Bachelor's Track Program: Applied Mathematics and Artificial Intelligence

1. Open Doors winner's skill set

Winning the Open Doors competition requires a firm grasp of:

- basic concepts, rules, and laws of arithmetic;
- basic concepts of information theory, graph theory, and information encoding methods.

The winner is expected to demonstrate a solid command of the following skills:

- modeling real situations in the language of algebra;
- creating equations and inequalities, functions based on the problem statement; examining the constructed models using the apparatus of algebra;
- modeling real situations in the language of geometry; examining the constructed models using geometric concepts and theorems;
- solving applied problems, including socioeconomic ones, involving the determination of maximum and minimum values;
- modeling the simplest real situations in the language of probability theory and statistics;
- extracting and analyzing information presented in tables, diagrams, and graphs;
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- solving problems involving number system conversions and logical operations; constructing truth tables.

2. List of degree programs covered by the subject areas:

2.1 List of bachelor's degree programs

01.03.02 Applied Mathematics and Computer science
01.03.01 Mathematics
01.03.03 Mechanics and Mathematical Modeling
01.03.04 Applied mathematics
02.03.01 Mathematics and Computer Science

2.2 List of specialist's degree programs

01.05.01Fundamental Mathematics and Mechanics

3. Content

Field of science 1. Mathematical logic

Mathematics

1. Elements of combinatorics. Alternate and simultaneous selection. Rules of addition and multiplication. Permutations, placements and combinations without repetitions and with repetitions. Newton's binomial theorem.

Computer science

2. Algebra of logic. Boolean algebra. Basic operations of Boolean algebra: conjunction, disjunction, inversion, implication, equivalence. Truth tables.

Field of science 2. Mathematics

Mathematics

1. Operations with numeric and letter expressions. Natural, integer, rational, irrational and real numbers, ordinary and decimal fractions, rules for performing operations on numbers. Polynomials, abbreviated multiplication formulas. Percentage, proportions, basic problems on percentages. Transformation of numerical and letter expressions.

2. Transformations of expressions containing powers and logarithms. Power with natural, integer, rational and real exponent, properties of power. Root of natural power, arithmetic root, properties of roots. Logarithm of number, properties of logarithms. Transformation of expressions containing powers, roots and logarithms. Transformations of trigonometric expressions. Sine, cosine, tangent, cotangent of an arbitrary angle (number), radian measure of an angle. Trigonometric formulas. Transformation of trigonometric expressions.
3. Equations, inequalities, and their systems. Linear, quadratic, rational, fractional-rational, irrational, exponential, logarithmic, trigonometric equations and inequalities. Interval method for solving inequalities. Basic methods for solving systems of equations.
4. Functional dependencies. Function of a single real variable. Properties of the function. Extrema of a function and its maximum and minimum values. Linear, quadratic, power, exponential, logarithmic, trigonometric, and inverse trigonometric functions; inverse proportional relationships; properties of functions and their graphs.
5. Planimetry. Parallel and perpendicular lines. Triangle, quadrilateral and its types, regular polygon, circle and disk. Perimeters and areas of plane figures. Inscribed and circumscribed circles.

Field of science 3. Applied mathematics
Mathematics
1. Sequences and progressions. Arithmetic and geometric progressions. Convergent geometric series. Sum of a convergent geometric series. Compound interest formula. Progressions in solving practical real-world problems.
2. Elements of mathematical analysis. Derivative of a function, geometric, and physical meaning of the derivative. Rules for calculating derivatives. Applying the derivative to analyzing functions. Indefinite and definite integrals; their properties. Newton-Leibniz formula. Calculating the area of a plane figure using a definite integral.
3. Planimetry. Cartesian rectangular coordinate system on the plane. Equation of a circle. Vectors and operations with vectors; vector length; scalar product of vectors.
4. Stereometry. Relative position of lines; lines and planes; planes in space. Perpendicular and inclined, theorem of three perpendiculars. Polyhedra and their types: prism and pyramid. Solids of revolution: cylinder, cone, sphere. Surface areas and volumes of solid bodies. Cartesian rectangular coordinate system in space. Equation of a sphere. Vectors and operations with them. Scalar product of vectors.

