Approved by

Vice-Rector for Academic and

Methodological Activities

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THE PROGRAM
OF ENTRY TEST IN

MATHEMATICS

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INTRODUCTION

The Program is developed for enrollee applying for entry test in the form established by the University itself. The Program materials are intended to help enrollee to prepare for entry test in mathematics.

The Program is compiled on the basis of the curricula of secondary school (high school).

The amount of knowledge and the degree of mastery of the material correspond to the course of mathematics in secondary school (high school). The enrollee can use the entire arsenal of tools from this course including the calculus basics. Objects and facts are not studied in secondary school (high school) can also be used by enrollee.

The purpose of the entry test is to identify and to assess the basic knowledge and skills of an enrollee in mathematics formed during the study in secondary school (high school).

SKILLS SHOULD BE DEMONSTRATED BY ENROLLEE

1. Performing calculations and conversions

1.1. Performing arithmetic operations combining oral and written techniques; finding the values of nth roots where n is a natural number, powers with natural exponent, logarithms

1.2. Calculating the values of expressions performing necessary substitutions and conversions

1.3. Converting of expressions including exponents, roots, logarithms and trigonometric functions according to mathematical formulas and rules

2. Solving equations and inequalities

2.1. Solving rational, irrational, exponential, trigonometric, logarithmic equations and systems with such equations

2.2. Solving equations and the simplest systems of equations using the properties of functions and their graphs; using the graphical method for the approximate solution of equations and inequalities

2.3. Solving rational, exponential, logarithmic inequalities and systems with such inequalities

3. Performing actions with functions

3.1. Determining the value of a function by the value of an argument in a function is specified by different ways; describing behavior and properties of a function on the graph; finding the largest and the smallest values on the graph of a function; building the graphs of functions were studied

3.2. Calculating the derivatives and the antiderivatives of elementary functions

3.3. Investigating monotonicity of functions, the largest and the smallest values of a function

4. Performing actions with geometric shapes, coordinates and vectors

4.1. Solving planimetric problems to find geometric quantities such as lengths, angles, areas

4.2. Solving the simplest stereometric problems to find geometric quantities such as lengths, angles, areas; using laws and methods of plane geometry when solving problems of stereometry

4.3. Determining the coordinates of a point; performing operations on vectors; calculating the length and the coordinates of a vector; calculating the angle between vectors

5. Building and exploring the simplest mathematical models

5.1. Modelling of real-world situations with algebra; making equations and inequalities according to the problem; investigation of the models obtained thereby using the apparatus of algebra

5.2. Modelling of real-world situations with geometry; investigation of the models obtained thereby using geometric laws and theorems; solving practical problems related to finding geometric quantities

5.3. Evidence-based reasoning when solving problems; evaluating the logical correctness of a reasoning; recognizing a logically incorrect reasoning

5.4. Modelling of real-world situations with probability theory and statistics; calculating the probabilities of the simplest events

6. Using the acquired knowledge and skills in practical activities and everyday life

6.1. Analyzing real numerical data and statistical information; carrying out of practical calculations using formulas; using estimation in practical calculations

6.2. Describing real-world relationships between quantities using functions and interpreting their graphs; extracting information presented in tables, charts, graphs

6.3. Solving applied problems including those of a socio-economic and physical nature, for the largest and smallest values, for finding a speed and an acceleration

PROGRAM OVERVIEW

ALGEBRA

1 Algebra basics

1.1 Numbers, roots and powers

1.1.1 Integers
1.1.2 Power with natural exponent
1.1.3 Fractions, percentages, rational numbers
1.1.4 Power with integer exponent
1.1.5 Root with index $n > 1$ and its properties
1.1.6 Power with rational exponent and its properties
1.1.7 Properties of power with real exponent

1.2 Trigonometry Basics

1.2.1 Sine, cosine, tangent, cotangent of an arbitrary angle
1.2.2 Radian measure of an angle
1.2.3 Sine, cosine, tangent and cotangent of a number
1.2.4. Basic trigonometric identities
1.2.5 Cast formulas
1.2.6 Sine, cosine and tangent of sum and difference of two angles
1.2.7 Sine and cosine of a double angle

1.3 Logarithms

1.3.1 Logarithm of a number
1.3.2 Logarithm of a product, quotient, power
1.3.3 Natural and common logarithm, the number e

1.4 Conversion of Expressions

1.4.1 Conversion of expressions with arithmetic operations
1.4.2 Conversion of expressions with power operations
1.4.3 Conversion of expressions with nth roots where n is a natural number
1.4.4 Conversion of trigonometric expressions
1.4.5 Conversion of expressions with logarithm
1.4.6 Modulus (absolute value) of a number

