratory work) in the presence of the teacher. If the absence occurred without a valid reason, especially with regard to laboratory work, the issue of its completion is decided with the teacher in agreement with the department management. A missed test is not counted regardless of the reasons for the absence; in this case, the student receives a "did not appear" mark, and if they are eligible to take the test, they must take it during an additional session.

Announcement of test results

The results of the MT are announced after the verification. When communicating in person, at the student's request, they can receive an explanation in which they can see their grade according to certain assessment criteria.

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 via and are 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 information, 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 practical and laboratory classes, students are surveyed on topics related to the subject. Modular tests are conducted twice 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 lectures.

Calendar control

Calendar control is conducted 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 final test.

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 using tests on the Sikorsky platform;
- 2) work in nine practical classes;
- 3) work in 3 laboratory classes;
- 4) modular tests;
- 5) Homework assignment.

Information on the above points, summarized in a table

No.	Test	Maximum score	Number	Total
1	Attendance at lectures (test after lecture)	1	9	9
2	Work in practical classes	2	9	18

3.	Work in laboratory classes	10	3	30
4.	Modular test (MT)	2	6	12
5.	Home control work (HCW)	31	1	31
6.	Bonuses	10	1	10
7.	Credit (if you did not score 60)	40	1	40
	Total without bonuses			10
	Total with bonuses			110

In order to receive the highest rating, students must actively participate in practical and laboratory classes, actively supplement the answers of other students, clearly and logically express their own position on discussion issues, and timely complete MT, HCW, and express controls. 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 MT and express controls; inadequate preparation for practical and laboratory classes; inaccuracies, incompleteness, errors in answers, or reliance on unreliable sources.

The instructor evaluates the student's work in each practical and laboratory class and enters the grades for the work and results of the MT and express controls into 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)

A recommended list of questions for the semester exam (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 practical and laboratory classes, MT, HCW, tests, and quick checks.

When preparing for a practical or 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 practical and laboratory classes, each student should try to master the practical skills that can be mastered on their own. Students should not refuse to answer the teacher'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, 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 practical and laboratory class 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 Radio Engineering Department, Sergii Litvintsev

Approved by: Radio Engineering Department (Minutes No. 06/2025 dated 06/17/2025).

Approved by: Academic Council of the REF (Minutes No. 06/2025 dated 26.06.2025)

10. Appendix A

Semester control is carried out by means of a 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 solving a problem related to the module topic.

A sample test paper is provided below.

Sample final test

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

Level of higher education

first (bachelor's)

(degree name)

Specialty

172 Electronic Communications 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

Statistical Radio Engineering

(name)

TEST SHEET No. _____

1 *Questions from Block I*

2 *Questions from Block II*

3 *Task from section III*

Approved at the department meeting

Radio Engineering

(name of department)

Minutes No. _____

dated

"

_____ 202

Head of the Radio Engineering
Department

(signature)

(First name LAST NAME)

The exam consists of two theoretical questions and one problem, each of which is worth 20 points. In case of ambiguity, an additional question in the form of a problem may be added, which is worth 20 points.

Theoretical question

- complete answer (at least 90% of the required information) — 15–20 points;
- sufficiently complete answer (at least 75% of the required information or minor inaccuracies) — 9–14 points;
- incomplete answer (at least 60% and some errors) — 2–8 points;
- unsatisfactory answer — 0 points.

Practical task

The practical task requires the student to solve a problem related to the module topic.

- correct answer with all necessary intermediate results and calculations (at least 90% of the required information) — 15–20 points;
- correct answer with partial calculations (at least 75% of the required information or minor inaccuracies) — 9–14 points;
- partially correct answer with partial calculations (at least 60% and some errors) — 2–8 points;
- incorrect answer — 0 points.

Additional question

- correct solution — 19–20 points;
- correct solution with minor errors — 15–18 points;
- correct solution path, incorrect answer — 10–14 points;
- incorrect solution — 0 points.

