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MINISTRY OF SCIENCE AND HIGHER EDUCATION OF THE RUSSIAN FEDERATION
Federal State Autonomous Educational Institution
Higher Education
"NORTH CAUCASUS FEDERAL UNIVERSITY"

APPROVED BY
Acting Director of the Institute
Advanced Engineering
Cand. Tech. Sci., Associate Professor
A.A. Porokhnya

DISCIPLINE ASSESSMENT TOOLS FUND
Linear Algebra

Field of study	11.03.02 Infocommunication Technologies and Communication Systems
Profile	Intelligent Data Processing in Infocommunication Systems and Networks
Year of start of training	<u>2026</u>
Form of study	<u>Full-time</u>
Implemented in a semester	<u>1</u>

Introduction

1. Purpose

The fund of assessment tools for the discipline "Linear Algebra" is designed for an objective assessment of the level of competence formation.

2. FOS is an appendix to the program of the discipline "Linear Algebra".

3. Developer L.V. Andrukhiv, Associate Professor of the Department of Mathematical Modeling of the Faculty of Mathematics and Computer Science named after Professor M.I. Chervyakov, Cand. ped. Sci.

4. An examination of the FOC was carried out.

Members of the expert group:

Chairman: V.P. Mochalov, Professor of the Department of Digital, Robotic Systems and Electronics of the Institute of Advanced Engineering.

Members of the Commission:

S.V. Yakovlev, Associate Professor of the Department of Digital, Robotic Systems and Electronics of the Institute of Advanced Engineering.

S.V. Melnikov, Senior Researcher of the Interdisciplinary Training and Research Center for Agricultural Technologies, Associate Professor of the Department of Digital, Robotic Systems and Electronics of the Institute of Advanced Engineering.

Representative of the employer's organization:

Mironov V.A., General Director of Orintex LLC.

Expert opinion: The FAT for the discipline allows you to assess the level of competence formation. Start approbation.

5. The validity period of the FAT is determined by the period of implementation of the educational program.

1. Description of indicators and assessment criteria at various stages of their formation, description of assessment scales

Competency(s), indicator(s)	Levels of competence formation			
	The minimum level has not been reached (Unsatisfactory) 2 points	Minimum level (satisfactory) 3 points	Intermediate level (good) 4 points	High level (excellent) 5 points
Competence: OPK-1. Able to use the provisions, laws and methods of natural sciences and mathematics to solve problems of engineering activities. OPK-1-				
ID-1 OPK-1 understands the fundamental laws of nature and the basic physical mathematical laws and methods of accumulating, transmitting and processing information.	Does not use basic information and mathematical methods	Poorly uses basic information and mathematical methods	Uses basic information and mathematical methods quite fully	Widely uses basic information and mathematical methods
ID-2 OPK-1 applies physical laws and mathematical methods to solve problems of a theoretical and applied nature.	Does not use basic information and mathematical methods	Poorly uses basic information and mathematical methods	Uses basic information and mathematical methods quite fully	Widely uses basic information and mathematical methods
ID-3 OPK-1 uses the knowledge of physics and mathematics to solve practical problems.	Has difficulty applying logical thinking in practice, uses information and mathematical knowledge.	Makes mistakes, applying logical thinking in practice and using information and mathematical knowledge.	In general, he successfully applies logical thinking in practice, uses information and mathematical knowledge.	Successfully applies logical thinking in practice, uses information and mathematical knowledge.

