Postgraduate track program: Applied Mathematics and Artificial Intelligence

1. Olympiad winner's skill set

To win the Olympiad, you should have a firm grasp of mathematics, data analysis and machine learning concepts, namely:

- mathematical logic, algorithms, machine learning, and information technology;
- data analysis, neural network design and training, and software development;
- graph theory, modular arithmetic, real and complex analysis, and the fundamental laws of probability distributions.

You should also have a solid command of the following skills:

- solving ordinary differential equations and partial differential equations;
- investigating system stability;
- constructing functions of random variables, and applying limit theorems;
- using modern software development methodologies, including the Unified Process and agile methodologies like Scrum or XP.

2. List of degree programs covered by subject area

2.1. List of master programs

01.04.01	Mathematics
01.04.02	Applied Mathematics and Computer Science
01.04.03	Mechanics and Mathematical Modelling
01.04.04	Applied Mathematics
01.04.05	Statistics
02.04.01	Mathematics and Computer Sciences
09.04.01	Information Science and Computer Engineering
09.04.03	Applied Computer Science
09.04.04	Software Engineering

2.2. List of doctoral programs

1.1.1 Real, complex and functional analysis
1.1.2 Differential equations and mathematical physics
1.1.4 Probability theory and mathematical statistics
1.1.5 Mathematical logic, algebra, number theory and discrete mathematics
1.1.6 Computational mathematics
1.2.1 Artificial intelligence and machine learning
1.2.2 Mathematical modelling, numerical methods and software packages
1.2.3 Theoretical informatics, cybernetics
2.3.1 System analysis, management and information processing, statistics
2.3.5 Mathematical and software foundation for data science
2.3.7 Computer modelling and computer-aided design

3. Content

Mathematics

Linear algebra and analytic geometry

1. Complex numbers. Algebraic and exponential (polar) forms. Roots of complex numbers. De Moivre's formula. The fundamental theorem of algebra.
2. Polynomials. The roots of a polynomial. The multiplicity of a root. The little Bezout theorem. Polynomial long division. The greatest common divisor of polynomials. The Lagrange and Newton interpolating polynomials. Irreducible polynomials. The unique factorization theorem for polynomials.
3. Gaussian elimination. Cramer's rule. The Rouche-Capelli theorem.
4. Real and complex vector spaces. A basis, the dimension and coordinates of a vector. Vector subspaces. Sum and intersection of subspaces. A linear transformation of a finite-dimensional vector space, the matrix of a linear transformation. The change of basis formulas.
5. The characteristic polynomial of a linear. Eigenvectors and eigenvalues of a linear transformation.
6. The Jordan normal form of a linear transformation on a complex vector space.
7. Bilinear forms. Symmetric bilinear forms and quadratic forms. Positive-definite and negative-definite quadratic forms. Sylvester's law of inertia. Sylvester's criterion.
8. Euclidean spaces. Self-adjoint and orthogonal linear transformations. An orthogonal diagonalization of the quadratic form.
9. The three-dimensional space. The dot product, the cross product, and the triple product.
10. Various ways to define a straight line and a plane in three-dimensional space. The angle between a straight line and a plane, the angle between two straight lines, the angle between two planes. The distance from a point to a plane. The distance between two lines.
11. Curves of the second order.
12. Surfaces of the second order.

Real and complex analysis (calculus)

13. Limit of a sequence: definition and properties. Cauchy's criterion. Limit inferior and limit superior. The Bolzano–Weierstrass theorem. The limit of a function at a point. The equivalence of Cauchy's and Heine's definitions.
14. Function continuity at a point. Behavior of a continuous function on a segment: the Weierstrass and Bolzano-Cauchy theorems. The inverse function theorem. Uniform continuity, Cantor's theorem.
15. Derivative of a function (of a single variable) at a point: definition and basic properties. The derivative of a composition of functions. Differentiability of a function at a point. Function differential at a point. Derivative of an inverse function. Higher order derivatives and differentials. The Leibniz rule. Rolle's Theorem, the mean value theorem, and Cauchy's mean value theorem. L'Hôpital's rule. Taylor's expansion with the Peano and Lagrange form of the remainder. Using Taylor's expansion and L'Hôpital's rule for limit calculations. Using derivative to study the properties of a function of a single variable: monotonicity, extrema, convexity, inflexion points.
16. Indefinite integral. Definite integral. Darboux's criterion of the integrability of a function. Properties of an integral with a variable upper limit: continuity, differentiability. The Newton–

