National Technical University of Ukraine «IGOR SIKORSKY KYIV POLYTECHNIC INSTITUTE»

Department emblem (if available)

Department of Mathematical Physics and Differential Equations

Higher Mathematics 1. Analytic Geometry and Linear Algebra
Working Program of the Academic Discipline (Syllabus)

Course Details

Level of higher education	**First (Bachelor's)**
Branch of knowledge	G Engineering, Manufacturing and Construction
Specialty	G7 Automation, Computer-Integrated Technologies and Robotics
Educational program	Computer-Integrated Technologies and Robotics
Course status	Mandatory
Form of study	Full-time (day)
Year of study, semester	1st year, autumn semester (1)
Course workload	**180 hours / 6 ECTS credits**

	Lectures	Practical classes (seminars)	Laboratory classes (computer practicum)	Individual classes	Self-study
Hours	**30**	**60**	**0**	**0**	**90**

Semester control / control measures	Exam	Credit	MCW (specify number)	CGW, CW, GW (specify number)	HCW (specify number)	Essay (specify number)
	+	-	1	1	0	0

Class schedule	On the university website: rozklad.kpi.ua
Language of instruction	Ukrainian
Information about the course leader / teachers	Lecturer: PhD (Physics and Mathematics), Associate Professor Olha Sulima olgasulimakpi@gmail.com Practical classes: PhD (Physics and Mathematics), Associate Professor Maryna Savchuk https://intellect.kpi.ua/profile/sov203 maryna1savchuk@gmail.com https://intellect.kpi.ua/profile/smv319 Practical classes: PhD (Physics and Mathematics), Associate Professor Olha Kachaienko kachayenko@ukr.net https://intellect.kpi.ua/profile/kob7
Course placement	https://ecampus.kpi.ua Department website, library information resources

Course Program

1. Course description, its aim, subject of study and learning outcomes

The aim of the course "Higher Mathematics 1. Analytic Geometry and Linear Algebra" is to develop students' integral competence: the ability for logical thinking, analysis and synthesis, the formation of students' personality, the development of their intellect and abilities, the ability to solve complex specialized problems and practical issues of professional activity in the latest technologies, and to use methods of mathematical analysis in engineering calculations.

The course aims to provide students with the knowledge, skills and abilities needed to master professionally oriented disciplines and to give the necessary basic mathematical training for solving specialized problems

of instrument engineering, for the development, improvement and operation of existing automation systems using modern hardware, software and information technologies, and for theoretical research of automation objects.
Teaching mathematics involves:
– development of logical and algorithmic thinking;
– mastering the main methods of investigating and solving mathematical problems;
– mastering the main numerical methods of mathematics;
– the ability to apply mathematical knowledge independently and to carry out mathematical analysis of applied engineering problems.
The objective of studying the course is to develop competences (GC – general, PC – professional (special, subject-specific)):

General Competences (GC)
GC 1. Ability to learn and master modern knowledge.
GC 2. Knowledge and understanding of the subject area and understanding of professional activity.
GC 3. Ability to apply knowledge in practical situations.
GC 4. Ability to make informed decisions.
GC 5. Ability to search for, process and analyse information from various sources.
GC 7. Ability to work autonomously and in a team.
GC 8. Ability to communicate in the state language both orally and in writing.
GC 9. Ability to communicate in a foreign language.
GC 10. Skills in using information and communication technologies.

Professional Competences (PC)
PC 1. Ability to apply knowledge of mathematics to the extent necessary to use mathematical methods for the analysis and synthesis of automation systems.
PC 2. Ability to apply methods of systems analysis, mathematical modelling and numerical methods to develop mathematical models of individual elements and of automation systems as a whole, and to analyse the quality of their operation using the latest computer technologies.

Programme Learning Outcomes (PLO)
PLO 1. To know linear and vector algebra, differential and integral calculus of functions of one and several variables, power and functional series, and differential equations to the extent necessary to use mathematical tools and mathematical methods in the field of automation.
PLO 2. To be able to apply methods of systems analysis, modelling, identification and numerical methods to develop mathematical and simulation models of individual elements and of automation systems as a whole, and to analyse the quality of their operation using the latest computer technologies.
PLO 3. To be able to use a variety of specialized software to solve typical engineering problems in the field of automation, in particular mathematical modelling, computer-aided design, database management and computer graphics methods.