2 Equations and Inequalities

2.1 Equations

2.1.1 Quadratic equations

2.1.2 Rational equations

2.1.3 Irrational equations

2.1.4 Trigonometric equations

2.1.5 Exponential equations

2.1.6 Logarithmic equations

2.1.7 Equivalence of equations and systems of equations

2.1.8 Simple systems of equations in two unknowns

2.1.9 Basic methods to solve systems of equations: substitution, addition

2.1.10 Equation solving using graphs and properties of functions

2.1.11 Solution set of equations with two variables and systems
of such equations: representation on a coordinate plane

2.1.12 Mathematical methods application. Interpretation of a
result. Taking real limitations into account

2.2 Inequalities

2.2.1 Quadratic inequalities

2.2.2 Rational inequalities

2.2.3 Exponential inequalities

2.2.4 Logarithmic inequalities

2.2.5 Systems of linear inequalities

2.2.6 Systems of inequalities with one variable

2.2.7 Equivalence of inequalities and their systems

2.2.8 Using properties and graphs of functions to solve inequalities

2.2.9 Solution set of inequalities with two variables and systems
of such equations: representation on a coordinate plane

3 Functions

3.1 Definition and Graph of a Function

3.1.1 Function. Domain of a function

3.1.2 Codomain of a function

3.1.3 Graph of a function. Function application examples

3.1.4 Inverse function. Graph of an inverse function

3.1.5 Graph Translations. Shifting. Reflecting

3.2 Study of Functions Basics

3.2.1 Monotonicity of a function. Intervals of increase and decrease
3.2.2 Even and odd functions
3.2.3 Periodicity of a function
3.2.4 Restriction of a function
3.2.5 Extrema (maxima and minima) of a function

3.3 Basic Elementary Functions

3.3.1 Linear function and its graph
3.3.2 Reciprocal function and its graph
3.3.3 Quadratic function and its graph
3.3.4 Exponential function with a natural number as an exponent and its graph
3.3.5 Trigonometric functions and their graphs
3.3.6 Exponential function and its graph
3.3.7 Logarithmic function and its graph

4 Calculus Basics

4.1 Derivative

4.1.1 Derivative of a function. Geometric interpretation of the derivative
4.1.2 Physical interpretation of a derivative. Velocity of a
      process is given as a formula or a graph.
4.1.3 Equation of the tangent line at a function graph
4.1.4 Derivative of a sum, difference, product, quotient
4.1.5 Derivative of basic elementary functions
4.1.6 Physical interpretation of a derivative
4.1.7 The second derivative and its physical interpretation

4.2 Study of Functions

4.2.1 Application of differential calculus to the study and plotting of functions
4.2.2 Applications of derivatives

4.3 Antiderivative and Integral

4.3.1 Antiderivative of elementary functions
4.3.2 Integral application in physics and geometry

GEOMETRY

5 Plane Geometry

5.1 Triangle
5.2 Parallelogram, rectangle, rhombus, square
5.3 Trapezium
5.4 Circle and disk
5.5 Inscribed circle and circumscribed circle of a triangle
5.6 Polygon. Sum of angles of a convex polygon
5.7 Regular polygons. Inscribed circle and circumscribed circle of a regular polygon

6 Straight Lines and Planes

6.1 Intersecting, parallel and skew lines. Perpendicular lines
6.2 Parallelism of a straight line and a plane, properties and attributes
6.3 Parallelism of planes, properties and attributes
6.4 Perpendicularity of a straight line and a plane, properties and attributes; vertical and slanting lines; theorem of three perpendiculars
6.5 Perpendicularity of planes, properties and attributes
6.6 Parallel projection. Imaging of spatial geometrical figures

7 Polyhedra

7.1 Prism and its bases, lateral edges, height, lateral surfaces; straight prism; regular prism
7.2 Parallelepiped; cube; symmetries of a cube and a parallelepiped
7.3 Pyramid and its bases, lateral edges, height, lateral surfaces; triangular pyramid; regular pyramid
7.4 Sections of a cube, a prism, a pyramid
7.5 Polyhedra (tetrahedron, cube, octahedron, dodecahedron and icosahedron)

8 Solids and Surfaces of Revolution

8.1 Cylinder and its base, height, lateral surface, generatrix, unfolding
8.2 Cone and its base, height, lateral surface, generatrix, unfolding
8.3 Ball and sphere, their sections

9 Geometric measurements

9.1 Magnitude of an angle, degree measure of an angle, relation between angle and arc length
9.2 Angle between straight lines in space; angle between a straight line and a plane; angle between planes
9.3 Length of a line segment, a polygonal chain, a circle; perimeter of a polygon
9.4 Distance from a point to a line, from a point to a plane; distance between parallel and skew lines, distance between parallel planes
9.5 Area of a triangle, a parallelogram, a trapezium, a circle, a sector
9.6 Surface area of a cone, a cylinder, a sphere
9.7 Volume of a cube, a rectangular parallelepiped, a pyramid, a prism, a cylinder, a cone, a sphere

10 Coordinates and Vectors

10.1 Coordinates of a point on a straight line; cartesian coordinates on a plane and in space
10.2 Formula for the distance between two points; equation of a sphere
10.3 Vector, modulus of a vector, equality of vectors; addition of vectors, multiplication of a vector by a number.
10.4 Collinear vectors; decomposition of a vector in two non-collinear vectors
10.5 Coplanar vectors; decomposition of a vector in three non-coplanar vectors
10.6 Coordinates of a vector; dot product of vectors; angle between vectors

