National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute"

Department of Mathematical Analysis and Probability Theory
Probability

Analytical geometry and linear algebra

Syllabus for the academic discipline "Analytical Geometry and Linear Algebra" (Syllabus)

Course details

Higher education level	First (bachelor's)
Field of knowledge	17 Electronics, Automation, and Electronic Communications
Special	172 Electronic communications and radio engineering
Educational program	"Intelligent technologies of radio electronics"
Status of the discipline	Mandatory
Form of study	Full-time
Year of study, semester	1st year, fall semester
Scope of the discipline	120 hours (36 hours – Lectures, 36 hours – Practical lessons, 48 hours – Independent study)
Semester assessment/assessment measures	Credit/Module test, home control work
lesson schedule	http://rozklad.kpi.ua
Language of instruction	Ukrainian
Information about the course supervisor/teachers	Lecturer: Candidate of Physical and Mathematical Sciences, Senior Lecturer at the Department of Mathematical Analysis and Probability Theory Volodymyr Pavlenkov pavlenkov@matan.kpi.ua Practical / Seminar: Kroshko Natalia Vitalievna, Candidate of Physical and Mathematical Sciences, Associate Professor of the Department of Mathematical Analysis and Probability Theory,kroshko06@bigmir.net ; Maslyuk Anna Oleksiyivna, Candidate of Physical and Mathematical Sciences, Associate Professor of the Department of Mathematical Analysis and Probability Theory,masliukgo@ukr.net ; Tetiana Volodymyrivna Malovychko, Candidate of Physical and Mathematical Sciences, Associate Professor of the Department of Mathematical Analysis and Probability Theory,tatianamtv@protonmail.com ; Yurii Yevhenovych Prykhodko, Candidate of Physical and Mathematical Sciences, Assistant Professor, Department of Mathematical Analysis and Probability Theory,prykhodko@matan.kpi.ua .
Course placement	https://campus.kpi.ua

Curriculum

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

The credit module "Analytical Geometry and Linear Algebra" is part of the academic discipline "Higher Mathematics" (GN7) and belongs to the cycle of mathematical disciplines which, together with other disciplines of scientific and natural science training, form the necessary basis for the mastery of special engineering subjects.

Objectives of the discipline	The objectives of the academic discipline are: - to develop logical thinking, intellect, and abilities in students; - to develop the necessary intuition and erudition in the application of mathematics, to cultivate applied mathematical culture in students; - developing the ability to independently use and study mathematics literature, develop flexible thinking, creative independence, and action.
Subject of the academic discipline	General mathematical properties and patterns. Basic models and concepts of linear algebra, analytical geometry, their properties, and logical schemes for proving these properties.
Competencies	Ability to think abstractly, analyze, and synthesize (GC1); Ability to apply knowledge in practical situations (GC2); Ability to learn and master modern knowledge (GC7); Ability to identify, pose, and solve problems (PC8)
Program learning outcomes	Apply fundamental and applied sciences to analyze and develop processes occurring in telecommunications and radio engineering systems (PRO13)

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

Prerequisites: This course requires systematic and in-depth knowledge of school mathematics.

Post-requisites: Computer science.

Content of academic discipline

Names of sections and topics	Number of hours			
	Total	including		
		Lectures	Practical	MT
1	2	3	4	5
Section 1. ***Linear Algebra***				
Topic 1.1. Matrices and determinants.	14	6	6	2
Topic 1.2. Systems of linear equations.	10	4	4	2
Module test 1	6	-	2	4
Section 2. ***Vector algebra***				
Topic 2.1. Vectors and operations with them.	16	6	6	4
Topic 2.2. Complex numbers.	7	2	2	3
Module test 2	5	-	2	3
Section 3. ***Analytical geometry***				
Topic 3.1. A straight line on a plane.	9	4	2	3

Topic 3.2. A straight line and a plane in space.	11	4	4	3
Topic 3.3 Second-order curves	11	4	4	3
Topic 3.4 Second-order surfaces	6	4	2	-
Module test 3	7	-	2	5
Home test	10	-	-	10
Credit	8	2	-	6
Total hours	**120**	36	36	48