2. Prerequisites and postrequisites of the course (place in the structural and logical scheme of training under the relevant educational program)

The course is taught in the 1st semester on the basis of complete general secondary or vocational secondary education.

3. Course content

Topic 1. ***Elements of linear algebra and analytic geometry****:* Elements of linear algebra. Vector algebra. Elements of analytic geometry in the plane and in space.
Topic 2. ***Introduction to mathematical analysis:*** Number sets. Numerical sequences, limits. Limits and continuity of a function of one variable.

Topic 3. ***Differential calculus of a function of one variable:*** Derivative of a function, differential. Higher-order derivatives and differentials, their applications. Application of differential calculus to the investigation of functions and plotting their graphs.

4. Educational materials and resources

Main literature

1. Dubovyk V. P. Higher Mathematics / V. P. Dubovyk, I. I. Yuryk. – Kyiv: Vyshcha shkola, 2013. – 648 p. [in Ukrainian]
2. Kuzma O. V. Higher Mathematics. Analytic Geometry and Linear Algebra. Elements of Vector Algebra. Lecture Notes [Electronic resource]: textbook for students of specialty 151 "Automation and Computer-Integrated Technologies" / O. V. Kuzma, O. V. Sulima, T. O. Rudyk et al.; Igor Sikorsky Kyiv Polytechnic Institute. – Electronic text data (1 file: 1.50 MB). – Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2021. – 127 p. [in Ukrainian]
https://ela.kpi.ua/handle/123456789/42310
3. Hrymaliuk V. P. Higher Mathematics: in 2 parts: textbook / V. P. Hrymaliuk, M. M. Kukharchuk, V. V. Yasinskyi. – Kyiv: Vipol, 2004. – Part 1. – 376 p. [in Ukrainian]
4. Dubovyk V. P. Higher Mathematics. Collection of Problems: textbook / V. P. Dubovyk, I. I. Yuryk. – Kyiv: A.S.K., 2005. – 648 p. [in Ukrainian]
5. Kushlyk-Dyvulska O. I. Elements of Linear and Vector Algebra. Analytic Geometry. Introduction to Mathematical Analysis [Electronic resource]: collection of typical tasks for the credit module "Higher Mathematics 1" for students of the Publishing and Printing Institute / NTUU "KPI"; compiled by O. I. Kushlyk-Dyvulska, N. V. Polishchuk, N. P. Seleznova. – Electronic text data (1 file: 3.67 MB). – Kyiv: NTUU "KPI", 2015. – 149 p. – Title from the screen. – Access: http://ela.kpi.ua/handle/123456789/10429. [in Ukrainian]

Additional literature

1. Herasymchuk V. S. Higher Mathematics. A Complete Course in Examples and Problems: in 3 parts: textbook / V. S. Herasymchuk, H. S. Vasylchenko, V. I. Kravtsov. – Kyiv: Knyhy Ukrainy LTD, 2009. – Part 1. – 578 p.; 2010. – Part 2. – 470 p.; 2009. – Part 3. – 400 p. [in Ukrainian]
2. Stryzhak T. H. Mathematical Analysis: Examples and Problems: textbook / T. H. Stryzhak, N. R. Konovalova. – Kyiv: Lybid, 1995. – 240 p. [in Ukrainian]
3. Kushlyk-Dyvulska O. I. Elements of Linear and Vector Algebra. Analytic Geometry. Introduction to Mathematical Analysis [Electronic resource]: textbook [for students of the Publishing and Printing Institute, specialty 186 "Publishing and Printing"] / O. I. Kushlyk-Dyvulska, N. V. Polishchuk; executive editor S. D. Ivasyshen; Igor Sikorsky Kyiv Polytechnic Institute. – Electronic text data (1 file: 3.15 MB). – Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2017. – 141 p. – Title from the screen. – Access: http://ela.kpi.ua/handle/123456789/19572. [in Ukrainian]

Educational Content

5. Methods of mastering the course (educational component)

In lectures – lecture (electronic version), explanations, problem-based tasks

List of lectures

Lecture 1. Determinants and their properties

1.1. Basic concepts.
1.2. Second- and third-order determinants and their properties.
1.3. Minors and cofactors.
1.4. Calculation of determinants.
1.5. Cramer's rule for solving systems of linear algebraic equations (SLAEs).