Leibniz formula. Geometric applications of a definite integral. Improper integrals. Absolute convergence and conditional convergence. Cauchy's criterion, and Dirichlet's test of convergence.
17. Differentiability of a function of several variables. Necessary conditions and sufficient conditions for differentiability. Gradient of a function. Implicit function theorem. Local extrema of a function of several variables. Necessary conditions and sufficient conditions of a local extremum point. Conditional extrema of a function. The Lagrange multiplier method, necessary and sufficient conditions for conditional extrema.
18. Numeric series. Absolute and conditional convergence. Cauchy's criterion, comparison test, integral test, the Root and Ratio tests, Leibniz's and Dirichlet's tests. Function series. Uniform convergence. Cauchy's criterion, the Weierstrass test, and Dirichlet's test of uniform convergence. Power series. The radius of convergence, the Cauchy—Hadamard formula. The Taylor expansion. Taylor expansions for elementary functions.
19. Line integral. Green's theorem. Surface integrals. The Gauss—Ostrogradsky theorem. Stokes' theorem
20. A Fourier series. Pointwise convergence conditions. Uniform convergence conditions. The Fourier transform of an absolutely integrable function and its properties. The Fourier transform of a derivative and the derivative of a Fourier transform.
21. Functions of a Complex Variable. Analytic functions.
22. Integral of a function of a complex variable. Cauchy's integral theorem. Cauchy's integral formula.
23. Maximum modulus principle and the Schwarz lemma.
24. The Taylor and Laurent series.
25. Residues of complex functions. Cauchy's residue theorem. Calculation of integrals using residues. Jordan's lemma.
26. Conformal mappings. Möbius transformations. The Joukowsky transform.

Applied Mathematics

Graph theory and number theory

1. The Euclidean algorithm. GCD and LCM. The fundamental theorem of arithmetic.
2. Modular arithmetic. Congruence classes. The ring of integers modulo m. Invertible elements. The Chinese remainder theorem.
3. Fermat's little theorem. Wilson's theorem.
4. Euler's totient function. Euler's theorem.
5. Finite fields (Galois fields).
6. Graphs. Connected components in a graph. Depth-first and breadth-first search. Adjacency matrix. Planar graphs. Euler's theorem.
7. An Eulerian path in a graph. A Hamiltonian path in a graph. Dijkstra's algorithm. The Floyd-Warshall algorithm.
8. Spanning trees in a graph. Prim's algorithm. Kruskal's algorithm.

Differential equations

9. Ordinary differential equations. Separation of variables. Reduction of the order of the differential equation. The method of introducing a parameter.
10. Linear ODEs and systems of ODEs with constant coefficients.

11. Linear ODEs and systems of ODEs with variable coefficients. A fundamental solution set. The Wrońskian, Liouville's formula. The variation of constants method.
12. Calculus of variations. The Euler–Lagrange equation. A necessary condition for a weak local extremum.
13. Equilibrium of an autonomous system of differential equations. Classifying the equilibria of linear autonomous second-order systems. Stability and asymptotic stability of equilibrium.
14. First integrals of the autonomous system of differential equations. Theorem on the number of independent first integrals. Linear PDEs. General solution and the Cauchy problem.

Mathematical physics

1. Statement of problems of mathematical physics. Posed and ill-posed problems of mathematical physics.
2. Classification of second-order partial differential equations with two independent variables, linear with respect to higher derivatives.
3. Cauchy problems for equations of hyperbolic and parabolic types.
4. Method of separation of variables. Sturm-Liouville problem.
5. Hyperbolic type equations.
6. Parabolic type equations.
7. Elliptic type equations. Properties of harmonic functions.
8. Method of integral transformations.

Mathematical logic

1. Introduction to logic.
2. Predicate logic.
3. The theory of evidence.
4. Applications of mathematical logic.

Statistics & probability

1. Fundamentals of combinatorics: counting rules, addition and multiplication rules, combinations with and without repetitions, binomial coefficients and Newton's binomials.
2. Probabilistic space. Independent events. Addition theorem. Conditional probability. Complete event system. The formula for full probability. Bayes' formula.
3. Random variable and its distribution function. Mathematical expectation and dispersion of a random variable, their properties.
4. The main types of distributions of random variables: binomial, geometric, uniform, Poisson, exponential, and normal. Bernoulli's experiments. Chebyshev's inequality and the Central Limit Theorem.
5. Joint distribution of several random variables. Independence of random variables. Covariation. Correlation coefficient.
6. Estimation of numerical characteristics of distributions in the sample.

