INTERNATIONAL EUROPEAN UNIVERSITY
Education and Research Institute "European Business School"
Department of Information Technology

Approved by
The Scientific and Methodical Council of the University, protocol dd._____, 2023, No. _____

Chair of SMC _____

WORKING PROGRAM OF THE ACADEMIC DISCIPLINE:

LINEAR ALGEBRA AND ANALYTIC GEOMETRY

Knowledge area: 12 Information Technology

Specialty: 121 Software Engineering

Educational program: 121 Software Engineering

Discipline status: Compulsory

Kyiv – 2023

The working program of the Linear algebra and analytic geometry academic discipline is based on the 121 Software Engineering educational and professional program for the first (Bachelor) level of the 121 Software Engineering specialty approved by the University Academic Council on May 30, 2023, protocol No. 4.

Developer: Maryna Semeniuta, PhD in Physics and Mathematics, associate professor

Reviewers: Ivan Kazachkov, Doctor of Science (Techn.), professor
Zoia Sherman, PhD in Physics and Mathematics, associate professor

Guarantor of the educational program: Oleksandr Nesterenko, Doctor of Science (Techn.), professor

The working program of the academic discipline is reviewed and approved by the Department of Information Technology, protocol dd. August 31, 2023, No. 1.

Head of the Department  O.V. Nesterenko, Doctor of Science (Techn.), professor

The program is reviewed and approved by the Academic Council of the European Business School, protocol dd. September 11, 2023, No. 1.

Chair of the Academic Council _____ Y.S. Remyha, PhD in Economics, associate professor, Acting Director of the European Business School

Registration No.__8/23__

INTRODUCTION

The **program of the Linear algebra and analytic geometry academic discipline** is designed according to the Higher Education Standard of Ukraine (hereinafter referred to as the Standard) of the knowledge area: 12 Information Technology, specialty: 121 Software Engineering.

Discipline description (annotation). This academic discipline is an obligatory component of the Software engineering educational program for future software developers.

Table1

<table>
<tr><td rowspan="2">Criteria</td><td rowspan="2">Knowledge area, training program, educational level</td><td colspan="2">Discipline characteristics</td></tr>
<tr><td>full-time mode of study</td><td>part-time mode of study</td></tr>
<tr><td>Number of credits – 4</td><td>Knowledge area:
12 INFORMATION TECHNOLOGY</td><td colspan="2"><u>Compulsory</u></td></tr>
<tr><td>Sections – X</td><td rowspan="8">Specialty:
121 SOFTWARE ENGINEERING</td><td colspan="2">Year of training</td></tr>
<tr><td>Content sections – 2</td><td>2023-2024</td><td></td></tr>
<tr><td rowspan="2">Individual research task:</td><td colspan="2">Semester</td></tr>
<tr><td>1st</td><td></td></tr>
<tr><td rowspan="4">Weekly load:
class hours – 4
independent work of students – 6</td><td colspan="2">Lectures</td></tr>
<tr><td>24 hours</td><td></td></tr>
<tr><td colspan="2">Practical classes</td></tr>
<tr><td>24 hours</td><td></td></tr>
<tr><td rowspan="4">Educational level:
Bachelor</td><td colspan="2">Independent work</td></tr>
<tr><td>72 hours</td><td></td></tr>
<tr><td colspan="2">Type of control:</td></tr>
<tr><td>Pass/Fail test</td><td></td></tr>
</table>

Subject matter of the academic discipline: methods and models of linear algebra and analytic geometry.

Interdisciplinary links: the program is arranged according to the annotation of the educational and professional program of Bachelor training and is based on the school course in mathematics, as well as precedes the study of such compulsory disciplines as Computer discrete mathematics, Basics of programming, Mathematical analysis, Database organization, Mathematical foundations of software engineering.

The knowledge obtained while studying the Linear algebra and analytic geometry discipline is the foundation for mastering professional training disciplines as well as can be applied during on-the-job practical training, preparation of term papers and qualifying papers on the specialty.

1. GOAL AND OBJECTIVES OF THE ACADEMIC DISCIPLINE

1.1. The **goal** of the Linear algebra and analytic geometry discipline is to provide students with basic knowledge of basics of matrix numbering, vector algebra, analytical geometry in the plane and in space; the ability to solve various problems and apply acquired knowledge to study professional disciplines.