Field of science 4. Statistics and probability
Mathematics
1. Elements of probability theory. Various definitions of the probability of an event. Theorems of addition and multiplication of probabilities. Law of total probability; Bayes' formula; Bernoulli's formula.
2. Elements of statistics. Tabular and graphical representation of data. Numerical characteristics of data series.

Field of science 5. Computer science and artificial intelligence
Computer science
1. Graph theory. Basic concepts of graph theory. Constructing adjacency and weighing matrices from a graph and vice versa. Solving graph-based problems.
2. Algebra of logic (Boolean algebra). Basic operations of Boolean algebra: conjunction, disjunction, inversion, implication, and equivalence. Truth tables.

Field of science 6. Computer science and cybernetics

Computer science

1. Information theory. Concept of information. Types of information; methods of information coding (alphabetical, graphic, sound). System of information measurement units. Principle of binary information encoding.
2. Number systems. Positional number systems: decimal, binary, octal, and hexadecimal). Converting numbers from one numeral system to another. Binary arithmetic. Arithmetic operations in different number systems; methods for converting between systems with different bases.

4. Preparation materials

4.1. Recommended reading

Field of science 1. Mathematical logic

Reading list in English
1. Haghverdi E., Liugen Z. Mathematical foundations of information sciences. Singapore: World Scientific, 2024. 151 p. URL://https://zbmath.org/7852534 (free access)
2. Kueker D.W. Notes on Mathematical Logic. University Of Maryland, College Park. 114 p. URL://https://www.infobooks.org/pdfview/7461-notes-on-mathematical-logic-david-w-kueker/ (free access)
3. Morris J. Combinatorics. Alberta: University of Lethbridge, 2023. 357 p. URL://https://www.infobooks.org/pdfview/17730-combinatorics-joy-morris/ (free access)

Field of science 2. Mathematics

Reading list in English
1. Abramson J. College Algebra. OpenStax College, 2017. 619 p. URL://https://www.infobooks.org/pdfview/823-college-algebra-jay-abramson/(free access)
2. Gaudet D., Volpe A., Bohart J. Basic Arithmetic Student Workbook. Second Edition. April, 2013. 244 p. URL://https://www.infobooks.org/pdfview/1520-basic-arithmetic-student-workbook-donna-gaudet-amy-volpe-jenifer-bohart/(free access)
3. Hart C.A. Plane and Solid Geometry. London: Forgotten Books, 2013. 502 p. URL://https://www.infobooks.org/pdfview/782-plane-and-solid-geometry-cahart/(free access)
4. Indika, Sathish S.H., Leemis, Lawrence M. Exact expressions for trigonometric functions. Coll. Math. J. 55, No. 1, 40-45 (2024). URL://https://zbmath.org/7848819 (free access)
5. Kumar P., Sundaramoorthy K. Engineering mathematics – I. Chennai: Directorate of technical education government of Taminadu, 2015. 160 p. URL://https://www.infobooks.org/pdfview/835-engineering-mathematics-i-mramalingam-rssuganthi-br-narasimhan/ (free access)

Field of science 3. Applied mathematics

Reading list in English

1. Abramson J. College Algebra. Houston: OpenStax College, 2017. 619 p. URL://https://www.infobooks.org/pdfview/823-college-algebra-jay-abramson/(free access)
2. Hart C.A. Plane and Solid Geometry. London: Published by Forgotten Books, 2013. 502 p. URL://https://www.infobooks.org/pdfview/782-plane-and-solid-geometry-cahart/ (free access)
3. Indika S.S.H., Leemis L. M. Exact expressions for trigonometric functions. Coll. Math. J. 55, No. 1, 40-45 (2024). URL://https://zbmath.org/7848819(free access)
4. Kumar P., Sundaramoorthy K. Engineering mathematics – I. Chennai: Directorate of technical education government of Taminadu, 2015. 160 p. URL://https://www.infobooks.org/pdfview/835-engineering-mathematics-i-mramalingam-rssuganthi-br-narasimhan/(free access)
5. Stitz C., Zeager J. College Algebra. Kirtland: Lakeland Community College, 2010. 506 p. URL://https://www.infobooks.org/pdfview/826-college-algebra-carl-stitz-jeff-zeager/(free access)