Computer science, artificial intelligence

1. Regression analysis.
2. Binary classification.

3. Multiclass classification.
4. Mathematical models of neural networks.
5. Backpropagation algorithm.

Computer science, cybernetics

1. Mathematical models of dynamic systems, and their classification. Equations of statics and dynamics, linearization. The transfer function of continuous and digital systems, their transient and impulse transient characteristics. Frequency characteristics, frequency hodograph. Feedback principle. Typical dynamic links, groups of links. Structural transformations of systems.
2. Stability of dynamic systems, its various types. Algebraic and frequency stability criteria, Mikhailov-Nyquist criterion. Stability reserves.
3. Dynamic accuracy of systems, and its indicators. Coefficients and error values. Various types of quality factors, and frequency methods for their determination. Static and astatic systems.
4. The principle of superposition in cybernetics, features of control processes in nonlinear systems. Typical nonlinearities. Methods for analyzing nonlinear systems. The phase plane method, its advantages and disadvantages. Construction of transient processes using known phase trajectories. Harmonic and statistical linearization.
5. Root hodograph method in technical cybernetics. Properties of root hodographs, their construction. Analysis and synthesis of systems using the root hodograph.
6. Equations of dynamics of systems in state space. Obtaining equations of the state of continuous and discrete systems from their known transfer functions. Normal form of equations of state. Controllability and observability.

Computer science, software engineering

1. Definition of a project. Project goals. Definition of a software development process. Key project indicators.
2. Human resources management. Key roles of software developers. Project risk management.
3. Basics of Unified Process. Definition of a use case and iteration.
4. Inception phase. Requirements analysis. Role of a system analyst.
5. Elaboration phase. Definition of a project architecture. Building of an architecture.
6. Popular architecture prototypes.
7. Construction phase. Key artefacts of a project release.
8. Purpose of project testing. Tests types. Building of tests.
9. Definition of DevOps. Tasks of CD and CI.
10. History of the agile methodology. Comparing the agile methodology and UP.
11. Key practices of Scrum, XP, DSDM and FDD.
12. Popular chart notations (UML, Gantt etc).

Computer science, information systems

1. Information: collecting, transmitting, processing, accumulation, measurement; information units. Information and entropy.
2. The concept of the information system and information technology. Information systems classification.
3. Data classification.

4. Architecture of distributed systems. Distributed information processing.
5. Data processing. Concept of ETL process.
6. Data storage in information systems. Types of storage. Basic concepts of relational algebra.
7. Hardware and software of information technology. Parallel data processing in information systems. Basic classes of modern parallel systems.
8. Concept of a system. Types of systems.
9. Control object and control system. Information. Feedback. Subject of technical cybernetics and information theory.
10. Pragmatic, semantic and syntactic aspects of information.

4. Recommended references

4.1. Reading list

Mathematics

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Applied mathematics

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2. N. Christofides. Graph theory. An algorithmic approach. London 1975. https://djvu.online/file/YisZ9w23dBmHW Free access	6-8
3. L. Elsgolts. Differential Equations and the Calculus of Variations. University Press of the Pacific , 2003. https://ia800908.us.archive.org/2/items/ElsgoltsDifferentialEquationsAndTheCalculusOfVariations/Elsgolts-Differential-Equations-and-the-Calculus-of-Variations.pdf Free access	9-14

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2. Budak B.M., A.A. Samarskii, A.N. Tikhonov. A Collection of Problems on Mathematical Physics. Moscow, 1964. https://archive.org/details/a-collection-of-problems-on-mathematical-physics Free access	1-8
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Mathematical logic

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2. Kleene S. C. Mathematical logic. NY: Dover Publ., 2002. 432 p. URL: https://ru.z-library.rs/book/20334015/d9a33f/mathematical-logic.html Free access	1-4
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2. Колмогоров А. Н., Драгалин А. Г. Математическая логика: Введение в математическую логику. Изд.6: М.: URSS, 2023, 240 с. URL: https://vk.com/doc-91031095_651760865 Free access	1-4
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Statistics & probability

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2. Ralph Stair, Information Systems. Course Technology Cengage Learning, U.S.A. 704 p. URL: https://archive.org/details/informationsyste0000stai/mode/2up Limited access	1-10
3. John Gallaugher Information Systems: A Manager's Guide to Harnessing Technology. Flat World Knowledge, Inc., 2010. 328 p. URL: https://archive.org/details/informationsyste0000gall/mode/2up	1-10