Teaching materials and resources

Basic literature

1. Linear Algebra and Analytic Geometry: Textbook / V. V. Buldygin, I. V. Alekseeva, V. O. Gaidei, O. O. Dykhovichnyi, N. R. Konovalova, L. B. Fedorova; edited by Prof. V. V. Buldygin. — Kyiv: TViMS, 2011. — 224 p. https://ela.kpi.ua/handle/123456789/16193
2. Mathematics at a technical university [Electronic resource]: textbook / I. V. Alekseeva, V. O. Gaidei, O. O. Dykhovichnyi, L. B. Fedorova; edited by O. I. Klesov; Igor Sikorsky Kyiv Polytechnic Institute. – Electronic text data (1 file: 4.01 MB). – Kyiv: Igor Sikorsky KPI, 2018. – Vol. 1. – 496 p. http://ela.kpi.ua/handle/123456789/24338
3. Analytical Geometry and Linear Algebra / Lecture Notes for Students of Technical Faculties Compiled by: Z. P. Ordynska, I. V. Orlovsky, M. K. Runovska. – 176 p. https://matan.kpi.ua/public/files/%D0%90%D0%BB%D0%B3%D0%B5%D0%B1%D1%80%D0%B0_%D0%B3%D0%B5%D0%BE%D0%BC%D0%B5%D1%82%D1%80%D0%B8%D1%8F_%D0%BB%D0%B5%D0%BA%D1%86%D0%B8%D0%B8.pdf
4. Mathematics in a modern technical university. Practical guide. In 4 parts. Part 1. Linear algebra and analytical geometry [Electronic resource]: textbook / NTUU "KPI"; compiled by I. V. Alekseeva, V. O. Gaidei, O. O. Dykhovichnyi, [et al.]. – Electronic text data (1 file: 2.45 MB). – Kyiv: NTUU "KPI". 2015. –180 p. https://ela.kpi.ua/handle/123456789/16606

Additional literature

1. Dubovyk V. P. Higher Mathematics: Textbook. / Dubovyk V. P., Yurik I. I. – Kyiv: A.S.K., 2005. – 648 p.
2. Grymalyuk V. P. Higher Mathematics: In 2 parts: textbook / Grymalyuk V. P., Kukharchuk M. M., Yasinsky V. V. – Kyiv: Vipol, 2004. – Part 1. – 376 p.
3. Collection of problems from analytical geometry and vector algebra: textbook manual / V. V. Buldygin, V. A. Zhuk, S. O. Ruschytska, V. V. Yasinsky. — Kyiv: Vyshcha shkola, 1999. — 192 p.
4. Dubovyk V. P. Higher Mathematics. Collection of Problems: Textbook. / V. P. Dubovyk, I. I. Yurik. — Kyiv: A.S.K., 2005. — 648 p.
5. Linear Algebra and Analytical Geometry. Collection of Individual Homework Assignments for First-Year Students of Technical Faculties. / Compiled by: I. V. Alekseeva, V. O. Gaidei, O. O. Dykhovichnyi, L. B. Fedorova, G. D. Nefyodova, Yu. O. Hrehul. — Kyiv: NTUU "KPI," 2016. — 348 p.

Information resources

Distance learning course "Linear Algebra and Analytical Geometry" https://do.matan.kpi.ua/course/view.php?id=2

Educational content **Methodology for mastering the academic discipline (educational component)**