ASSESSMENT TOOLS FOR CHECKING THE LEVEL OF COMPETENCE FORMATION

Job Number	Correct answer	Content of the question	Competence
1.	Yes	Are the matrices $\begin{pmatrix} 7 & -12 \\ -4 & 7 \end{pmatrix}$ and $\begin{pmatrix} 26 & 45 \\ 15 & 26 \end{pmatrix}$?	OPK-1
2.	11	How many inversions does a substitution contain? $\begin{pmatrix} 32 & 14 & 43 & 56 & 20 \\ 27 & 59 & 44 & 31 & 12 \end{pmatrix}$	OPK-1
3.	2	Find the rank of the matrix $A = \begin{pmatrix} 0 & 2 & -4 \\ -1 & -4 & 5 \\ 3 & 1 & 7 \\ 2 & 3 & 0 \end{pmatrix}$.	OPK-1
4.	Yes	Is a system of 4-dimensional arithmetic vectors $a_1 = [1, 1, 1, 1]$, $a_2 = [1, 2, 3, 4]$, $a_3 = [1, -1, -1, 3]$, $a_4 = [1, 4, 5, 2]$ linearly dependent?	OPK-1
5.	2	Find the rank of the vector system $a_1 = [1, 2, 3, 4]$, $a_2 = [2, 3, 4, 5]$, $a_3 = [3, 5, 7, 9]$, $a_4 = [1, 1, 1, 1]$	OPK-1
6.	-8	Calculate the determinant $\begin{vmatrix} 1 & 2 & 3 \\ 5 & 1 & 4 \\ 3 & 2 & 5 \end{vmatrix}$.	OPK-1
7.	-50	Calculate the determinant $\begin{vmatrix} -1 & 5 & 4 \\ 3 & -2 & 0 \\ -1 & 3 & 6 \end{vmatrix}$.	OPK-1

8.	60	Calculate the determinant $\begin{vmatrix} 4 & 3 & 3 & 5 \\ 3 & 4 & 3 & 2 \\ 3 & 2 & 5 & 4 \\ 2 & 4 & 2 & 3 \end{vmatrix}$.	OPK-1
9.	-153	Compute the $\begin{vmatrix} 1 & -1 & 1 & -2 \\ 1 & 3 & -1 & 3 \\ -1 & -1 & 4 & 3 \\ -3 & 0 & -8 & -13 \end{vmatrix}$ determinant using the definition and properties of the determinant.	OPK-1
10.	-279	Calculate the determinant $\begin{vmatrix} 1 & -1 & 1 & -2 \\ 1 & 3 & -1 & 3 \\ -1 & 1 & 4 & 3 \\ -3 & 0 & -8 & -13 \end{vmatrix}$ by decomposing by the second column.	OPK-1
11.	no	Is algebra a $\langle Z, - \rangle$ semigroup?	OPK-1
12.	no	Is algebra a $\langle N, + \rangle$ group?	OPK-1
13.	Yes	Is algebra a $\langle R, +, \cdot \rangle$ ring?	OPK-1
14.	1) $\forall a, b \in P: ab = ba$, 2) $\forall a, b, c \in P: (ab)c = a(bc)$, 3) $\exists e \in P \forall a \in P: a \cdot e = e \cdot a = a$, 4) $\forall a \in P: a \neq 0 \exists a^{-1} \in P$.	List the properties of the field $\langle P, +, \cdot \rangle$ by multiplication.	OPK-1
15.	1) $A + B = B + A$ (commutativity); 2) $A + (B + C) = (A + B) + C$ (associativity); 3) $A + 0 = A$ for matrix 0 of the same type as the matrix A ; 4) for any matrix, A there is a matrix $(-A)$ of the same type as $A + (-A) = 0$.	What are the properties of addition of matrices of the same type?	OPK-1

16.	1) $(km)A = k(mA)$; 2) $1 \cdot A = A$; 3) $(k + m)A = kA + mA$; 4) $k(A + B) = kA + kB$.	List the properties of the matrix multiplication operation by a number.	OPK-1
17.	1) $A \cdot B \neq B \cdot A$. 2) $(A \cdot B) \cdot C = A \cdot (B \cdot C)$. 3) $(A + B) \cdot C = AC + BC$, 4) $A \cdot (B + C) = AB + AC$.	List the properties of the matrix multiplication operation?	OPK-1
18.	1) $z_1 + z_2 = (x_2 + iy_1) + (x_2 + iy_2) =$ $= (x_1 + x_2) + i(y_1 + y_2)$ 2) $z_1 - z_2 = (x_1 + iy_1) - (x_2 + iy_2) =$ $= (x_1 - x_2) + i(y_1 - y_2)$ 3) $z_1 \cdot z_2 = (x_1 + iy_1) \cdot (x_2 + iy_2) =$ $= (x_1x_2 - y_1y_2) + i(x_1y_2 + x_2y_1)$	What are the rules governing the addition, subtraction, and multiplication of complex numbers in algebraic form?	OPK-1
19.	1) commutativity; 2) associativity; 3) reversibility; 4) the existence of a neutral element; 5) the presence of symmetrical elements.	List the main properties of binary algebraic operations.	OPK-1
20.	1) permutation of two lines of the matrix; 2) multiplying the matrix row by a number other than zero; 3) addition of any line of the matrix with another line multiplied by a number other than zero.	List the basic elementary transformations of matrix strings.	OPK-1
21.	1) $a + b = b + a$, 2) $(a + b) + c = a + (b + c)$ 3) $\forall a : a + \theta = a$	What are the properties n of the addition of n -dimensional arithmetic vectors?	OPK-1

