

**MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
TERNOPIL VOLODYMYR HNATIUK NATIONAL PEDAGOGICAL
UNIVERSITY
FACULTY OF PHYSICS AND MATHEMATICS**



**PROGRAM
ENTRANCE EXAM IN «MATHEMATICS»**

upon admission to study for the degree of "Bachelor" for entrants based on the complete general secondary education

Considered and approved at the meeting of the Department of Mathematics and Methods of its Teaching
(protocol №10 from April 21th 2023))

TERNOPIL – 2023

An explanatory note

Entrance exam in mathematics at Ternopil Volodymyr Hnatiuk National Pedagogical University is held at four faculties: Physics and Mathematics, Engineering Education, Chemistry and Biology, Geography and Primary education section (Faculty of Pedagogics and Psychology).

There is no doubt that the future specialist of any profile: teacher, engineer, programmer, etc. must have a deep knowledge of mathematical research methods. For successful learning both mathematics and related disciplines at the university, the entrant must have a thorough knowledge of elementary (school) mathematics.

The purpose of the entrance test in mathematics is to assess the degree of readiness of entrants in mathematics for the purpose of competitive selection for study at Ternopil Volodymyr Hnatiuk National Pedagogical University:

The objectives of the entrance test in mathematics are to assess the knowledge and skills of entrants:

The program of the entrance exam is made in accordance with the program of external independent assessment of learning outcomes in mathematics, obtained on the basis of complete general secondary education, approved by the order of the Ministry of Education and Science of 04.12.2019 № 1513.

The proposed program summarizes the content of sections of the school curriculum, which indicates the basic conceptual apparatus, which must have a graduate. There is also a list of the main questions that are submitted for the entrance examination. This list will allow the entrant to systematize their knowledge and help to focus on what issues to look for when preparing for the entrance exam in mathematics.

The form of the entrance examination for entrants on the basis of complete general secondary education is an oral examination.

Requirements for the preparation of entrants in mathematics

The main requirements for the preparation of entrants in mathematics are:

- mathematical knowledge formation as an integral part of general human culture, a necessary condition for its full life in modern society based on acquainting students with ideas and methods of mathematics as a universal language of science and technology, an effective tool for modeling and researching processes and phenomena;
- entrants' intellectual development, development of their logical and abstract thinking, memory, attention, intuition, ability to analyze, classify, generalize, draw conclusions by analogy, derive consequences from these assumptions through consistent considerations etc.;
- learning by entrants the system of mathematical knowledge and skills necessary for admission to higher educational institutions on the basis of complete general secondary education.

The entrants need to know:

- methods to define the elementary functions, their properties; geometric transformations for plotting functions;
- trigonometric functions formulas and their consequences; values of trigonometric ratios for common angles;
- algorithms for solving exponential, logarithmic equations and inequalities;
- definition of derivative and differentiation rules of simple and complex functions; function research algorithm and constructing their graphs using a derivative;
- integrals of elementary functions; rules for calculating indefinite and definite integrals;
- formulas for calculating the volumes and areas of surfaces specified in the program, polyhedra and solid of revolution.

The entrants must have competencies:

- to build mathematical models of real objects, processes and phenomena and to study these models using mathematics;
- perform mathematical calculations (perform actions with numbers given in different forms, compose and solve problems on proportions, approximate calculations, etc.);
- perform interest calculations; solve three main problems on interest;
- perform expression transformations (understand the meaning of each element of an expression, find valid values of variables, find numerical values of expressions for given values of variables, etc.);
- build and analyze graphs of the simplest functional dependencies, investigate their properties;
- to solve equations, inequalities and their systems of the first and second degrees and those reduced to them, and also to solve text problems using equations, inequalities and their systems;

- simplify trigonometric expressions, solve the simplest trigonometric equations and inequalities;
- perform transformations of expressions that contain powers and logarithms; solve exponential and logarithmic equations and inequalities and systems of equations and inequalities;
- find geometric shapes in pictures and set their properties;
- find quantitative characteristics of geometric figures (length, size of angles, area, volume): straight prism, pyramid, cone, sphere, cylinder, including applied content;
- solve the simplest combinatorial problems and calculate the probabilities of random events;
- analyze information presented in graphical, tabular, textual and other forms.