Full-time/distance learning Lectures

No	Lecture topic and list of main questions (list of teaching aids, references to literature, and assignments for independent study)
1	**Matrices.** Definition of a matrix. Linear operations on matrices and their properties. Matrix multiplication and its properties. Matrix transposition. *Recommended reading:* [1], section 1; [2], section 2.
2	**Matrix determinants.** Definition of a matrix determinant. Properties of determinants. Methods for calculating determinants. The concept of an inverse matrix and the theorem on the conditions for the existence and construction of an inverse matrix. *Recommended reading:* [1], section 1; [2], section 2.
3	**Linear systems of algebraic equations and methods for solving them.** Definition of a linear system of algebraic equations of arbitrary order. Matrix method. Cramer's method. *Recommended reading:* [1], section 1; [2], section 2.
4	**Matrix rank.** Definition of a linear system of algebraic equations of arbitrary order. Gauss method. *Recommended reading:* [1], section 1; [2], section 2.
5	**Study of systems of linear algebraic equations.** Kronecker–Capelli theorem. Linear homogeneous systems: condition for the existence of nonzero solutions. Fundamental system of solutions of a homogeneous SLAR. General solution of a nonhomogeneous SLAR. *Recommended reading:* [1], section 1; [2], section 2.
6	**Vectors in a plane and in space.** Linear dependence of vectors, basis, and dimension of a linear space. Expansion of a vector according to a given basis. Coordinates of a vector. Linear operations on vectors in coordinate form. *Recommended reading:* [1], section 2; [2], section 3.
7	**Scalar product of vectors.** Definition and properties of the scalar product in the space of geometric vectors. Scalar product in coordinate form. Vector length and angle between vectors. Orthogonality of vectors. Definition of vector product, its properties, coordinate form. Definition of mixed product, its properties, coordinate form. Application of vector products in geometry, mechanics, and physics. *Recommended reading:* [1], section 2; [2], section 3.
8.	**Vector and mixed products of vectors.** Definition and properties of the vector product and its properties, the concept of anticommutativity. Definition and properties of the mixed product of vectors. Application of vector and mixed products of vectors to solving the simplest problems of analytical geometry. *Recommended reading:* [1], section 2; [2], section 3.
9	**Complex numbers.** Representation of complex numbers on a plane. Algebraic, trigonometric, and exponential forms of complex numbers. Algebraic operations on complex numbers. Moivre's formula. *Recommended reading:* [1], section 2; [2], section 3.
10	**The simplest problems of analytical geometry.** The subject and method of analytical geometry. Cartesian and polar coordinate systems. Finding the distance between points and dividing a segment in a given ratio. *Recommended reading:* [1], section 3; [2], section 4.
11	**A straight line on a plane.** Equations of a straight line on a plane in various forms, the concepts of a direction vector and a normal vector. Methods of applying vector characteristics of a straight line to solving problems in analytical geometry. Distance from a point to a straight line. Mutual position of straight lines on a plane. *Recommended reading:* [1], section 3; [2], section 4.

12	**Plane and straight line in space.** General equation of a surface and curve in space. Derivation of the main types of plane equations (general, segment, normal) and types of line equations (vector, canonical, parametric, and general form). Finding the distance from a point to a plane. Mutual position of two planes in space, two lines in space. Mutual position of a line and a plane in space. *Recommended reading:* [1], section 3; [2], section 4.
13	**Mutual position of lines and planes in space** Mutual position of two planes in space, two lines in space. Mutual position of a line and a plane in space. Common perpendicular of non-intersecting lines. Distances between different linear objects in space. *Recommended reading:* [1], section 3; [2], section 4.
14	**Second-order algebraic curves on a plane.** Definition and derivation of canonical equations of an ellipse, hyperbola, and parabola. Properties of second-order curves. *Recommended reading:* [1], section 3; [2], section 4.
15	**Quadratic forms**. The concept of a quadratic form. Reduction of a second-order quadratic form to canonical form. Eigenvalues and eigenvectors of a matrix. Silvestre's criterion. *Recommended reading:* [1], section 3; [2], section 4
16	**Second-order surfaces.** Elements of linear algebra Definitions and canonical equations of second-order surfaces (ellipsoid, hyperboloid, paraboloid, hyperbolic paraboloid). Surfaces of rotation of a line around an axis: mechanical method of obtaining and deriving the equation. Cylindrical and conical surfaces. Investigation of the shape of surfaces by their equations using the method of intersections. *Recommended reading:* [1], section 3; [2], section 4.
17	**Final lecture.** Summary and systematization of the material covered in the course material.
18	**Conducting the test.**