Field of science 4. Statistics and probability

Reading list in English
1. Evans M.J., Rosenthal J.S. Probability and Statistics: The Science of Uncertainty. Toronto: University of Toronto. 2023. URL://https://www.utstat.toronto.edu/mikevans/jeffrosenthal/book.pdf (free access)
2. Probability and Counting Rules. 66 p. URL://https://www.grovecity.k12.pa.us/cms/lib/PA02000125/Centricity/Domain/203/ch04.pdf (free access)
3. Ross S.M. A First Course in Probability— 8th ed. 545 p. URL://https://www.seyedkalali.com/wp-content/uploads/2016/11/A-First-Course-in-Probability-8th-ed.-Sheldon-Ross.pdf (free access)
4. Ross S. M. Introduction to probability and statistics for engineers and scientists 5th ed. Berkeley: University of California, 2014. 730 p. URL://https://minerva.it.manchester.ac.uk/~saralees/statbook3.pdf(free access)

Field of science 5. Computer science and artificial intelligence

Reading list in English
1. Hall B.J. Beej's Guide to C Programming. 2024. 332 p. URL://https://www.infobooks.org/pdfview/beejs-guide-to-c-programming-brian-beej-jorgensen-hall-210/(free access)
2. Haghverdi E., Liugen Z. Mathematical foundations of information sciences. Singapore: World Scientific, 2024. 151 p. URL://https://zbmath.org/7852534(free access)
3. Kueker D.W. Notes on Mathematical Logic. College Park: University of Maryland. 114 p. URL://https://www.infobooks.org/pdfview/7461-notes-on-mathematical-logic-david-w-kueker/(free access)
4. Morris J. Combinatorics. Lethbridge: University of Lethbridge, 2023. 357 p. URL://https://www.infobooks.org/pdfview/17730-combinatorics-joy-morris/ (free access)

Field of science 6. Computer science and cybernetics

Reading list in English

1. Cafiero C. An Introduction to Programming and Computer Science with Python. Burlington: University of Vermont, 2022. 402 p. URL://https://www.infobooks.org/pdfview/an-introduction-to-programming-and-computer-science-with-python-clayton-cafiero-210/(free access)
2. Haghverdi E., Liugen Z. Mathematical foundations of information sciences. Singapore: World Scientific, 2024. 151 p. URL://https://zbmath.org/7852534(free access)
3. Morris J. Combinatorics. Lethbridge: University of Lethbridge, 2023. 357 p. URL://https://www.infobooks.org/pdfview/17730-combinatorics-joy-morris/(free access)
4. Rozhkovskaya N. Blue Book of Mathematics for Elementary School Teachers, 2021. 167 p. URL://https://www.math.ksu.edu/~rozhkovs/math320_Bversion.pdf (free access)

4.2. Recommended online courses

Field of science 1. Mathematical logic

Online courses in English	Link	Course description
Statistics and probability	URL://https://www.khanacademy.org/math/statistics-probability	This online course offers comprehensive coverage of fundamental statistical concepts. Course modules explore combinatorics, probability theory, and statistical analysis techniques. The course aims to build strong foundational knowledge for students pursuing mathematics, data science, or research fields.
Get ready for probability and combinatorics	URL://https://www.khanacademy.org/math/get-ready-for-precalculus/x65c069afc012e9d0:get-ready-for-probability-and-combinatorics	Course modules cover essential probability principles, including sample spaces and basic probability rules, along with foundational concepts in combinatorics. The curriculum explores probability calculations, tree diagrams, and fundamental counting principles through interactive learning materials.
Combinatorics and Probability	URL://https://www.coursera.org/learn/combinatorics?irclickid=S%3ALS9awVoxyKRa30qrT6uyWVUkCzxd1O0QZRTc0&irgwc=1&utm_medium=partners&utm_source=impact&utm_campaign=1310690&utm_content=b2c	This online course provides comprehensive coverage of combinatorial settings and the basics of probability theory. Course modules develop combinatorial analysis through enumeration techniques and probability foundations.

Field of science 2. Mathematics

Online courses in	Link	Course description

English		
Mathematics	URL://https://open.etu.ru/	This comprehensive mathematics course covers fundamental theoretical concepts through analytical problem-solving approaches, featuring video lectures on mathematical theory and problem analysis, organized into systematic modules.
Geometry (all content)	URL://https://www.khanacademy.org/math/geometry-home	This comprehensive geometry course systematically covers all fundamental concepts of plane geometry (planimetry).
Pre-University Calculus	URL://https://www.edx.org/learn/calculus/delft-university-of-technology-pre-university-calculus	This preparatory calculus course establishes fundamental mathematical concepts through three core content areas: functional analysis, equation solving techniques, and the foundations of analytic geometry.
Solution of Problems of Different Levels on Trigonometry	URL://https://stepik.org/course/176260/promo	This course covers trigonometric formulas, equations and functions, and their graphs.