Questions for creating exam tickets

Questions from Block I

1. Random event, impossible, reliable, incompatible, opposite.
2. First addition theorem.
3. Second addition theorem.
4. First multiplication theorem.
5. Second multiplication theorem.
6. Total probability formula.
7. Bayes' formula.
8. Integral distribution function F .
9. Probability density W .
10. Mathematical expectation.
11. Variance, standard deviation.
12. Random event vs. random process.
13. Initial moment functions.
14. Central moment functions.
15. Covariance function K .
16. Correlation function R .
17. Characteristic function θ .
18. Stationary random process.
19. Ergodic random process.
20. Correlation interval.
21. Wiener-Khinchin formula.
22. Average power of a stationary random process.
23. Energy spectrum width $\Delta\omega$.
24. 3σ rule

Questions from question block II

1. The normalization property of a linear circuit.
2. Normal (Gaussian) random process.
3. White noise.
4. Thermal, fractional, flicker noise.
5. Noise coefficient and noise temperature.
6. Noise resistance and noise conductivity.
7. Interrelation of noise properties.
8. Transmission coefficient of an optimal filter against a background of white noise.
9. Transmission coefficient of an optimal filter against a background of non-white noise.
10. Impulse response of a matched filter.
11. Signal at the output of a matched filter.
12. Optimal filter for a rectangular video pulse.
13. Optimal filter for a rectangular radio pulse.
14. Optimal filter for a sequence of impulse signals.

Tasks from Block III

1. Calculate the mathematical expectation of a random signal
2. Calculate the variance of a random signal
3. Perform correlation analysis of a known signal
4. Perform correlation analysis of an unknown signal
5. Calculate the thermal noise of the device
6. Calculate the fractional noise of the device
7. Calculate the flicker noise of the device
8. Calculate the passage of a random signal through a linear circuit
9. Calculate the energy spectrum of a random signal after passing through a linear circuit
10. Calculate the parameters of the filter that is optimal for this signal

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 TEST

in the academic discipline
STATISTICAL RADIO ENGINEERING
of the first (bachelor's) level of higher education

form of study

full-time

During practical classes, after completing certain topics, students are given a one-time opportunity to write a midterm exam, which consists of test questions. Two midterm exams are held during the module, each of which is graded on a scale of 0 to 6 points.

Assignments for the MT

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

MT-1

1. Random event, impossible, reliable, incompatible, opposite.
2. First addition theorem.
3. Second addition theorem.
4. First multiplication theorem.
5. Second multiplication theorem.
6. Total probability formula.
7. Bayes' formula.
8. Integral distribution function F.
9. Probability density W.
10. Mathematical expectation.
11. Variance, standard deviation.
12. Random event vs. random process.
13. Initial moment functions.
14. Central moment functions.
15. Covariance function K.
16. Correlation function R.
17. Characteristic function θ .

MT-2

1. Ergodic random process.
2. Correlation interval.
3. Wiener-Khinchin formula.
4. Average power of a stationary random process.
5. Energy spectrum width $\Delta\omega$.
6. 3σ rule
7. Normalization property of a linear circle.
8. Normal (Gaussian) random process.
9. White noise.
10. Thermal, fractional, flicker noise.
11. Noise coefficient and noise temperature.
12. Noise resistance and noise conductivity.
13. Interrelation of noise properties.

12. Appendix C

RATING SYSTEM FOR ASSESSING LEARNING OUTCOMES

in the academic discipline
STATISTICAL RADIO ENGINEERING
of the first (bachelor's) level of higher education

form of study

Daily

1. A student's grade for an academic discipline consists of points awarded for:

- assessment of residual knowledge in 9 lectures;
- work in 9 practical classes;
- work in 3 laboratory classes;
- modular tests (MT);
- home control work (HCW).

Distribution of teaching 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	Practical work	Lab work	SS	MT	HCW	Semester assessment
5	4	54	18	18	18	66	2	1	Credit

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

- 1) Attendance at lectures (test after the lecture) — maximum number of points — $1 \times 9 = 9$;
- 2) Completion and defense of 3 laboratory works, maximum number of points — $3 \times 10 = 30$;
- 3) Attendance and work in practical classes, number of points $9 \times 2 = 18$;
- 4) Two module control works (MT), divided into two one-hour control works, maximum number of points — $6 \times 2 = 12$;
- 5) Completion and defense of a home control work (HCW), maximum number of points — 31.