Practical lessons

No. **No**	Name of the topic and list of main questions
1	Matrices and operations on them.
2	Determinant of a matrix.
3	Inverse matrix. Solving matrix equations.
4	Systems of linear algebraic equations.
5	Systems of arbitrary dimension. Gauss method. Construction of a general solution.
6	Writing MODULE TEST -1.
7	Vectors. Basic concepts. Linear operations with vectors. Basis decomposition.
8	Scalar product of vectors.
9	Vector and mixed products.
10	Complex numbers and operations with them.
11	Writing MODULE TEST -2.
12	A straight line on a plane. Different types of equations of a straight line on a plane.
13	A line and a plane in space. Constructing equations of a line and a plane.
14	Mutual position of lines, planes, a line and a plane in space.
15	Curves of the second order. Ellipse, hyperbola, parabola.
16	Reducing a second-order curve to canonical form. Eigenvalues and eigenvectors of a matrix.
17	Writing MODULE TEST -3
18	Second-order surfaces. Sylvester's criterion.

Independent work of students/postgraduates

Studying the discipline includes the following types of independent work:

- preparation for lectures and practical lessons, completion of homework assignments;
- completing homework assignments (written individual assignments, test assignments in distance learning courses on the Moodle platform);
- preparation for modular control work;
- preparation for the exam.

Tests

One Module test is planned, which is divided into parts:

MODULE TEST -1 "Elements of Linear Algebra," MODULE TEST -2 "Vectors," MODULE TEST -3 "First- and Second-Order Objects in the Plane and in Space."

Policy and control **Policy of the academic discipline (educational component)**

Recommended teaching methods: studying the main and supplementary literature on the topics of the lectures, solving problems in practical lessons and when doing homework.
Students are advised to take detailed lecture notes. An important aspect of quality assimilation of the material and mastery of methods and algorithms for solving the main problems of the discipline is independent work. It includes reading literature, reviewing literature on the topic, preparing for lessons, completing homework assignments, and preparing for MODULE TEST and tests.

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, please visit: https://kpi.ua/code

Standards of ethical conduct

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, please visit: https://kpi.ua/code

Types of control and rating system for assessing learning outcomes (RSA) (full-time/distance learning)

Distribution of study time by type of lesson and assignment in accordance with the working curriculum.

Semester	Teaching time		Distribution of teaching hours			Control measures		
	Credits	Academic hours	Lectures	Practical	MT	MODULE TEST	HCW	Semester. Assessment.
1	4	120	36	36	48	1	1	Credit

During the first lesson, students are introduced to the rating system of assessment (RS) for the discipline, which is based on the Regulations on the system of assessment of learning outcomes https://document.kpi.ua/files/2020_1-273.pdf.
Current control: frontal (oral, written), MODULE TEST , HCW.
Calendar control: conducted twice per semester as monitoring of the current status of syllabus requirements, the results of which are reflected in the Electronic Campus system https://campus.kpi.ua.
The rating system includes all types of testing: tests, quality of final coursework. Each student receives their final rating for the discipline.

A student's credit module rating is calculated on a 100-point scale and consists of points awarded for:

- work in practical lessons;
- writing a Module test;
- completion of the HCW.

Answers during practical lessons

- if the task is completely solved or the answer to the question is complete, the applicant receives the maximum number of points;
- if the answer is correct, but in the solution there are inaccuracies, then the applicant receives 0.5 of the planned points;

- if the answer is unsatisfactory, the method of solving the problem is incorrect – 0 points

The maximum score is 30.

Module test

Module test consists of three parts

MT-1 "Matrices and Systems" weighted score 14
MT-2 "Vectors and complex numbers" weighted score 12
MT- 3 "Analytical geometry" weighted score 14

The parts of the Module test can be written as a written assignment or in the form of Moodle tests, at the lecturer's discretion.

The maximum score is 40.

There are no plans to reschedule the MT.