Lecture 2. Matrices

2.1. Matrices and operations on them.
2.2. Inverse matrix and its construction.
2.3. Matrix method.

Lecture 3. Solving systems of linear algebraic equations

3.1. The concept of matrix rank and its calculation.
3.2. Consistency criterion for systems of linear algebraic equations, the Kronecker-Capelli theorem.
3.3. Gauss method.
3.4. Systems of linear homogeneous equations.

Lecture 4. Vectors in space. Dot product

4.1. Basic concepts.
4.2. Linear operations on vectors.
4.3. Vectors in a rectangular coordinate system.
4.4. Dot product of vectors and its properties.

Lecture 5. Cross product and scalar triple product of vectors. Linearly dependent and independent systems of vectors

5.1. Cross product and its main properties.
5.2. Scalar triple product of three vectors, coplanarity of vectors.
5.3. Linearly dependent and independent systems of vectors.

Lecture 6. Analytic geometry in space. Plane in space

6.1. Equation of a surface in space.
6.2. Equation of a line in space.
6.3. General equation of a plane.
6.4. Intercept form of the equation of a plane.
6.5. Relative position of two planes.
6.6. Equation of a plane passing through three given points.

Lecture 7. Planes in space. Normal equation of a plane

7.1. Normal equation of a plane. Distance from a point to a plane.
7.2. Pencil of planes.
7.3. Bundle of planes.
7.4. Relative position of three planes in space.

Lecture 8. Straight line in space. Line and plane in space. Straight line in the plane

8.1. Types of equations of a line in space.
8.2. Relative position of two lines in space.
8.3. Position of a line relative to a plane.
8.4. General equation of a line.
8.5. Types of equations of a line.
    8.5.1. Intercept form of the equation of a line.
    8.5.2. Vector equation of a line.
    8.5.3. Canonical and parametric equations of a line.
    8.5.4. Slope-intercept equation of a line.
    8.5.5. Normal equation of a line.
8.6. Relative position of two lines in the plane. Angle between lines.

Lecture 9. Second-order curves in the plane

9.1. Circle, ellipse.
9.2. Hyperbola and its construction.
9.3. Parabola and its canonical equations.

Lecture 10. Introduction to mathematical analysis. Number sets. Numerical sequences

10.1. Number sets.
10.2. The concept of a numerical sequence and its limit.
    10.2.1. The concept of a sequence.
    10.2.2. Limit of a sequence.
10.3. Infinitesimal and infinitely large sequences.

Lecture 11. Function. Limit of a function at a point

11.1. Function. Basic concepts and definitions. Basic elementary functions.
11.2. Limit of a function at a point.
11.3. Infinitesimal and infinitely large functions. Important limits.
11.4. Continuous functions.

Lecture 12. Important limits. Continuity of a function

12.1. Limit of a function as $x \to \infty$.
12.2. Important limits.
12.2.1. The first important limit.
12.2.2. The second important limit.
12.3. Comparison of infinitesimal functions.
12.4. Continuity of a function at a point. Points of discontinuity.
12.5. Main theorems on continuous functions.

Lecture 13. Differential calculus of functions of one variable. Derivative of a function of one variable

13.1. The concept of a derivative. Geometric meaning of the derivative.
13.2. Continuity and differentiability of a function.
13.3. Differentiation rules. Derivatives of basic elementary functions.
13.4. Differentiation of a composite function.
13.5. Derivative of an inverse function. Differentiation of inverse trigonometric functions.
13.6. Table of derivatives. Examples of applying the main differentiation formulas.
13.7. Differentiation of functions given in parametric and implicit forms.
13.8. Logarithmic differentiation. Derivative of a power-exponential function.