	$4) \forall a = [\alpha_1, \alpha_2, \dots, \alpha_n] \exists (-a) =$ $= [-\alpha_1, -\alpha_2, \dots, -\alpha_n] : a + (-a) = \theta$		
22.	$1) \forall a : a \cdot 1 = 1 \cdot a = a,$ $2) \forall \alpha, \beta \in P, \forall a : (\alpha\beta)a = \alpha(\beta a),$ $3) \forall \alpha, \beta \in P, \forall a : (\alpha + \beta) \cdot a = \alpha a + \beta a,$ $4) \forall a, b, \forall \alpha \in P : \alpha(a + b) = \alpha a + \alpha b.$	What are the properties of the product of scalars by n -dimensional arithmetic vectors?	OPK-1
23.	$1) \text{ A system of vectors consisting of one zero vector is linearly dependent.}$ $2) \text{ If a system contains a linearly dependent subsystem, then the system is linearly dependent.}$ $3) \text{ If there is at least one zero vector among the vectors of the system, then the system of vectors is linearly dependent.}$ $4) \text{ If not all of the vectors of the system are zero and this system is linearly dependent, then it is possible to find a linearly independent subsystem of vectors, through which any of the vectors of the system is linearly expressed.}$ $5) \text{ A system of two vectors is linearly dependent if and only if the vectors are proportional.}$	List the properties of linearly dependent vector systems.	OPK-1
24.	$1) \text{ The rank of the invertible matrix is equal to its order.}$ $2) \text{ The rank of the transposed matrix is equal to the rank of the main matrix.}$ $3) \text{ The rank of the product of the matrices is not higher than the rank of each of the factors.}$ $4) \text{ The rank of the product of an arbitrary matrix } A \text{ on the right or left by a non-degenerate matrix is equal to the rank of the matrix } A.$	List the properties of the matrix rank.	OPK-1
25.	$1) \text{ Matrix method;}$ $2) \text{ Cramer's method;}$	List the main methods for solving systems of linear equations.	OPK-1

	3) Gaussian method.		
26.	The matrix method and the Cramer method can be used to solve only those systems in which the number of equations is equal to the number of unknowns, and the matrix consisting of coefficients with unknowns is non-degenerate.	Which systems of linear equations can be solved by the matrix and Cramer methods?	OPK-1
27.	1) Permutation of the equations of the system. 2) Multiplying both sides of the equation by a number other than zero. 3) Adding to one equation another multiplied by some number other than zero.	List the elementary transformations of systems of linear equations.	OPK-1
28.	1) If the rank of the main matrix of the system is not equal to the rank of the extended matrix, then the system is incompatible. 2) If the rank of the main matrix of the system is equal to the rank of the extended matrix, and is equal to the number of unknowns of the system, then the system is definite. 3) If the rank of the main matrix of the system is equal to the rank of the extended matrix, and is less than the number of unknowns of the system, then the system is indefinite.	List the consequences of the Kronecker-Capelli theorem (a criterion for the compatibility of systems of linear equations).	OPK-1
29.	1) Using the Gaussian method, to find a general solution to a homogeneous system of linear equations. 2) Take any determinant of order other than zero, Δ_{n-r} that is, an order equal to the number of free unknowns of the system. 3) Substitute the elements of the determinant in the general solution instead of free unknowns Δ and find the values of the main unknowns.	Write down the algorithm for building a fundamental system of decisions.	OPK-1