1.2. **Key objectives** of the Linear algebra and analytic geometry discipline are to provide students with logical thinking; contemporary theoretical knowledge in algebraic and geometric methods of solving mathematical problems; application of this knowledge to solve applied problems; ability to independently use and study the literature on mathematics, as well as the development of their intellect, creative independence.

1.3. **Competencies and learning outcomes** encouraged by the discipline (interrelation with the statutory content of student training stipulated in learning outcome terms of the Standard).

According to the Standard requirements, the discipline provides students with the following ***competencies*** (Table 2):

Table 2

Integral competence	Ability to solve complicated specialized tasks and practical problems in software development characterized by complexity and uncertainty of conditions.
General competencies	Ability to abstract thinking, analysis and synthesis. Ability to learn and acquire contemporary knowledge. Ability to find, process and generalize information from different sources.
Specialized (professional, subject) competencies	Ability to think algorithmically and logically.

Specification of competencies according to the National Qualifications Framework descriptors in the Competency matrix form:

Table 3

No.	Competence	Knowledge	Skills / Abilities	Communication	Autonomy and responsibility
Integral competence					
1.	Ability to solve complicated specialized tasks and practical problems in software development characterized by complexity and uncertainty of conditions.	Experience in using methods and models of linear algebra and analytic geometry in different industries.	Use mathematical apparatus, mathematical methods and models of linear algebra and analytic geometry to solve practical problems.	Human-machine interaction	Independent construction of mathematical models and approbation on the production site
General competencies					

2.	Ability to abstract thinking, analysis and synthesis. Ability to learn and acquire contemporary knowledge. Ability to find, process and generalize information from different sources.	basic mathematical apparatus, principles of designing mathematical models.	mathematically investigate applied problems.	Relation between theoretical and practical knowledge	Monitoring of information processing processes
Specialized (professional, subject) competencies					
3.	Ability to think algorithmically and logically.	mathematical methods and models of linear and vector algebra, analytical geometry.	to solve the set mathematical problems; independently study and learn the mathematical apparatus found in the special literature necessary for mastering the profession, choose the optimal methods of solving problems, carry out interpretation and evaluation of the results; choose and use the necessary computational tools.	to apply mathematical methods and models in professional activities	Description of information processes

Integrated final program learning outcomes encouraged by the academic discipline:

Program learning outcomes	To analyze, intentionally search for and select information and reference resources and knowledge required to solve professional problems, taking into account current scientific and technological achievements. To know and apply appropriate mathematical concepts, methods of domain, system and object-oriented analysis and mathematical modeling for software development.

Learning outcomes:

After learning the discipline, students should

know:

- basic concepts and methods of solving typical problems of linear algebra and analytic geometry;
- the role and place of linear algebra and analytic geometry in modern information

and communication space and professional activities of a specialist;
- methods of linear algebra and analytic geometry for the study of applied problems.

be able to:
- solve the set mathematical problems;
- independently study and recognize mathematical apparatus found in special literature necessary for mastering the profession;
- investigate applied problems mathematically;
- choose optimal methods of problem solving, interpret and evaluate results; choose and use necessary computing tools.

2. INFORMATION CAPACITY OF THE ACADEMIC DISCIPLINE

SECTION 1

CONTENT SECTION 1.
ELEMENTS OF LINEAR ALGEBRA

Topic 1.1. Matrices and determinants. Matrix equations.
Topic 1.2. Systems of linear equations. Matrix method of solving systems of linear equations. Cramer's formulas.
Topic 1.3. Gauss method for solving a system of linear equations. Rank. Compatibility criterion for a system of linear equations. Homogeneous systems of linear equations. Fundamental system of solutions.

CONTENT SECTION 2.
ELEMENTS OF VECTOR ALGEBRA AND ANALYTIC GEOMETRY

Topic 2.1. Vector, basic concepts. Actions on vectors, their properties.
Topic 2.2. Scalar, vector and mixed products of vectors.
Topic 2.3. Method of coordinates in the plane and space. Various coordinate systems.
Topic 2.4. A straight line in the plane.
Topic 2.5. Plane and straight line in space.
Topic 2.6. Curves and surfaces of the second order.