SECTIONS OF DISCIPLINES FOR ENTRANCE EXAM AND THEIR SUMMARY

ALGEBRA AND THE BEGINNING OF ANALYSIS

Numbers and expressions. Real numbers (natural, integers, rational and irrational), their comparison and actions with them. Numerical sets and relations between them. Ratios and proportions. Interest. The main tasks for interest. Rational, irrational, power, exponent, logarithmic, trigonometric expressions and their transformations.

Equations, inequalities and their systems. Linear, quadratic, rational, irrational, exponential, logarithmic, trigonometric equations, inequalities and their systems. Application of equations, inequalities and their systems for solving text problems.

Functions. Linear, quadratic, power, exponent, logarithmic and trigonometric functions, their main properties. Numerical sequences. Derivative of a function, its geometric and physical meaning. Derivatives of elementary functions. Rules of differentiation. Investigation of a function using a derivative. Plotting graphs of functions. Initial and definite integral. Application of a definite integral to the calculation of the areas of curvilinear trapezoids.

Elements of combinatorics, the beginnings of probability theory and elements of statistics. Permutations (without repetitions). Combinatorial rules of sum and product. Probability of a random event. Selective characteristics.

GEOMETRY

Planimetry. The simplest geometric figures on the plane and their properties. Round and circle. Triangles. Quadrangle. Polygons. Geometric quantities and their measurements. Coordinates and vectors on the plane. Geometric transformations.

Stereometry. Lines and planes in space. Polyhedra, solid of revolution. Coordinates and vectors in space.

REFERENTIAL LIST OF THEORETICAL ISSUES TO BE INCLUDED IN THE ENTRANCE EXAM

ALGEBRA AND THE BEGINNING OF ANALYSIS

Section: **NUMBERS AND EXPRESSIONS**

1. Properties of mathematic operations with real numbers. Rules for comparing real numbers.
2. Signs of divisibility of natural numbers by 2, 3, 5, 9, 10.
3. Rules for rounding integers and decimal fractions;
4. Definition of the root of the n th degree and the arithmetic root of the n th degree. Root's properties.
5. Definition of degree with natural, integer and rational indicators, their properties.
6. Numerical intervals.
7. Module of a real number and its properties
8. Attitudes, proportions. The main property of proportion.
9. Definition of interest. Rules for performing interest calculations - find the ratio of numbers in the form of a percentage, a percentage of a number, a number by the value of its percentage.
10. Defining the range of valid values of expression variables with variables.
11. Definition of identically equal expressions, identical transformation of expression, identity.
12. Definition of monomial and polynomial. Rules for addition, subtraction and multiplication of monomials and polynomials.
13. Formulas of abbreviated multiplication.
14. Decomposition of a polynomial into factors.
15. Definition of an algebraic fraction. Rules for performing actions with algebraic fractions.
16. Definitions and properties of logarithm, decimal and natural logarithms.
17. Logarithm inverse properties.
18. Definition of sine, cosine, tangent, cotangent of a numerical argument. Basic trigonometric identity and its consequences.
19. Cofunction identities.
20. Ptolemy's identities, the sum and difference formulas.

Section: **EQUATIONS, INEQUALITIES AND THEIR SYSTEMS**

1. Equation with one variable, definition of the root (solution) of the equation with one variable.
2. Inequality with one variable, definition of the solution of inequality with one variable.
3. Definition of the solution of the system of equations with two variables and the main methods of their solutions;
4. Methods for solving rational, irrational, exponential, logarithmic, trigonometric equations.
5. Methods for solving the simplest linear, quadratic, rational, exponential, logarithmic inequalities and simple inequalities, which are reduced to the simplest

Section: **FUNCTION**

1. Definition of arithmetic and geometric progressions.
2. Formulas of the n th term of arithmetic and geometric progressions.
3. Formulas of the sum of n first terms of arithmetic and geometric progressions.
4. The formula for the sum of infinite geometric progression with the denominator $|q| > 1$.
5. Definition of the function, area of definition, area of values of the function, graph of the function.
6. Methods of setting functions, basic properties and graphs of linear, quadratic, power, exponential, logarithmic and trigonometric functions.
7. Definition of the derivative of a function at a point. Physical and geometric content of the derivative.
8. Table of derivatives of elementary functions.
9. Rules for finding the derivative of the sum, product, fraction of two functions.
10. Sufficient condition for the growth (decline) of the function in the interval.
11. Extremes values of function.
12. Definition of the largest and smallest values of function
13. Definition of the primary function, definite integral, curvilinear trapezoid.
14. Antiderivative formula sheet.
15. Rules for finding the antiderivative .