Lecture 14. Derivative and differential of a function

14.1. Higher-order derivatives.
14.2. Differential of a function and its properties.
14.3. Higher-order differentials.
Main theorems of differential calculus
14.4. Mean value theorems of differential calculus.
14.5. L'Hôpital's rule.
14.6. Taylor's formula.

Lecture 15. Application of differential calculus to the investigation of a function

15.1. Application of the derivative to investigating the monotonicity of functions.
15.2. Finding extrema of functions.
15.3. Maximum and minimum values of a function on a closed interval.
15.4. Convexity of the graph of a function. Points of inflection.
15.5. Finding asymptotes of the graph of a function.
15.6. General scheme for investigating a function.

In practical classes – assignments (according to the list of main literature given above)

List of practical classes (indicative)

Practical class 1.	Calculation of determinants. Cramer's rule.
Practical class 2.	Matrices and operations on them. Construction of the inverse matrix.
Practical class 3.	Solving systems of linear algebraic equations by the matrix method.
Practical class 4.	Solving systems of linear algebraic equations by the Gauss method.
Practical class 5.	Investigating an algebraic system for consistency and constructing the general solution of the system.
Practical class 6.	Solving systems of linear homogeneous algebraic equations. Solving SLAEs.
Practical class 7.	Analysis of SLAEs. Vectors in space. Dot product.
Practical class 8.	Cross product and scalar triple product. Basis, decomposition of a vector in terms of basis vectors.
Practical class 9.	Various types of equations of a straight line.
Practical class 10.	Normal equation of a line. Distance from a point to a line.

Practical class 11.	Plane in space, general equation.
Practical class 12.	Normal equation of a plane.
Practical class 13.	Solving typical problems (review of the CGW, elements of linear algebra, elements of analytic geometry).
Practical class 14.	Straight line in space. Line and plane.
Practical class 15.	Second-order curves in the plane. Ellipse, hyperbola.
Practical class 16.	Second-order curves in the plane. Parabola. Polar equations.
Practical class 17.	Revision. Test on the topic "Elements of Vector Algebra and Analytic Geometry".
Practical class 18.	Calculating limits of numerical sequences. Review of the test.
Practical class 19.	The first remarkable limit. Corollaries. The second remarkable limit. Corollaries.
Practical class 20.	Calculating limits. Equivalent infinitesimals.
Practical class 21.	Basic equivalences. Investigating a function for continuity.
Practical class 22.	Calculating the derivative of a function of one variable. Derivative of a product and a quotient.
Practical class 23.	Derivative of an implicitly defined function. Derivative of a parametrically defined function.
Practical class 24.	Power-exponential function. Logarithmic derivative.
Practical class 25.	Calculating limits using L'Hôpital's rule. Applications of the derivative to problems of geometry and mechanics.
Practical class 26.	Taylor's formula. Applied problems.
Practical class 27.	*Application of differential calculus to the investigation of a function.*
Practical class 28.	Convexity of the graph of a function. Points of inflection. Finding asymptotes of the graph of a function. General scheme for investigating a function.
Practical class 29.	Test on the topic "Function of One Variable".
Practical class 30.	Review of the test. Complete investigation of a function and plotting its graph.

6. Student's independent work

Students' independent work includes consolidating and deepening knowledge from the lecture materials, independent study of selected topics using the recommended teaching materials, preparation for practical classes, completion of a home control work, and completion of the calculation and graphic work (divided into two parts according to the scheduled semester attestations).

Policy and Control

7. Course policy (educational component)

The following requirements apply to students:

- ***attendance rules:***
  - *do not be late for classes; if more than 15 minutes late, enter in the second half of the class so as not to distract others; notify the teacher in advance about missing a class for a valid reason or due to illness (confirm with a copy of a medical certificate);*
  - *in distance learning mode: Zoom conference via the teacher's link;*
- ***rules of conduct in class:***
  - *engaging in any activity not directly related to the course or to maintaining health is prohibited;*
  - *the use of communication devices to search the Internet or the Moodle distance learning platform for information needed to complete assignments is allowed;*
  - *disrupting classes in any way is prohibited;*
- ***rules for awarding bonus and penalty points:***