Content sections and topics	Amount of hours			
	Total	including		
		Lectures	Practical classes	Independent work
Section 1.				
Content section 1. Methods and models of linear algebra				

Topic 1.1. Matrices and determinants. Matrix equations.	12	2	2	8
Topic 1.2. Systems of linear equations. Matrix method of solving systems of linear equations. Cramer's formulas.	12	2	2	8
Topic 1.3. Gauss method for solving a system of linear equations. Rank. Compatibility criterion for a system of linear equations. Homogeneous systems of linear equations. Fundamental system of solutions.	16	4	4	8
Content section 2: Methods and models of vector algebra and analytic geometry				
Topic 2.1. Vector, basic concepts. Actions on vectors, their properties.	12	2	2	8
Topic 2.2. Scalar, vector and mixed products of vectors.	12	2	2	8
Topic 2.3. Method of coordinates in the plane and space. Various coordinate systems.	12	2	2	8
Topic 2.4. A straight line in the plane.	12	2	2	8
Topic 2.5. Plane and straight line in space.	16	4	4	8
Topic 2.6. Curves and surfaces of the second order.	16	4	4	8
Total per section 1	120	24	24	72

4. TOPICS OF LECTURES

No.	Topics and list of key questions
1	MATRICES AND DETERMINANTS. MATRIX EQUATIONS. Matrices, main concepts. The determinant of a matrix, calculation of determinants of arbitrary order. Matrix equation and method of its solution.
2	SYSTEMS OF LINEAR EQUATIONS. MATRIX METHOD OF SOLVING SYSTEMS OF LINEAR EQUATIONS. CRAMER'S FORMULAS. Systems of linear equations, basic definitions. Methods of solving nondegenerate systems of linear equations: matrix method, Cramer's formulas.
3	GAUSS METHOD FOR SOLVING A SYSTEM OF LINEAR EQUATIONS. RANK. COMPATIBILITY CRITERION FOR A SYSTEM OF LINEAR EQUATIONS. HOMOGENEOUS SYSTEMS OF LINEAR EQUATIONS. FUNDAMENTAL SYSTEM OF SOLUTIONS. Gauss method for solving an arbitrary system of linear equations. The rank of a matrix. Kronecker-Capelli theorem. Homogeneous systems of linear equations. Fundamental system of solutions.
4	VECTOR, BASIC CONCEPTS. ACTIONS ON VECTORS, THEIR PROPERTIES. The concept of vector. Actions on vectors. Vector projection on an axis. Linear combination of vectors. Linear dependent and independent vectors. Basis. Directional cosines.
5	SCALAR, VECTOR AND MIXED PRODUCTS OF VECTORS. Scalar, vector, mixed product, their properties. Physical content of scalar and vector product. Geometric content of vector and mixed products.

6	Method Of Coordinates In The Plane And Space. Various Coordinate Systems. Athene and rectangular coordinate system in the plane and in space. Division of a segment in a given relation. Polar coordinate system. Cylindrical and spherical coordinates.
7	A STRAIGHT LINE IN THE PLANE. General, canonical and parametric direct equations in the plane. Conditions of parallelism, perpendicularity and angle between two lines. Equation of a straight line with an angular coefficient. Equation of a line passing through 2 points. Equation of a line in segments on axes. The normalized equation of a line. The bundle of a line.
8	PLANE AND STRAIGHT LINE IN SPACE. General equation of plane in space and its study. Equation of the plane in segments. Equation of the plane passing through 3 points. Conditions of parallelism, perpendicularity and angle between two planes. The normalized equation of a plane. Canonical and parametric equation of a line in space. Equation of a line passing through two points. A bundle of planes. Reciprocal arrangement of lines and planes in space.
9	CURVES AND SURFACES OF THE SECOND ORDER. Curves (lines) of the second order: circle, ellipse, hyperbola, parabola. Derivation of their equations and main characteristics. Surfaces of the second order. Sphere. Ellipsoid. Hyperboloids. Paraboloids.