30.	1) To find a partial solution X_0 to a given system of linear equations. 2) To compile a corresponding homogeneous system of linear equations. 3) To find the fundamental system of solutions of a homogeneous system: $X_1, X_2, \dots, X_{n-r}$. 4) Write the general solution X_k in the form $X_k = X_0 + \lambda_1 X_1 + \lambda_2 X_2 + \dots + \lambda_{n-r} X_{n-r}$, where $\lambda_i \in R, i = \overline{1, n-r}$.	Write down the algorithm for finding a general solution to a joint inhomogeneous system of linear equations.	OPK-1
31.	If, according to a certain law, two elements of a given set, given in a certain order, are matched by an element of the same set, then a binary algebraic operation is said to be specified on the set.	Define a binary algebraic operation.	OPK-1
32.	When studying algebras with two binary algebraic operations, they are denoted by "+" and "·" and, regardless of their nature, are called addition and multiplication.	How are binary algebraic operations notated in algebras with two binary algebraic operations?	OPK-1
33.	The algebraic form of notation of a complex number z is its representation in the form $z = x + iy$, where $x, y \in R, i^2 = -1$, x is the real part, iy is the imaginary part, y is the coefficient for the imaginary part, i and is the imaginary unit.	Define the algebraic form of complex number notation.	OPK-1
34.	The trigonometric form of writing a complex number is its representation in the form $z = r(\cos \varphi + i \sin \varphi)$, where $r = z $ is the modulus of the complex number, $r \geq 0$, is $0 \leq \varphi \leq 2\pi$ the argument of the complex number.	Give a definition of the trigonometric form of writing a complex number.	OPK-1
35.	An exponential form of notation of a complex number is its representation in the form $z = r \cdot e^{i\varphi}$,	Define the indicative form of writing a complex number.	OPK-1

	where r is the modulus and φ is the argument of the complex number.		
36.	In the trigonometric and exponential forms of writing a complex number, it is convenient to perform the operations of multiplication, division, elevation to an integer, and root extraction.	What actions are convenient to perform on numbers in trigonometric and representative forms of notation?	OPK-1
37.	Let the number of columns of the order matrix $A (m, n)$ be equal to the number of rows of the order matrix $B (n, k)$. Then the order matrix $C (m, k)$, where $c_{ij} = a_{i1}b_{1j} + a_{i2}b_{2j} + \dots + a_{in}b_{nj}$ ($i = 1, 2, \dots, m; j = 1, 2, \dots, k$) is called the product A by B and is denoted AB by .	Define the product of matrices.	OPK-1
38.	The rule of matrix multiplication can be formulated as follows: in order to obtain the element in i the -th row and j the -th column of the product of the two matrices, you need to i multiply the elements of the -th row of the first matrix by the corresponding elements j of the -th column of the second matrix and add the resulting products.	Formulate a rule for multiplying matrices.	OPK-1
39.	If, for two permutations of the same number of numbers n , each number of one permutation corresponds to the number of the other permutation, then this correspondence is called a substitution of n -that degree.	Give a definition of the substitution of n -that degree.	OPK-1
40.	n An n -dimensional arithmetic vector a is an ordered sequence of field elements $P \alpha_1, \alpha_2, \dots, \alpha_n$ and is denoted as $a = [\alpha_1, \alpha_2, \dots, \alpha_n]$. In this case, α_i ($i = \overline{1, n}$) they are called components n of an n -dimensional vector a .	Give a definition n of the n -dimensional arithmetic vector.	OPK-1