- *penalty points are given for late completion and defence of the CGW; bonus points are given for activity in practical classes;*
- *the maximum number of bonus and penalty points is determined in accordance with the Regulations on the System for Assessing Learning Outcomes at Igor Sikorsky Kyiv Polytechnic Institute, the Regulations on Current, Calendar and Semester Control of Learning Outcomes at Igor Sikorsky Kyiv Polytechnic Institute, and other regulations and recommendations in force at Igor Sikorsky Kyiv Polytechnic Institute;*

- ***assessment policy for control measures:***
  - *control measures are assessed in accordance with the Regulations on the System for Assessing Learning Outcomes at Igor Sikorsky Kyiv Polytechnic Institute, the Regulations on Current, Calendar and Semester Control of Learning Outcomes at Igor Sikorsky Kyiv Polytechnic Institute, and other regulations and recommendations in force at Igor Sikorsky Kyiv Polytechnic Institute;*
  - *the lower limit of a positive assessment for each control measure must be at least 60% of the points allocated to that control measure;*
  - *a negative result is assessed as 0 points.*

Academic Integrity

The policy and principles of academic integrity are defined in Section 3 of the Code of Honour of Igor Sikorsky Kyiv Polytechnic Institute. More details: https://kpi.ua/code.

Norms of Ethical Behaviour

The norms of ethical behaviour of students and staff are defined in Section 2 of the Code of Honour of Igor Sikorsky Kyiv Polytechnic Institute. More details: https://kpi.ua/code.

Appeals against Control Measure Results

Students have the right to raise any issue related to the procedure for conducting or assessing control measures and to expect it to be considered by a commission.

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

Current control (maximum score – 50 points):

– writing thematic control works (TCW 1, TCW 2);

– writing the modular control work (MCW parts 1, 2);

– writing and defending the calculation and graphic work (CGW parts 1, 2);

Table of correspondence between rating points and types of current control.

Type of current control	*Maximum possible number of points*
TCW 1, TCW 2	10 points (5+5)
MCW (parts 1, 2)	20 points (10+10)
CGW (parts 1, 2)	20 points (10+10)

Scoring criteria:

1. Completion of the thematic control work.

Thematic control works (TCW 1, TCW 2) are conducted on the topics of the section "Elements of Linear Algebra and Analytic Geometry".

"excellent" – 5 points – The tasks are completed correctly and contain all the necessary calculations and explanations.

"good" – 4–4.5 points – The tasks are completed correctly, but there are shortcomings. In particular, correct approaches to the solution are used, but explanations are completely missing, there are calculation errors, etc. However, these shortcomings indicate insufficient attention while completing the task rather than a lack of knowledge and skills.

"satisfactory" – 3–3.5 points – The tasks are completed partially or with some errors. In particular, a formula is written incorrectly, which leads to a wrong answer, or there are significant errors in transforming analytical expressions. However, the generally correct approach to solving the tasks is shown.

"unsatisfactory" – 0–2.5 points – The tasks are completed incorrectly or with significant errors (less than 60% of the meaningful steps are performed correctly).

2. Completion of the modular control work.

The modular control work (MCW) consists of two parts and covers the topics of the sections "Elements of Linear Algebra and Analytic Geometry" and "Differential Calculus of a Function of One Variable". The modular control work contains a theoretical and a practical part.

"excellent" – 9.5–10 points – The answer to the theoretical questions is complete and correct and contains the necessary explanations, analytical expressions and graphs. The practical tasks are completed correctly and contain all the necessary calculations and explanations.

"good" – 7.5–9 points – The answer to the theoretical questions is sufficiently complete and correct and contains the necessary explanations, analytical expressions and graphs. However, the analytical expressions do not include explanations of their components, the graphs lack the necessary labels, and the answer is not illustrated with an example. The practical tasks are completed correctly and correct approaches to the solution are used, but explanations are completely missing, there are calculation errors, etc. Thus, the tasks are not complete enough, but at least 75% of the essential content is presented.

"satisfactory" – 6–7 points – The answer to the theoretical questions is correct but incomplete. Some necessary analytical expressions or graphs are missing. The answer contains a significant amount of information that corresponds to the general topic of the question but does not specify the aspects stated in the question itself. The practical tasks are completed partially or with some errors. In particular, a formula is written incorrectly, which leads to a wrong answer, or there are significant errors in transforming analytical expressions. However, the generally correct approach to solving the tasks is shown. The answer is at least 60% complete in terms of essential content.