Section: **ELEMENTS OF COMBINATORICS, THE BEGINNINGS OF PROBABILITY THEORY AND ELEMENTS OF STATISTICS.**

1. Definition of permutation, combination, placement (without repetitions).
2. Combinatorial rules of sum and product.
3. Classical definition of the probability of an event, the simplest cases of calculating the probability of events.
4. Definition of sample characteristics of data series (sample size, mode, median, average value).
5. Graphic, tabular, textual and other forms of presentation of statistical data.

GEOMETRY

Section: **PLANIMETRY**

1. The concept of point and line, ray, segment, broken, angle.
2. Axioms of planimetry.
3. Adjacent and vertical angles, angle bisector.
4. Adjacent and vertical angles properties .
5. Angle bisector properties.
6. Parallel and perpendicular lines.
7. The distance between parallel lines;
8. Perpendicular and inclined, perpendicular bisector, the distance from a point to a straight line.
9. Signs of parallel lines.
10. Thales' theorem, generalized Thales' theorem.
11. Round, circle and their elements.

12. Central, inscribed angles and their properties.
13. Tangent to a circle and its properties
14. Types of triangles and their main properties.
15. Signs of equality of triangles.
16. Median, bisector, height of a triangle and their properties.
17. Triangle sum theorem. Нерівність трикутника.
18. The middle line of a triangle and its properties.
19. A circle circumscribed around a triangle and a circle inscribed in a triangle.
20. Pythagorean theorem.
21. The relationship between the sides and angles of a right triangle.
22. The Law of Sines.
23. The Law of Cosines.
24. Similar triangles, signs of similarity of triangles.
25. Quadrilateral and its elements.
26. Parallelogram and its properties. Signs of a parallelogram.
27. Rectangle, rhombus, square, trapezoid and their properties.
28. Trapezoid, midline of a trapezoid and its properties.
29. Inscribed in a circle and described around the circle quadrilaterals.
30. Quadrilateral angles sum.
31. Polygon and its elements.
32. Perimeter of a polygon.
33. Regular polygon and its properties.
34. Inscribed in a circle and described around the circle polygons
35. The length of the segment, circle and its arc.
36. The magnitude of the angle, measuring angles.
37. Formulas for calculating the area of a triangle, parallelogram, rhombus, square, trapezoid, regular polygon, circle, circular sector.
38. Rectangular coordinate system, the coordinates of the point.
39. Formula for calculating the distance between two points and the formula for calculating the coordinates of the middle of the segment.
40. Equation of line and circle.
41. The concept of vector, zero vector, modulus of vector.
42. Collinear vectors, opposite vectors, equal vectors.
43. Coordinates of the vector.
44. Addition, subtraction of vectors, multiplication of a vector by a number.
45. The angle between the vectors.
46. Scalar product of vectors.
47. The main types and content of geometric transformations on the plane (motion, symmetry relative to a point and relative to a straight line, rotation, parallel transfer).
48. Equality of figures.

Section: **STEREOMETRY**

1. Axioms and theorems of stereometry.
2. Mutual placement of lines in space, lines and planes in space, planes in space.

3. Parallel lines, line and plane, planes.
4. Parallel design.
5. Perpendicularity of a line and a plane, two planes.
6. Projection of the inclined plane, orthogonal projection.
7. The theorem on three perpendiculars.
8. The distance from a point to a plane, from a point to a straight line, from a straight line to a parallel plane, between parallel lines, between parallel planes.
9. The angle between lines, line and plane, planes.
10. Dihedral angle, linear angle of dihedral angle.
11. Polyhedra and their elements, the main types of polyhedra: prism, parallelepiped, pyramid, truncated pyramid.
12. Solids of revolution and their elements, the main types of solids of revolution: cylinder, cone, sphere, sphere.
13. Sections of polyhedra.
14. Sections of the cylinder and cone: axial sections, sections of planes parallel to their bases.
15. Section of a sphere with a plane.
16. Formulas for calculating the area of surfaces and volumes of prisms and pyramids.
17. Formulas for calculating the volume of a cylinder, cone, sphere.
18. Formulas for calculating the area of the sphere.
19. Rectangular coordinate system in space, point coordinates.
20. Formula for calculating the distance between two points and formula for calculating the coordinates of the middle of the segment.
21. The concept of vector, modulus of vector, collinear vectors, equal vectors, coordinates of the vector.
22. Addition, subtraction of vectors, multiplication of a vector by a number;
23. Scalar product of vectors.
24. The angle between the vectors.
25. Symmetry with respect to the origin and coordinate planes.