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4.2. Recommended online-courses

Mathematics

Online courses in English	**Link**	**Summary**
Linear algebra	https://www.khanacademy.org/math/linear-algebra	The course covers basic concepts and facts of linear algebra: vectors, spans, linear transformations, matrices, determinants, eigenvectors and so on.
Calculus: Single Variable Part 1 – Functions.	https://www.coursera.org/learn/single-variable-calculus	The course covers the following topics: Taylor series, limits, Lopitale rule, asymptotics
Calculus: Single Variable Part 2 – Differentiation.	https://www.coursera.org/learn/differentiation-calculus	This course covers: derivatives, differentiation rules, linearization, higher derivatives, optimization, differentials, and differentiation operators.
Calculus: Single Variable Part 3 – Integration.	https://www.coursera.org/learn/integration-calculus	The course covers integrating differential equations, techniques of integration, the fundamental theorem of integral calculus, and difficult integrals.

Calculus: Single Variable Part 4 – Applications.	https://www.coursera.org/learn/applications-calculus	This introductory calculus course explores fundamental concepts like derivatives and integrals, applying them to calculate areas, and volumes, and solve problems in geometry, physics, and other fields. The course also introduces probability and the concept of averages and mass.
Introduction to Complex Analysis	https://www.coursera.org/learn/complex-analysis	The course covers the following topics: complex numbers, power series and Laurent series, conformal mappings
Online courses in Russian	**Link**	**Summary**
Линейная алгебра	https://teach-in.ru/course/linear-algebra/lecture	The course contains basic facts and concepts of linear algebra from matrices and linear systems to bilinear forms and tensors
Аналитическая геометрия	https://openedu.ru/course/msu/ANGEOM/	This course is a complete course of classical analytic geometry.
Calculus: Single Variable Часть 1 – Функции. (на русском)	https://www.coursera.org/learn/single-variable-calculus	The course covers the following topics: Taylor series, limits, Lopitale rule, asymptotics
Математический анализ	https://www.lektorium.tv/	The course consists of several modules: differential calculus of functions of one variable; differential calculus of functions of several variables; integral calculus; ordinary differential equations
Ряды и интегралы	https://openedu.ru/course/spbu/INTEGRAL/?session=fall_2021	This course delves into the theory and applications of integration, covering both definite and indefinite integrals. Students will learn various integration techniques and explore the properties of infinite series, including determining their convergence.
Introduction to Complex Analysis (на русском)	https://www.coursera.org/learn/complex-analysis	The course covers the following topics: complex numbers, power series and Laurent series, conformal mappings

Applied Mathematics

Online courses in English	**Link**	**Summary**
Introduction to graph theory	https://www.classcentral.com/course/graphs-9213	The course contains basic concepts and applications of graph theory
Introduction to number theory	https://www.open.edu/openlearn/science-maths-	The course contains basic concepts of algebraic number theory from Euclid's algorithm to modular arithmetic

	technology/introduction-number-theory/content-section-0	
Ordinary Differential Equations.	https://www.udemy.com/course/ordinary-differential-equations/	The course covers the following topics: ODES of the 1st order, linear ODES of the highest order, systems of ODES of the 1st order, theory of stability, Laplace transform, numerical methods for solving DU
Online courses in Russian	**Link**	**Summary**
Основы теории графов	https://stepik.org/course/74545	The course contains basic concepts and algorithms of graph theory
Элементы теории чисел	https://teach-in.ru/course/elements-of-number-theory-nesterenko	The course contains basic concepts of number theory, including continued fractions and quadratic irrationalities
Дифференциальные уравнения	https://openedu.ru/course/ITMOUniversity/DIFEQ/	The course covers the following topics: ODES of the 1st order, linear ODES of the highest order, systems of ODES of the 1st order, theory of stability

Mathematical physics

Online courses in English	**Link**	**Summary**
Introduction to partial differential equations. MIT.	https://ocw.mit.edu/courses/18-152-introduction-to-partial-differential-equations-fall-2011/	This course introduces the fundamental concepts of partial differential equations (PDEs), focusing on three main types: diffusion, elliptic, and hyperbolic.
Partial differential equations. India's national course platform	https://www.classcentral.com/course/swayam-partial-differential-equations-17721	This course provides an introduction to first-order and second-order linear partial differential equations (PDEs), focusing on key concepts and applications relevant to students with backgrounds in Mathematics, Physics, and Engineering.
Online courses in Russian	**Link**	**Summary**
Математическая физика	https://openedu.ru/course/spbstu/MATHPH/	The course is designed for students of technical/engineering background.