"unsatisfactory" – 0–5 points – The answer to the theoretical questions contains less than 60% of correct and meaningful information. Key explanations and important analytical expressions are missing. The practical tasks are completed incorrectly or with significant errors (less than 60% of the meaningful steps are performed correctly).

3. Completion of the calculation and graphic work.

The calculation and graphic work (CGW) consists of two parts and covers the topics of the sections "Introduction to Mathematical Analysis" and "Differential Calculus of a Function of One Variable". A defence of the calculation and graphic work is required. A student is admitted to the defence provided that all tasks are completed correctly, with possible minor shortcomings and errors.

"excellent" – 9.5–10 points – The tasks are completed correctly and contain all the necessary calculations and explanations.

"good" – 7.5–9 points – The tasks are completed correctly and correct approaches to the solution are used, but explanations are completely missing, there are calculation errors, etc. Thus, the tasks are not complete enough, but at least 75% of the essential content is presented.

"satisfactory" – 6–7 points – The tasks are completed partially or with some errors. In particular, a formula is written incorrectly, which leads to a wrong answer, or there are significant errors in transforming analytical expressions. However, the generally correct approach to solving the tasks is shown. The answer is at least 60% complete in terms of essential content.

"unsatisfactory" – 0–5 points – The tasks are completed incorrectly or with significant errors (less than 60% of the meaningful steps are performed correctly).

Calendar control is carried out twice a semester to monitor the current status of meeting the syllabus requirements.

Table of correspondence between attestation dates and the conditions for receiving attestation.

Attestation date	*Conditions for receiving attestation*	
	Current rating	*Current control measure*
Week 7	≥ 50% of the maximum possible number of points at that moment	TCW 1, TCW 2 MCW (part 1)
Week 13	≥ 50% of the maximum possible number of points at that moment	TCW 1, TCW 2 MCW (parts 1, 2) CGW (parts 1, 2)

Semester control: exam (maximum score – 50 points).

The exam paper consists of two theoretical questions and three practical tasks. The number of points a student can receive for answering a theoretical question or solving a practical task:

– a complete answer to a theoretical question or a correctly solved practical task – 10 points;

– minor errors in the answer to a theoretical question or in solving a practical task – 6 points;

– an incomplete answer to a theoretical question or errors in solving a practical task – 3 points;

– no answer to a theoretical question or the practical task is not completed – 0 points.

A student's rating for the credit module is determined on a 100-point scale and consists of the points received for all types of current control and the points received at the exam.

Conditions for admission to semester control: a minimum positive grade for the modular control work and the calculation and graphic work. The semester rating is at least 36 points.

Current control: express surveys, surveys on the topic of the class, writing control works, test.
Calendar control: carried out twice a semester to monitor the current status of meeting the syllabus requirements.
Semester control: exam.
Conditions for admission to semester control: credit for the calculation and graphic work, semester rating of at least 36 points.
Exam retakes take place within the period set by the dean's office.

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

Number of points	*Grade*
100-95	Excellent
94-85	Very good

84-75	Good
74-65	Satisfactory
64-60	Sufficient
Less than 60	Unsatisfactory
Admission conditions not met	Not admitted

9. Additional information on the course (educational component)

List of questions for semester control:

1. The concept of a matrix. Operations on matrices.

2. The concept of a matrix determinant. Properties of determinants.

3. Calculation of second-, third- and higher-order determinants.

4. Rank of a matrix. Inverse matrix.

5. Systems of linear algebraic equations.

6. The Gauss method of successive elimination of variables.

7. Cramer's formulas.

8. Matrix form of a system of linear equations.

9. The concept of a set. Operations on sets.

10. Complex numbers. Operations on complex numbers.

11. The concept of a function. Ways of defining a function. Graph of a function.

12. Classification of functions: bounded, monotonic, periodic, even and odd.

13. The concept of a composite function.

14. The concept of an inverse function.

15. Basic elementary functions and their graphs.

16. The concept of a numerical sequence. Limit of a numerical sequence. Convergent and divergent sequences.

17. The concept of a subsequence.

18. Monotonic sequence.

19. The concept of a partial limit of a sequence. Lower and upper limits of a sequence. Cauchy criterion for the convergence of a sequence.