Homework

Weighting score 30
Homework assignments are completed and defended in parts that correspond in content to the modular control work. Each part of the homework assignment is submitted before the modular control work is written, within the deadlines set by the lecturer.
If less than 60% of the homework assignment is completed, it will not be counted and must be reworked (in this case, the final score for the corresponding part will not exceed 60% of the maximum score for that part). There are no plans to rewrite the counted part of the homework assignment in order to raise the score.
A part of the coursework submitted late will be graded no higher than 60% of the maximum score for that part.

Parts of the homework assignment may be written or in the form of Moodle tests, at the lecturer's discretion.

The maximum score is 30.

Penalty and bonus points

- failure to complete homework assignments, unpreparedness for practical lessons (-2 points for each established case without a valid reason);
- answers to questions during lectures (+1 point, must be announced by the lecturer during the lecture that the student has provided a sufficient answer and deserves a bonus);
- successful participation in the higher mathematics competition (up to +5 points).

The maximum (and minimum) number of incentive (penalty) points is from -10 to +10.

Form of semester assessment – test

The test is conducted during the last lecture, and the grade is based on the student's semester rating RC

The starting scale is RC = 100 points. The rating scale is R = RC = 100 points.

Conditions for a positive interim assessment.

To receive a "pass" on the first (week 8) and second (week 14) interim assessments, the student must have at least 50% of the possible points at the time of the calendar assessment.

Retaking a positive final semester assessment in order to improve it is not permitted.

A student is admitted to the exam if their semester rating is not less than 60 points, and they must have passed the Module tests and HCW (completed at least 60%).

Students who have a starting RC rating at the end of the academic semester points to the exam and must complete additional tasks before the first retake. Students with a rating of have the opportunity to earn points to reach the passing grade by completing an admission test during the last week of the academic semester (this test should be organized by practical training instructors).

- A student who has fulfilled the admission requirements but wants to improve their final grade has the right to write a test paper (this does not apply to students who have written an admission test). In this case, the student's final grade is calculated using the formula $R = R3$, where $R3$ is the grade earned for writing and defending the

credit test.

- The exam itself consists of 5 questions (4 tasks and a theoretical question), with each task worth 20 points. In order to comply with the principles of academic integrity, the exam will be conducted remotely via Zoom (or GoogleMeet) with cameras turned on to record the student, their workplace, and their written work. The exam duration is 90 minutes. After writing the paper, it must be defended in an interview, during which points will be awarded for each question.
- If, for various technical reasons, a student is unable to record the writing of the test paper on camera, then such a student will be deprived of the opportunity to write the test paper, and their grade will be based on their semester rating.
- The examiner reserves the right to stop a student from writing the exam if, for technical reasons, the video recording of the exam has stopped working.
- Students who wish to write the exam will be deprived of the opportunity to receive a final grade based on their semester rating. If the exam is written with an unsatisfactory grade, it can be retaken during an additional session.
- A student who has fulfilled the admission requirements and wishes to write a credit assignment must notify the examiner in writing no earlier than 2 days before the date of the credit assignment (the notification is written in free form, with the student's surname, initials, date, and signature). A photocopy of this notification can be sent via Telegram.

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

Additional information on the discipline (educational component)

During the legal regime of martial law, the educational process at Igor Sikorsky KPI for full-time and part-time higher education students may be conducted remotely. In the case of distance learning, the educational process is organized using messengers (Telegram, Viber, etc.), video conferences in Zoom, and the Moodle educational platform. Current control can be carried out in the form of test controls in Moodle. The RS may also be changed in accordance with the order of Igor Sikorsky KPI or the decision of the department.

Work program for the academic discipline (syllabus):

Compiled by:

Senior lecturer of the Department of Mathematics and Theory of Probability, Candidate of Physical and Mathematical Sciences, Pavlenkov V.V.

Approved by the Department of Mathematical Analysis and Probability Theory (Minutes No. 13 of 06/25/2024)

Approved by the Methodological Council of the RTF (Minutes No. 06-2024 dated 28.06.2024)