5. TOPICS OF PRACTICAL CLASSES

No.	Topic	Amount of hours
1.	MATRICES AND DETERMINANTS. MATRIX EQUATIONS. Matrices, main concepts. The determinant of a matrix, calculation of determinants of arbitrary order. Matrix equation and method of its solution.	2
2.	SYSTEMS OF LINEAR EQUATIONS. MATRIX METHOD OF SOLVING SYSTEMS OF LINEAR EQUATIONS. CRAMER'S FORMULAS. Systems of linear equations, basic definitions. Methods of solving nondegenerate systems of linear equations: matrix method, Cramer's formulas.	2
3.	GAUSS METHOD FOR SOLVING A SYSTEM OF LINEAR EQUATIONS. RANK. COMPATIBILITY CRITERION FOR A SYSTEM OF LINEAR EQUATIONS. HOMOGENEOUS SYSTEMS OF LINEAR EQUATIONS. FUNDAMENTAL SYSTEM OF SOLUTIONS. Gauss method for solving an arbitrary system of linear equations. The rank of a matrix. Kronecker-Capelli theorem. Homogeneous systems of linear equations. Fundamental system of solutions.	4
4.	VECTOR, BASIC CONCEPTS. ACTIONS ON VECTORS, THEIR PROPERTIES. The concept of vector. Actions on vectors. Vector projection on an axis. Linear combination of vectors. Linear dependent and independent vectors. Basis. Directional cosines.	2
5.	SCALAR, VECTOR AND MIXED PRODUCTS OF VECTORS. Scalar, vector, mixed product, their properties. Physical content of scalar and vector product. Geometric content of vector and mixed products.	2
6	Method Of Coordinates In The Plane And Space. Various Coordinate Systems. Athene and rectangular coordinate system in the plane and in space. Division of a segment in a given relation. Polar coordinate system. Cylindrical and spherical coordinates.	2

7	A STRAIGHT LINE IN THE PLANE. General, canonical and parametric direct equations in the plane. Conditions of parallelism, perpendicularity and angle between two lines. Equation of a straight line with an angular coefficient. Equation of a line passing through 2 points. Equation of a line in segments on axes. The normalized equation of a line. The bundle of a line.	2
8	PLANE AND STRAIGHT LINE IN SPACE. General equation of plane in space and its study. Equation of the plane in segments. Equation of the plane passing through 3 points. Conditions of parallelism, perpendicularity and angle between two planes. The normalized equation of a plane. Canonical and parametric equation of a line in space. Equation of a line passing through two points. A bundle of planes. Reciprocal arrangement of lines and planes in space.	4
9	CURVES AND SURFACES OF THE SECOND ORDER. Curves (lines) of the second order: circle, ellipse, hyperbola, parabola. Derivation of their equations and main characteristics. Surfaces of the second order. Sphere. Ellipsoid. Hyperboloids. Paraboloids.	4
Total:		24

6. INDEPENDENT WORK

No.	Topic	Amount of hours
1.	MATRICES AND DETERMINANTS. MATRIX EQUATIONS. Matrices, main concepts. The determinant of a matrix, calculation of determinants of arbitrary order. Matrix equation and method of its solution.	8
2.	SYSTEMS OF LINEAR EQUATIONS. MATRIX METHOD OF SOLVING SYSTEMS OF LINEAR EQUATIONS. CRAMER'S FORMULAS. Systems of linear equations, basic definitions. Methods of solving nondegenerate systems of linear equations: matrix method, Cramer's formulas.	8
3.	GAUSS METHOD FOR SOLVING A SYSTEM OF LINEAR EQUATIONS. RANK. COMPATIBILITY CRITERION FOR A SYSTEM OF LINEAR EQUATIONS. HOMOGENEOUS SYSTEMS OF LINEAR EQUATIONS. FUNDAMENTAL SYSTEM OF SOLUTIONS. Gauss method for solving an arbitrary system of linear equations. The rank of a matrix. Kronecker-Capelli theorem. Homogeneous systems of linear equations. Fundamental system of solutions.	8
4.	VECTOR, BASIC CONCEPTS. ACTIONS ON VECTORS, THEIR PROPERTIES. The concept of vector. Actions on vectors. Vector projection on an axis. Linear combination of vectors. Linear dependent and independent vectors. Basis. Directional cosines.	8
5.	SCALAR, VECTOR AND MIXED PRODUCTS OF VECTORS. Scalar, vector, mixed product, their properties. Physical content of scalar and vector product. Geometric content of vector and mixed products.	8
6.	Method Of Coordinates In The Plane And Space. Various Coordinate Systems. Athene and rectangular coordinate system in the plane and in space. Division of a segment in a given relation. Polar coordinate system. Cylindrical and spherical coordinates.	8
7.	A STRAIGHT LINE IN THE PLANE. General, canonical and parametric direct equations in the plane. Conditions of parallelism, perpendicularity and angle between two lines. Equation of a straight line with an angular	8

	coefficient. Equation of a line passing through 2 points. Equation of a line in segments on axes. The normalized equation of a line. The bundle of a line.	
8.	PLANE AND STRAIGHT LINE IN SPACE. General equation of plane in space and its study. Equation of the plane in segments. Equation of the plane passing through 3 points. Conditions of parallelism, perpendicularity and angle between two planes. The normalized equation of a plane. Canonical and parametric equation of a line in space. Equation of a line passing through two points. A bundle of planes. Reciprocal arrangement of lines and planes in space.	8
9.	CURVES AND SURFACES OF THE SECOND ORDER. Curves (lines) of the second order: circle, ellipse, hyperbola, parabola. Derivation of their equations and main characteristics. Surfaces of the second order. Sphere. Ellipsoid. Hyperboloids. Paraboloids.	8
Total:		72