BASICS OF COMBINATORICS, STATISTICS AND PROBABILITY THEORY

11 Basics of Combinatorics

11.1 Formulas for combinations and permutations. Newton's binomial theorem

12 Basics of Statistics

12.1 Tabular and graphical presentation of data
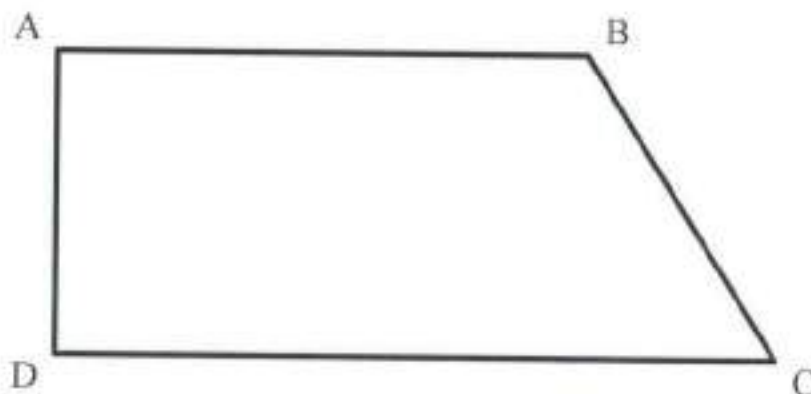12.2 Numerical characteristics of data series

13 Basics of Probability Theory

13.1 Probability of an event
13.2 Statistics and probability theory application

EXAMPLES OF TESTS FOR ENTRANCE EXAM

1. Single answer questions (5 points each, 20 points total)
What figure is shown in the picture?

a) Triangle
b) Trapezium
c) Pentagon
d) Paralellepiped

2. Algebra, combinatorics, statistics and probability theory exercises (10 points each, 40 points total)
Solve for a:

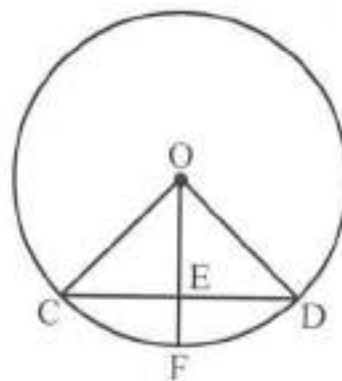$$\frac{1}{18}(7 - 4a) + 2 = \frac{a}{3} - \frac{4 - a}{12}$$

$a = $ ___ .

3. Plane geometry exercises (10 points each, 20 points total)
Given:
A circle with centre O
$\overline{OE} \perp \overline{CD}$; $OC = 8$; $OE = 6$.
Find: CD

$CD = $ ___ .

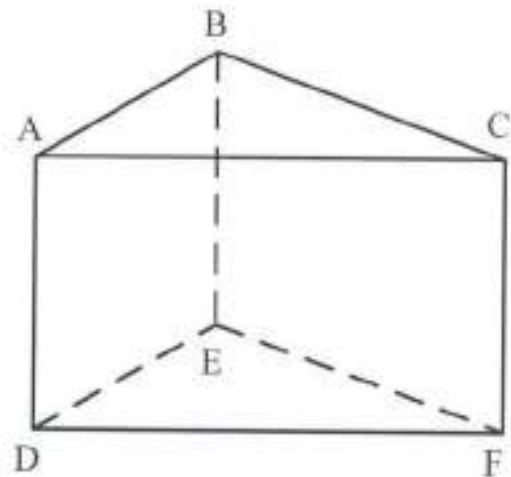## 4. Stereometry exercises (10 points each, 20 points total)

Find the total area of the right triangular prism with an altitude of length 8 cm if the sides of the triangular bases have lengths of 13 cm, 14 cm, and 15 cm

Given:

A prism $ABCDEF$

$AB = 13$ cm; $BC = 14$ cm; $AC = 15$ cm

Find: T

$T =$ _____ cm.

ENTRY TEST EVALUATION CRITERIA

The entrance test is conducted in test form on the digital platform of "Crimean Federal University named after V. I. Vernadsky": https://cn-exams.edcampus.ru.

Enrollee is invited to perform test tasks of 4 types:

1. Single choice tasks (2 tasks on algebra and 2 tasks on geometry. A total of 4 assignments are worth **20 points**, each correct answer is worth **5 points**).

2. Solving a problem in algebra as well as combinatorics, statistics and probability theory (3 tasks on algebra and 1 task on combinatorics, statistics or probability theory. Each correctly solved problem is worth **10 points**, a total of 4 correctly solved problems are worth **40 points**).

3. Solving a problem in plane geometry (2 tasks on plane geometry. Each correctly solved problem is worth **10 points**, a total of 2 correctly solved problems are worth **20 points**).

4. Solving a problem in stereometry (2 tasks on stereometry. Each correctly solved problem is worth **10 points**, a total of 2 correctly solved problems are worth **20 points**).

Time for test tasks is 120 minutes.

The entry test score is evaluated on the basis of the 100 point system as the sum of the points scored on all tasks.

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