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

Radio Engineering Faculty
Radio Engineering Department

Mobile Communication Systems (PN-08)

Course syllabus (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*
Status of discipline	*Compulsory for professional training*
Form of study	*Full-time (day)*
Year of training, semester	*4th year, 7th semester*
Scope of the discipline	*Total: 5 ECTS credits / 150 hours* *Lectures: 18 hours* *Laboratory classes: 36 hours* *Self-study by students: 96 hours.*
Semester control/control measures	*Modular tests, calculation work, exam* *Ongoing assessment/defense of laboratory work*
Class schedule	*Lectures (once a week starting from week 1* *Laboratory work (once every two weeks)*
Language of instruction	*Ukrainian*
Information about the course coordinator/teachers	*Lecturer:* ***Maksym Rusov,*** *Laboratory work: Assistant Professor of Radio Engineering* ***Boris Vandilovsky (mega.greed.bv@gmail.com)***
Course location	*The course is hosted on the Sikorsky distance learning platform:* https://do.ipo.kpi.ua/course/view.php?id=7167

Course program

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

The purpose of the academic discipline "Mobile Communication Systems" (MCS) is to provide basic knowledge of the principles of construction and operation of modern and promising mobile

communication systems. In accordance with the requirements of the professional educational program, after completing the academic discipline, students must demonstrate the following learning outcomes:

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

1) Knowledge:

- the physical basis of radio signal transmission in MSC;
- methods of frequency-territorial planning of SMZ;
- OFDM and F-OFDM multi-frequency multiplexing technologies;
- modern methods of noise-resistant coding in SMZ networks;
- theoretical foundations of MIMO and Massive MIMO multi-antenna systems;
- standards and protocols for 4G and 5G mobile communication networks;
- basics of modern mobile communication network design.

2) Skills:

- select parameters for signal transmission paths in SMZ networks;
- calculate the efficiency parameters of SMZ networks for given radio signal reception conditions;
- have a basic understanding of practical radio network planning for SMZ.

3) Experience: use of modern software tools for planning and modeling new generation SMZ networks.

The discipline provides for the completion of a thesis project for master's students in both professional and scientific fields.

The knowledge and skills acquired as a result of studying the discipline provide the opportunity to work in organizations and companies engaged in the organization, design, and operation of terrestrial mobile communications.

General competencies (GC)

GC-4 – Knowledge and understanding of the subject area and understanding of professional activities.

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

Professional competencies (PC)

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.

PC-19 – Ability to apply and analyze various types of signal modulation and coding in radio communication channels of modern information and communication radio frequency systems.

PC-20 – Ability to select random signal parameters and optimize the communication channel according to the required criteria in the presence of noise and interference, perform engineering calculations of the main characteristics of random signals and devices for their processing.

PC-22 – Ability to analyze the architecture, calculate parameters, and formulate requirements for the components of modern 4G mobile information and communication systems.

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**:

PRL-01 – Analyze, argue, and make decisions when solving specialized tasks and practical problems in telecommunications and radio engineering, which are characterized by complexity and incomplete certainty of conditions.

PLR-03 – Identify and apply in professional activities methods for testing information and telecommunications networks, telecommunications and radio engineering systems for compliance with the requirements of domestic and international regulatory documents.

PLR-17 – Understand and comply with domestic and international regulatory documents on the development, implementation, and technical operation of information and telecommunications networks, telecommunications and radio engineering systems.

PLR-19 – Perform standard tests of information and communication networks, telecommunications and radio engineering systems for compliance with the requirements of domestic and international regulatory documents.

PLR-22 – Monitor the technical condition of information and communication networks, telecommunications and radio engineering systems during their technical operation in order to identify deterioration in performance or failures, and systematically record this by means of documentation.

PLR-27 – Select modulation parameters and apply methods of noise-resistant and efficient coding of information and communication radio systems.

PLR-28 – Perform calculations for decision-making and calculate the parameters of random signals when building an information and communication radio engineering system that works with random signals.

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 "Mobile Communication Systems" is included in the list of normative disciplines aimed at forming the professional competencies of a specialist.

Prerequisites – the academic discipline is specialized and is taught in the 7th semester of the 4th year of study in 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: "Fundamentals of Electronic Communications and Radio Engineering. Part 1. Fundamentals of Electronic Communications Networks," "Computer Science. Part 1. Fundamentals of Programming and Algorithms," "Computer Science. Part 2. Fundamentals of Computing," "Fundamentals of Metrology."