7. TRAINING METHODS

Teaching the Linear algebra and analytic geometry discipline, one uses information and practical training methods: classical lectures, laboratory and practical classes using simulation laboratory workshops, as well as consultations on the accomplishment of independent work of students, written assignments during test works.

Methods of learning and cognitive activity: explanatory and illustrative method, reproductive method, problem presentation method, partially exploratory or heuristic method, research method.

Methods of stimulation and motivation of learning and cognitive activity: inductive and deductive teaching methods; methods of stimulation and motivation of learning.

8. CONTROL METHODS

The plan of the Linear algebra and analytic geometry discipline implies carrying out of current and final control.

Current control is the assessment of the level of knowledge, skills and abilities of students carried out during the educational process by conducting a written survey at the end of sections (module colloquium). Modular control in special situations can be carried out in the form of a computer-based online test with a fixed answer time.

9. FORM OF STUDENT PERFORMANCE FINAL CONTROL

The form of final control is the **Pass/Fail test** taken on-campus (or in the form of computer test in case of a specific situation) in the period stipulated by the Dean's office or according to the individual schedule stipulated by the curriculum.

10. SCORING SYSTEM

Scoring during the semester

No.	Type of activity	Number of points per didactic unit	Number	Total points
1	Testing on lecture materials	3	8	24
3	Accomplishment of independent works	3	12	36
Exam		40		40
Maximum grade				100

General assessment of student knowledge due to current control

The results of current control of student knowledge are assessed in general ranging from **0** to **60** points.

Students are allowed to final control if they fulfil the requirements of the training program and obtain at least **36** points for the current learning activity.

Final assessment of student knowledge

Final assessment of student knowledge is conducted in the form of **exam**.

Knowledge assessment criteria during the exam

Maximum amount of points that can be obtained in the exam is **40** points.

Allocation of assessment points during final control in the academic discipline

Grade in points for current assessment	Grade in points for final assessment	Grade according to the national scale
54-60	36-40	Excellent
45-53	30-35	Good
36-44	24-29	Satisfactory
less than 36	less than 24	Fail

Assessing the answer to the particular question, one takes into account the following gaps and mistakes:

– untidy preparation of work (nonconventional abbreviations, unclear handwriting, use of pencils instead of clear inks) (minus **2** points);

– incorrectness in certain economic categories and definitions (minus **4** points).

Assessment criteria for answers to theoretical questions of the exam card:

1. The full answer to the question rated as ***excellent*** should correspond to the following requirements:

– detailed, comprehensive representation of the content of the given problem;

– full list of economic categories and laws required to reveal the question;

– ability to carry out a comparative analysis of various theories, concepts, approaches and make logical conclusions and generalizations;

– ability to apply methods for the scientific analysis of economic phenomena, processes and characterize their features and forms of appearance;

– demonstration of the ability to express and reason your own attitude to alternative views on this question;

– use of relevant actual and statistical data, knowledge of dates and historical periods that prove key points of the answer.

2. The answer to the question is rated as ***good*** if:

– the answer for the highest grade does not reveal at least one of the above-mentioned points (if it is definitely required to reveal the question comprehensively), or if:

– revealing the question correctly in general according to the above-mentioned requirements, one makes some mistakes while using digital materials.

3. The answer to the question is rated as ***satisfactory*** if:

– the answer for the highest grade does not reveal four and more points specified in its requirements (if they are required to reveal the question comprehensively);

– there are four or more gaps characterizing individually assessment criteria;

– conclusions made during the answer do not correspond to correct or generally defined ones with the absence of evidence for opposite facts given in the answer;

– the character of the answer gives reason to state that persons fail to understand the question properly or do not know the correct answer, and that is why fail to answer in actual fact, making serious mistakes.

Taking into account the above-said, the exam results are assessed between **0** and **40** points. Besides, if the answer is rated as less than 30%, students receive the fail grade due to the exam results and the fail overall final grade.