Rating point system

1. Testing of knowledge level after each lecture

1.1. Testing is conducted immediately after the lecture. Testing time — 72 hours.

1.2. Testing is conducted by taking tests in the Moodle system on the Sikorskii platform (<https://do.ipk.kpi.ua>).

1.3. The questions in the tests correspond to the topic of the lecture.

1.4. The weight of one question (correct answer) is 0.25 points.

1.5. The maximum possible number of points for one lecture is 1 point.

2. Laboratory work

2.1. Completion of homework on laboratory work — 1 point (availability of the homework file or its presence in the report when performing offline).

2.2. Completion of laboratory work.

— When performing the work in person: 2 points for all completed and working tasks. Confirmation of completion is provided by screenshots in the report.

— When performing the work online: 1 point for one mandatory task (presence of a file for the task).

— Preparation of a report on the results of the laboratory work.

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

– complete mastery of the material during the defense (at least 90% of the required information) — 5 points;

– partial mastery of the material (at least 80%) — 6 points;

– partial mastery of the material (at least 70%) — 5 points;

– satisfactory mastery of the material (at least 60%) — 4 points;

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

Defense on the day of completion or at the next class — +1 point for one lab report (bonus).

Well-designed laboratory work report (presence of all graphical constructions, thorough conclusions) — 1 point.

Late defense of the work — -1 point.

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

3. Modular test (MT)

– complete answer (at least 90% of the required information) — 6 points;

– complete answer (at least 80% of the required information) — 5 points;

– sufficiently complete answer (at least 70%) — 4 points;

– incomplete answer (more than 60%) — 3 points;

– unsatisfactory answer — 0 points.

4. Practical classes

Attendance:

– attendance at practical classes — 1 point for each class;

Participation in problem solving:

– solving a problem at the blackboard — graded from 0 to 5. All grades are summed up and converted to rating points with a coefficient of 0.2;

– answering from your seat "for a plus" — 1 "plus" for each correct answer. All "pluses" are summed up and converted with a coefficient of 0.5 to rating points.

5. Home control work (HCW)

Completing the HCW:

– HCW assignments correspond to the module topics;

– HCW is completed during the semester;

– the teacher determines the deadline for submitting the HCW for review;

– The date of submission of the HCW is considered to be the date when a hard copy of the HCW is handed over to the teacher, in which at least 90% of the task has been completed and the work has a finished appearance and layout.

Compliance with the assigned HCW task:

- complete and accurate solution of the task — 16 points;
- partial solution of the task — 12 points;
- incomplete solution of the task — 9 points;
- task not completed or does not correspond to the approved topic — 0 points.

Formatting and structure:

- full compliance with the requirements and the presence of all necessary structural elements — 5 points;
- formatting with minor violations or not all structural elements present — 4 points;
- formatting with violations, recommended structure violated, minor grammatical and stylistic errors — 3 points;
- the final project is not formatted or there is a complete lack of structure, with a significant number of grammatical and stylistic errors — 0 points;

Originality of the solution provided:

- the solution provided was not discussed in the lecture course and was not proposed as a solution option in practical classes — 5 points.

Defense of the final project:

- complete mastery of the material presented in the final coursework, understanding of its essence — 9–10 points;
- partial mastery of the material (more than 75%) or incomplete understanding of the issues covered — 7–8 points;
- poor command of the material (more than 60%) or lack of understanding of the essence of the issues covered — 6 points;
- unsatisfactory mastery of the material (less than 60%) and lack of understanding of the essence of the issues covered — 0 points.

The HCW is considered passed if it receives at least 18 points.

6. Bonus and penalty points

Penalty points (not taken into account during wartime):

- late defense of laboratory work — -1 point for each;
- late submission of the HCW for review — up to -10 points (-1 point for each day of delay);
- late writing or rewriting of MT — -2 points for each.

Incentive points:

- early submission of HCW for review — 5 points if the HCW is submitted for review one week before the deadline or earlier;

- original solution of the MT;
- original solution of laboratory work, or solution of a task in addition to the one provided;
- proposing your own version of tests;
- proposed your own version of the coursework.

A student cannot receive more than 10 penalty points or 20 bonus points!

The maximum number of points is 100. Completion of HCW and defense of all laboratory work is a prerequisite 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 scored less than 60 points, as well as those who want to improve their grade, take a test. In this case, points for passing the test are added to the HCW points, and this rating is final, i.e., during the test, it is possible to receive fewer points than before.