Post-requisites – knowledge gained in this discipline will ensure mastery of the following disciplines: "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

1. RSA
2. Introduction to mobile communication systems
   a. Generations of mobile communications
   b. What a mobile network consists of
3. History of telephony
4. Traffic theory, Erlang formulas
5. Circuit Switch vs Packet Switch, OSI models
6. Nyquist theorem (Shannon, Kotelnikov), Aliasing, Compressed sensing, significance for communication channels

7. Modular test 1
8. T1/E1 standards
9. Voice codecs in mobile networks
10. Frequency ranges of mobile networks
11. Types of modulation in mobile networks
12. Methods of single-channel access to radio resources:
    a. TDMA,
    b. CDMA,
    c. OFDMA,
    d. NR numerology
13. Modular test 2
14. BS sites and antennas
    a. Base station structure and antenna system
    b. Antennas for the MZ network
    c. Energy budget of the communication line
15. MIMO
16. Massive-MIMO
17. EMF-Control of electromagnetic radiation power level
18. Modular test 3
19. Internet of Things IoT
20. Radio system architectures in networks:
    a. GSM,
    b. UMTS,
    c. LTE,
    d. 5G
21. Mobile network components:
    a. base stations subscriber databases Circuit Switch Core,
    b. Packet Core,
    c. IMS,
22. 5G communication generation and its features
23. NTN satellite communication systems
24. AI/ML in telecommunications
25. 6G and promising technologies
26. Modular test 4
27. Calculation assignment
28. Exam

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 literature

1. Yong Soo Cho & others. MIMO-OFDM WIRELESS COMMUNICATIONS WITH MATLAB. John Wiley & Sons (Asia). 2010.
2. Andreas F. Molisch. WIRELESS COMMUNICATIONS. John Wiley & Sons Ltd., 2011.
3. Sauter M. From GSM to LTE-Advanced Pro and 5G. An Introduction to Mobile Networks and Mobile Broadband. Third Edition, 2017 John Wiley & Sons Ltd. - 2017. - 530 p.
4. Ajay R. Mishra. Fundamentals of Network Planning and Optimisation 2G/3G/4G: Evolution to 5G. John Wiley & Sons Ltd. 2018. - 427 p.

Educational content

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

To study the academic discipline, 18 lectures and 9 laboratory classes are planned, during which students must complete modular tests, control tests after listening to lectures, calculation work, and defend laboratory works after their completion.

Lectures

No	Lecture topic and list of main questions
1	*Lecture* RSA Introduction to mobile communication systems
2	*Lecture 2* Generations of mobile communications What a mobile network consists of History of telephony Traffic theory, Erlang formulas Circuit Switch vs Packet Switch, OSI models Nyquist theorem (Shannon, Kotelnikov), Aliasing, Compressed sensing, significance for communication channels
3	*Lecture 3* T1/E1 standards Voice codecs in mobile networks Frequency ranges of mobile networks Types of modulation in mobile networks
4	*Lecture 4* Modulations in MZ Part 2 Methods of single-channel access to radio resources: TDMA, CDMA, OFDMA, NR numerology BS sites and antennas
5	*Lecture 5* BS structure and antenna system Antennas for the MZ network Energy budget of the communication line MIMO Massive-MIMO
6	*Lecture 6* Massive-MIMO Part 2 EMF-Control of electromagnetic radiation power levels Internet of Things IoT

	NTN Satellite Communication Systems
7	*Lecture 7* Radio system architectures in networks: GSM, UMTS, LTE, 5G Mobile network components: base stations, subscriber databases, Circuit Switch Core, Packet Core, IMS,
8	*Lecture 8* 5G communication generation and its features
9	*Lecture 9* NTN satellite communication systems AI/ML in telecommunications 6G and promising technologies

Laboratory classes

No.	Class topic and list of key questions
1	*Laboratory work 1* Introduction to Atoll software, exploring methods of interaction with GIS
2	*Laboratory work 2* Methodology for selecting base station parameters and their location using Atoll software
3	*Laboratory work 3* Research on the model for predicting radio signal propagation losses and the dependence of losses on base station parameters
4	*Laboratory work 4* Study of the methodology for selecting the location of a group of base stations and research on their performance
5	*Laboratory work 5* Introduction to BTS site manager software
6	*Laboratory work 6* Configuring mobile communication network systems in a base station
7	*Laboratory work 7* Configuring a radio relay line via the Intracom interface
8	*Lab work 8* Introduction to the LTE standard base station
9	Defense of lab work and completion of missed assignments

Distance learning platform

For better assimilation of the subject matter during remote work, we use email, the Sikorsky distance learning platform with Moodle, and the Google Meet and ZOOM platforms for online meetings, which make it easier to post methodological recommendations, teaching materials, literature, etc.

- simplify the placement of methodological recommendations, teaching materials, literature, etc.;
- provide feedback to students on learning tasks and course content;
- 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 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 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 MCT. The MCT covers questions on several sections of the module, for which lecture material has already been read and laboratory classes have been completed.

Calculation work (CW)

In order to better assimilate the course material, a calculation assignment is planned, which is presented in the form of an analysis and calculation of mobile network parameters). To prepare for the CW, students should use the recommended literature, lecture notes, and methodological guidelines. Individual assignments for the CW are given by the instructor, who also sets deadlines for their submission.