41.	A system of vectors $a_1, a_2, \dots, a_k$ is said to be linearly dependent if there exist scalars $\lambda_1, \lambda_2, \dots, \lambda_k$, not all equal to zero, and such that $\lambda_1 a_1 + \lambda_2 a_2 + \dots + \lambda_k a_k = \theta$.	Give a definition of the linear dependence of a system of vectors $a_1, a_2, \dots, a_k$.	OPK-1
42.	A linearly independent subsystem of a system of vectors $a_1, a_2, \dots, a_k$ is called the maximum linearly independent subsystem if the addition of any vector from the system to it $a_1, a_2, \dots, a_k$ makes it linearly dependent.	Define the maximum linearly independent subsystem of vectors.	OPK-1
43.	A minor element is M_{ij} a a_{ij} determinant that is obtained from the determinant of matrix A by crossing out the row and column passing through this element	What is called an element's minor? a_{ij}	OPK-1
44.	1) If one of the lines consists of zeros, then the determinant is equal to 0 2) A determinant containing two identical strings is equal to 0. 3) A determinant containing two proportional strings is equal to 0. 4) If one of the lines of the determinant is a linear combination of its other strings, then it is equal to 0.	In what cases is the determinant of the matrix equal to zero according to the properties of the determinant?	OPK-1
45.	Whichever row (column) of the determinant of n the n -th order we take, the determinant is equal to the sum of the products of the elements of a certain row (column) by their algebraic complements.	Formulate a theorem on the decomposition of the determinant by the elements of any of its rows (columns).	OPK-1
46.	Two matrices of the same type A and B are called equivalent if it is possible to pass ($A \sim B$) from the matrix A to the matrix B using a finite number of elementary transformations	Which matrices are called equivalent?	OPK-1
47.	Two systems with the same unknowns are called equivalent (equivalent) if each decision of one of	What systems of linear equations are called equivalent (equivalent)?	OPK-1

	them is the solution of the other or both systems are incompatible		
48.	If in a system n of linear equations with unknowns n the determinant composed of coefficients with unknown is Δ different from zero, then the system has a single solution that is found by the formula $x_i = \frac{\Delta_i}{\Delta}, \quad i = \overline{1, n}, \text{ where } \Delta_i \text{ is the determinant obtained from the determinant by } \Delta \text{ replacing } i \text{ the } i\text{-th column with a column of free terms.}$	Formulate Kramer's theorem (rule) for solving systems of linear equations.	OPK-1
49.	A system of linear equations is compatible if and only if the rank of the main matrix (matrix A) of the system is equal to the rank of the extended matrix $(A B)$.	Formulate the Kronecker-Capelli theorem (criterion for the compatibility of a system of linear equations)	OPK-1
50.	A homogeneous system of linear equations obtained from an inhomogeneous system by replacing free terms with zeros in it is called a reduced (corresponding) homogeneous system.	Which homogeneous system of linear equations is called reduced (corresponding)?	OPK-1
51.	The solution of a system of linear inequalities is a set of values of unknowns $x_1 = \alpha_1, x_2 = \alpha_2, \dots, x_n = \alpha_n$ for which each of the inequalities of this system holds.	What is called solving a system of linear inequalities?	OPK-1
52.	Two systems of linear inequalities with unknowns are $x_1, x_2, \dots, x_n$ said to be equivalent if each solution of the first system is a solution of the second, and any solution of the second system is a solution of the first.	Which systems of linear inequalities are called equivalent?	OPK-1

2. Description of the rating scale

Within the framework of the rating system, students' progress in each discipline is assessed during current control and intermediate certification.

3. Criteria for assessing competencies

An "excellent" grade is given to a student if the theoretical content of the topic is mastered completely, without gaps; exhaustively, consistently, clearly and logically coherently presents the material; freely copes with tasks, questions and other types of application of knowledge; uses additional material in the answer all the tasks provided for by the program are completed, the quality of their performance is evaluated by the number of points close to the maximum; analyzes the results obtained; shows independence in the performance of tasks.

A grade of "good" is given to a student if the theoretical content of the topic is fully mastered, the necessary practical competencies are basically formed, all the educational tasks provided for by the training program are completed, the quality of their implementation is quite high. The student knows the material firmly, presents it competently and to the point, avoiding significant inaccuracies in answering the question.

The grade "satisfactory" is given to a student if the theoretical content of the topic is partially mastered, but the gaps are not significant, most of the tasks provided for by the program are completed, but there are errors in them, when answering the question, the student makes inaccuracies, insufficiently correct wording, there are violations of the logical sequence in the presentation of the program material.

An "unsatisfactory" grade is given to a student if he does not know a significant part of the program material, makes significant mistakes, performs practical work unconfidently, with great difficulty, the necessary practical competencies are not formed, most of the educational tasks are not completed, the quality of their performance is evaluated by the number of points close to the minimum.