20. The concept of the limit of a function. Criterion for the existence of a limit. Properties of limits.

21. Limit of a monotonic function. The first remarkable limit.

22. Infinitesimal functions. Infinite limit and infinitely large functions.

23. The concept of a continuous function. Continuity criterion. Arithmetic operations on continuous functions.

24. Continuity of a composite function.

25. One-sided continuity. Points of discontinuity of a function and their classification.

26. Properties of functions continuous on a closed interval. Uniform continuity.

27. Inverse function and its continuity.

28. General power, exponential and logarithmic functions and their continuity. The second remarkable limit.

29. The concept of a matrix. Elements of a matrix. Dimension of a matrix.

30. Operations on matrices: multiplication of a matrix by a number, addition, subtraction and multiplication of matrices.

31. Cartesian coordinates in the plane.

32. Straight line. Division of a segment in a given ratio.

33. Distance between points. Circle.

34. Polar coordinates.

35. Transformation of coordinates.

36. Cartesian coordinates in space.

37. Types of second-order curves and their properties.

38. Ellipse, hyperbola, parabola and their construction.

39. Reduction of general equations of second-order curves to canonical form.

40. Equations in polar coordinates.

41. Classification of second-order curves.

42. The concept of a vector. Operations on vectors: addition of vectors and multiplication of a vector by a number. Coordinates of a vector.

43. Dot product of vectors.

44. Cross product of vectors.

45. Scalar triple product of vectors.

46. Equation of a straight line in the plane.

47. Slope-intercept equation of a line.

48. Intercept form of the equation of a line.

49. General equation of a line.

50. Conditions for parallelism and perpendicularity of two lines.

51. Angle between lines.

52. Distance from a given point to a line.

53. Distance between two points.

54. Equation of a line passing through two points.

55. Equation of a line passing through a given point parallel or perpendicular to a given vector.

56. General equation of a plane. Investigation of the general equation of a plane.

57. Equation of a plane passing through three points.

58. Distance from a point to a plane.

59. Conditions for parallelism and perpendicularity of two planes.

60. Angle between planes.

61. Equation of a line in space.

62. Line and plane in space.

63. Distance from a point to a line.

64. Relative position of two lines.

65. Distance between two lines.

66. Various types of second-order surfaces.

67. Transformation of the general equation of a surface.

68. Classification of second-order surfaces.

69. Rectilinear generators of second-order surfaces.

70. Problems leading to the concept of a derivative.

71. Definition of a derivative, its geometric and mechanical meaning.

72. Basic rules of differentiation of functions.

73. Derivative of a composite function.

74. Derivative of an inverse function.

75. Derivatives of elementary functions.

76. Derivative of a parametrically defined function.

77. Higher-order derivatives.

78. Application of the derivative to the investigation of a function: finding the maximum and minimum values of a function on a given interval, intervals of monotonicity (decrease and increase), extrema of a function, intervals of convexity and points of inflection.

79. The concept of the differential of a function.

80. Rules for calculating the differential.

81. Higher-order differentials.

82. Application of differentials to approximate calculations.

83. Main theorems of differential calculus. Theorems of Fermat, Rolle, Lagrange and Cauchy.

84. Taylor's formula. Expansion of a function by Taylor's formula.

85. Resolving indeterminate forms. L'Hôpital's rules.

86. Asymptotes. Complete investigation of a function and plotting its graph.

Working program of the academic discipline (syllabus):

Compiled by
Associate Professor of the Department of Mathematical Physics and Differential Equations, Faculty of Physics and Mathematics, PhD (Physics and Mathematics), Associate Professor Olha Sulima
Approved by the Department of Mathematical Physics and Differential Equations, Faculty of Physics and Mathematics (minutes No. 10 of 24.06.2026)

Agreed by the Methodical Commission of the Faculty of Robotics and Instrument Engineering (minutes No. 6/26 of 26.06.2026)