Exam

The exam is held during the semester control (session) period, at the end of the academic semester after students have written their modular tests and calculation work. Based on the results of the rating points earned during the semester or by decision of the teacher, the student takes the exam. Six hours of class time are allocated for exam preparation. The list of questions corresponds to the questions that were covered in lectures and laboratory classes. During the distance learning period, the exam can be conducted 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 — in accordance with the Regulations on the Organization of the Educational Process at Igor Sikorsky KPI. At least once every two weeks, the instructor conducts consultations on various issues of 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 and calculations.

Rules for completing assignments

When studying the material of the course "Mobile Communication Systems," students:

1) during lectures:

- take periodic quick tests of residual knowledge from sections of the course, which may include creative assignments on topics not covered in lectures or quick test assignments;
- complete modular tests using the Sikorsky platform;

2) in laboratory classes:

- complete tasks that are mandatory according to the methodological guide;
- 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 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 "Mobile Communication Systems," 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 complete modular tests (MTR) using the Sikorsky platform. Dialogue between students and the lecturer in the form of questions and answers is permitted.

During laboratory classes, students complete mandatory assignments. Student work involves participation in interactive forms of class organization (answering questions posed by the instructor or other 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 discussions of issues that arise during the completion 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 and laboratory classes are covered in the course syllabus, which is available at Electronic Campus, on the website of the Radio Engineering Department, and on 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.

Student participation in solving problems that many students encounter when performing laboratory tasks is encouraged.

Students are encouraged to create new teaching materials (new test questions, suggestions for improvement, etc.) and to find errors in existing teaching materials.

Students can earn up to 10 additional points for the course.

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 laboratory work 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 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 laboratory classes, students are surveyed on topics related to the subject. Modular tests are conducted every three lectures to check students' residual knowledge.

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 to be an exam.

Assessment and control measures

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

1) assessment of residual knowledge through the completion of modular tests;

2) work in 8 laboratory classes;

3) completion of calculation work;

4) additional points for initiative shown during the course.

Information on the above points is summarized in the table

No.	Assessment	Maximum points	Number	Total
1	Attendance at lectures (test during lectures)	1	8	8
1.	Modular tests	6	4	24
2.	Work in laboratory classes 1–4	8	4	32
3.	Work in laboratory classes 5–8	2	4	8

4.	Calculation work	28	1	28
3.	Bonuses	10	1	10
6.	Exam (if you did not score 60)	40	1	40
	Total without bonuses			100
	Total with bonuses			11

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 the MT in a timely manner. Students are given a one-time opportunity to complete the MT.

The following factors lead to a lower student rating: failure to complete the MT; inadequate preparation for laboratory classes; inaccuracies, incompleteness, errors in answers, or reliance on unreliable sources.

The instructor evaluates the student's work at each laboratory class and enters the grades for the work and results of the completed assignments 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.

The student may appeal the teacher's grade by submitting a complaint to the teacher no later than the day after the student has been informed of the grade 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.

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)

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 and self-study.

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 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 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 education is permitted.

Work program for the academic discipline (syllabus):

Prepared by: Assistant Professor of the Radio Engineering Department, Boris Vandilovsky

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

RATING SYSTEM FOR ASSESSING LEARNING OUTCOMES

in the academic discipline
MOBILE COMMUNICATION SYSTEMS
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:

- assessment of residual knowledge in 9 lectures;
- work in 8 laboratory classes;
- modular tests (MT)
- calculations (RZ).

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	CW	Semester assessment
7	5	54	18	36	96	4	1	exam

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

1) Testing during lectures, maximum number of points 8.
2) Passing modular tests every three lectures, maximum number of points 24, 6 for each modular test.
3) Completion and defense of 8 laboratory works, maximum number of points 40, laboratories 1-4 are evaluated at 8 points, laboratories 5-8 at 2 points;
4) Completion of a calculation assignment, maximum number of points 28;
5) Bonus points — maximum number of points — 10.

Rating point system

1. Laboratory work

1.1. Completion of laboratory work.

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

1.2. Preparation of a report on the results of the laboratory work — maximum possible number of points — 1 point.

1.3. Defense of laboratory work:

— complete mastery of the material during the defense (at least 90% of the required information) — 2 points;

– partial mastery of the material (at least 80%) — 1.5 points;

– partial mastery of the material (at least 70%) — 1 point;

– satisfactory mastery of the material (at least 60%) — 0.5 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 assignment (bonus).

3. Modular test (MT)

MCTs are conducted after the completion of individual lecture sections by means of testing in the Moodle system. The maximum number of points is 24, calculated at 6 points per MCT, with a total of 4 MCTs.

4. Incentive and penalty points

Penalty points (not taken into account during wartime):

– late submission of laboratory work — −1 point for each.

Bonus points:

– timely defense of laboratory work — 1 point if the work is defended on the day of completion or at the next scheduled class;

– original solution of laboratory work, or solution of a task in addition to the one provided;

– active participation in lectures.

A student cannot receive more than 10 penalty points or 10 bonus points.

The maximum number of points is 99. The 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 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 an exam. This rating is final, meaning that during the exam, it is possible to earn fewer points than before.