Field of science 3. Applied mathematics

Online courses in English	Link	Course description
Mathematics for Economists	URL://https://www.xuetangx.com/course/hse0002/21367603	This course bridges mathematical theory with economic applications through rigorous problem-solving. It is aimed at teaching students to solve comparative statics and optimization problems, using the acquired mathematical tools.
Geometry (all content)	URL://https://www.khanacademy.org/math/geometry-home	This comprehensive geometry course systematically covers all fundamental concepts of plane geometry (planimetry).
Pre-University Calculus	URL://https://www.edx.org/learn/calculus/delft-university-of-technology-pre-university-calculus	This preparatory calculus course establishes fundamental mathematical concepts through three core content areas: functional analysis, equation solving techniques, and the foundations of analytic geometry.
Introduction to	URL://https://www.infobooks.or	This online course covers topics

Vectors	g/pdfview/12847-introduction-to-vectors-r-horan-m-lavelle/	including vectors, vector magnitude, vector operations, and vector decomposition onto a basis.
Calculus	URL://https://www.khanacademy.org/math/calculus-1	This course systematically develops single-variable calculus by exploring core topics such as limits and continuity; derivatives, including definitions and basic rules; applications of derivatives; function analysis; integrals; and applications of integrals.

Field of science 4. Statistics and probability

Online courses in English	**Link**	**Course description**
Statistics and probability	URL://https://www.khanacademy.org/math/statistics-probability	This comprehensive course systematically covers the mathematical foundations and applications of probability and statistics through examining three core disciplinary areas: combinatorics, probability theory, and statistical analysis.
High school statistics	URL://https://www.khanacademy.org/math/probability	This foundational course systematically introduces statistical concepts and methods.
AP®/College Statistics	URL://https://www.khanacademy.org/math/ap-statistics	This online course covers statistical analysis, probability, and inference.

Field of science 5. Computer science and artificial intelligence

Online courses in English	**Link**	**Course description**
Computer Science Fundamentals	URL://https://code.org/curriculum/csf	This course introduces students to foundational concepts in computer science while examining how computers and technology shape the world.
Introduction to Artificial Intelligence with Python	URL://https://pll.harvard.edu/course/cs50s-introduction-artificial-intelligence-python	This course explores the concepts and algorithms underlying modern artificial intelligence. Through hands-on projects, students gain an understanding of the theory behind graph search, classification, optimization, reinforcement learning, and other topics in artificial intelligence and machine learning.

Artificial Intelligence	URL://https://ocw.mit.edu/courses/6-034-artificial-intelligence-spring-2005/	This course explores applications of rule chaining, heuristic search, logic, constraint propagation, constrained search, and other problem-solving paradigms. In addition, it covers applications of decision trees, neural nets, SVMs, and other learning paradigms.
Mathematics for Computer Science	URL://https://ocw.mit.edu/courses/6-042j-mathematics-for-computer-science-fall-2010/	This course covers elementary discrete mathematics for computer science and engineering. Topics include formal logic notation, proof methods; induction, well-ordering; sets, relations; elementary graph theory; integer congruences; permutations and combinations, counting principles.

Field of science 6. Computer science and cybernetics

Online courses in English	**Link**	**Course description**
Computer Arithmetic – Computer Fundamentals. Pradeep K. Sinha & PritiSinha.	URL://https://www.infobooks.org/pdfview/1532-chapter-05-computer-arithmetic-computer-fundamentals-pradeep-k-sinha-pritisinha/	This presentation covers essential digital number systems.
Computer Science Fundamentals	URL://https://code.org/curriculum/csf	This course introduces students to foundational concepts in computer science while examining how computers and technology shape the world.
Information Technology I	URL://https://ocw.mit.edu/courses/15-564-information-technology-i-spring-2003/	This online course overs core IT concepts and helps students understand technical concepts underlying current and future developments in information technology.