STRUCTURE, CONTENT AND FORM OF THE EXAM

The exam is held orally on the basis of tickets approved by the chairman of the selection committee. The ticket consists of three questions (one theoretical and two problems).

The entrant is given 45 minutes to prepare, after which he gives an oral answer to the task of the selected ticket. This time is enough for preparation, problem solving and psychological adaptation.

Criteria for assessing the academic achievements of applicants

Assessment of the quality of mathematical training of entrants in mathematics is carried out in two aspects: the level of mastery of theoretical knowledge and the quality of practical skills, the ability to apply the studied material in solving problems.

The evaluation of the answer is carried out on a 100-point scale, the distribution of points of which is given in the table below.

Theoretical question	Problem №1	Problem №2	Total
40	30	30	100

The transfer of the number of points of the entrance exam to the rating (on a scale of 100-200 points) is carried out according to the table at the end of the program.

The following criteria and evaluation scale are used to assess the knowledge of applicants.

Assessment of the theoretical part of the entrance exam

40-30 - is placed when the entrant freely and correctly expresses the relevant mathematical considerations, convincingly argues; correctly formulates and proves theorems and properties; knows and correctly derives basic mathematical formulas and identities; correctly performs the pictures for problems; create the answer according to his own plan, accompanies the answer with his own examples.

29-20 – the entrant is well versed in the material, is able to think logically, make correct inferences and judgments, demonstrates understanding of the content of educational material, knows the properties of concepts and basic statements, but in proving them can make not serious mistakes. The answers to the questions allow for minor shortcomings that can be corrected on their own.

19-10 – the entrant has significant gaps in knowledge of theoretical material; reproduces knowledge superficially, at the level of memorization, does not know how to apply them in changed conditions, thinks in a stereotyped way; the answers for the questions are fragmentary.

9-0 – the entrant doesn't understand the question content, his answer is not directly related to the question or is absent, cannot think.

Assessment of the practical part of the entrance exam

30-24 — the entrant is able to solve problems of both mandatory and advanced levels of difficulty. Solutions are correct, complete, logical and rational. Knows basic formulas and theorems. Correctly performs pictures and graphs to the answer.

23-16 — the entrant is able to apply the acquired knowledge in solving typical problems and provide logical reasoning in atypical cases. There are some inaccuracies and minor technical errors in solving problems, which do not significantly affect the correctness of the answer.

15-8 — the entrant has an idea of solving simple typical problems, uses known formulas and methods of solving in standard situations, chooses the right path, but does not get a solution. Makes basic mistakes.

7-0 — the entrant does not have the spatial imagination, knowledge, skills and abilities to solve mathematical problems.

**Conversion table of the points' number of the entrance exam into the rating
(on a scale of 100-200 points)**

Points of entrance exam	Rating	Points of entrance exam	Rating	Points of entrance exam	Rating
0-9	Not pass	40	140	71	171
10	100	41	141	72	172
11	102	42	142	73	173
12	104	43	143	74	174
13	106	44	144	75	175
14	108	45	145	76	176
15	110	46	146	77	177
16	112	47	147	78	178
17	114	48	148	79	179
18	116	49	149	80	180
19	118	50	150	81	181
20	120	51	151	82	182
21	121	52	152	83	183
22	122	53	153	84	184
23	123	54	154	85	185
24	124	55	155	86	186
25	125	56	156	87	187
26	126	57	157	88	188
27	127	58	158	89	189
28	128	59	159	90	190
29	129	60	160	91	191
30	130	61	161	92	192
31	131	62	162	93	193
32	132	63	163	94	194
33	133	64	164	95	195

34	134	65	165	96	196
35	135	66	166	97	197
36	136	67	167	98	198
37	137	68	168	99	199
38	138	69	169	100	200
39	139	70	170		

Entrants with a rating of **at least 100** are allowed to participate in the competitive selection for admission to study.

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