The overall final grade in the discipline consists of the sum of points for the results of knowledge current control and for accomplishment of tasks defined for the exam.

The overall final grade cannot exceed **100 points**.

The overall final grade in points according to the national and ECTS scales is put into the examination and test register, academic card and credit book of students.

National and ECTS grading scale

<table>
<tr><td rowspan="2">Sum of points for all types of educational activities</td><td rowspan="2">ECTS grade</td><td colspan="2">Grade according to the national scale</td></tr>
<tr><td>for exam, term paper, practical training</td><td>for Pass/Fail test</td></tr>
<tr><td>90-100</td><td>A</td><td>excellent</td><td rowspan="5">pass</td></tr>
<tr><td>82-89</td><td>B</td><td rowspan="2">good</td></tr>
<tr><td>74-81</td><td>C</td></tr>
<tr><td>66-73</td><td>D</td><td rowspan="2">satisfactory</td></tr>
<tr><td>60-65</td><td>E</td></tr>
<tr><td>30-59</td><td>FX</td><td>fail with possible repeated pass</td><td>fail with possible repeated pass</td></tr>
<tr><td>1-29</td><td>F</td><td>fail with obligatory repeated learning of the discipline</td><td>fail with obligatory repeated learning of the discipline</td></tr>
</table>

11. METHODICAL SUPPORT:

- working program of the discipline;
- electronic course with lectures, guidelines to practical classes, tests and materials for independent work of students;
- list of questions for the exam.

12. RECOMMENDED READING

1. Mathematics at a technical university [Electronic resource]: textbook / I.V. Alieksieieva, V.O. Haidei, O.O. Dykhovychnyi, L.B. Fedorova; edited by O. I. Klesov; Igor Sikorsky Kyiv Polytechnic Institute. – Electronic text data (1 file, 4.01 Mbyte) – Kyiv: Igor Sikorsky KPI, 2018. – V. 1. – 496 p. https://ela.kpi.ua/handle/123456789/24338

2. Analytic geometry and linear algebra: lecture notes for students of technical faculties / Compiled by: Ordynska Z.P., Orlovskyi I.V., Runovska M.K. – K.: NTUU "KPI", 2014. – 176 p.

3. Linear algebra and analytic geometry: Workshop / I.V. Alieksieieva, V.O. Haidei, O.O. Dykhovychnyi, L.B. Fedorova. - K.: NTUU "KPI", 2013. – 180 p.

4. Higher mathematics: Collection of problems: study guide / Compiled by: V.P. Dubovyk, I.I. Yuryk, I.P. Vovkodav, et al. – K.: Ignatex-Ukraine, 2011. – 480 p. https://ela.kpi.ua/handle/123456789/16403

5. Linear algebra and analytic geometry: Study guide / V.V. Buldyhin, I.V. Alieksieieva, V.O. Haidei, O.O. Dykhovychnyi, N.R. Konovalova, L.B. Fedorova; edited by Prof. V.V. Buldyhin. – K.: TViMS, 2011. – 224 p. https://ela.kpi.ua/handle/123456789/16193

6. Buldyhin V.V., Zhuk V.A., Rushchytska S.O., Yasinskyi V.V. Collection of analytic geometry and vector algebra problems / V.V. Buldyhin, V.A. Zhuk, S.O. Rushchytska, V.V. Yasinskyi. – K.: Higher School, 1999. – 192 p.

7. Analytic geometry. Linear algebra: Collection of tasks for typical calculation work for first-year students of technical faculties / Compiled by: Konovalova N.R., Baranovska H.H. et al. – K.: Polytechnic Publishing Center, 2001.

Additional literature

8. Dubovyk V.P., Yuryk I.I. Higher mathematics: study guide for university students / V.P. Dubovyk, I.I. Yuryk. – K.: Ignatex-Ukraine, 2011. – 648 p.

9. Zhyltsov O.B., Torbin H.M. Higher mathematics with elements of information technologies: Study guide. – K.: IAPM, 2002. – 408 p.

10. Diuzhenkova L.I., Diuzhenkova O.Y., Mykhalin H.O. Higher mathematics. Examples and problems: Guide. – K.: Academy, 2002. – 624 p.

11. Higher mathematics workshop: Study guide for university students / I.I. Yurtin, O.Y. Diuzhenkova, O.B. Zhyltsov, et al.; edited by I.I. Yurtin. – K.: IAPM, 2003. – 248p.