Уравнения математической физики. МГУ. Горицкий А.Ю.	https://teach-in.ru/lecture/2020-09-12-Goritskiy-1	This course offers a comprehensive overview of partial differential equations (PDEs), covering all topics within the curriculum.
Лекции по уравнениям математической физики. НИЯУ МИФИ.	https://online.mephi.ru/course/view.php?id=884	Series of lectures on partial differential equations for engineers

Mathematical logic

Online courses in English	**Link**	**Summary**
Logic: The Basics by Stanford University	https://www.coursera.org/learn/logic	The course covers propositional and predicate logic, proof methods, and applications in computer science.
Introduction to Logic by University of Washington	https://www.coursera.org/learn/logic-uw	The course focuses on propositional and predicate logic, with an emphasis on using logic to solve problems.
Reasoning Under Uncertainty by MIT	https://www.edx.org/course/reasoning-under-uncertainty-mitx-6-034-1x	This course explores the application of logic to problems involving reasoning under uncertainty, with a focus on its relevance to artificial intelligence.
Mathematical Logic by the University of California, San Diego	https://www.coursera.org/learn/mathematical-logic	The course delves deeper into topics such as formal systems, Gödel's incompleteness theorems, and set theory.
Online courses in Russian	**Link**	**Summary**
Введение в математическую логику	https://www.coursera.org/learn/mathematical-logic	The course provides an understanding of logical principles and their application in various fields, including mathematics, computer science, philosophy and artificial intelligence.
Логика	https://stepik.org/course/114/syllabus	The course covers the basics of logic, propositional and predicate logic, set theory and logical paradoxes.
Математическая логика: основы.	https://stepik.org/course/15988/syllabus	The course focuses on the study of the basic concepts of mathematical logic, predicate logic and the basics of set theory.

Statistics & probability

Online courses in English	Link	Summary
Probability Theory	https://stepik.org/52134	The course includes the basic concepts of probability theory, the most important probability-theoretic models, limit theorems and some methods of mathematical statistics.
Introduction to Statistics.	https://www.coursera.org/learn/stanford-statistics	The Introduction to Statistics course at Stanford teaches you the concepts of statistical thinking that are necessary for studying data and communicating information. By the end of the course, you will be able to perform exploratory data analysis, understand key sampling principles, and select appropriate significance tests for different contexts. You will acquire basic skills that will prepare you to study more complex topics in statistical thinking and machine learning. Topics include descriptive statistics, sampling and randomized controlled experiments, probability, sample distributions and the central theorem, regression, general significance tests, re-sampling, and multiple comparisons.
Probability Theory: Foundation for Data Science.	https://www.coursera.org/learn/probability-theory-foundation-for-data-science	This course provides a foundational understanding of probability theory and its applications in statistics and data science. We'll explore key concepts like probability calculations, independent and dependent events, and conditional probabilities, along with discrete and continuous random variables. The course culminates with a focus on the Gaussian (normal) distribution, the Central Limit Theorem, and their essential role in statistical analysis and data science.
Combinatorics and Probability.	https://www.coursera.org/learn/combinatorics	This online course explores a wide range of combinatorial problems, emphasizing the ability to identify and apply these concepts in real-world scenarios and algorithmic tasks. You'll gain hands-on experience with the recursive counting technique and develop a solid foundation in probability theory, fostering both theoretical knowledge and practical intuition.
To p or not to p?	https://www.coursera.org/learn/probability-statistics	This course equips you with essential tools for dealing with uncertainty and making informed decisions. You'll learn about quantifying uncertainty using probability, descriptive statistics, and methods for estimating averages and proportions. The course also

		covers the fundamentals of hypothesis testing and explores multidimensional applications of key concepts, empowering you to make confident decisions in various real-world scenarios.
Online courses in Russian	**Link**	**Summary**
Introduction to Statistics.	https://www.coursera.org/learn/stanford-statistics	The Introduction to Statistics course at Stanford teaches you the concepts of statistical thinking that are necessary for studying data and communicating information. By the end of the course, you will be able to perform exploratory data analysis, understand key sampling principles, and select appropriate significance tests for different contexts. You will acquire basic skills that will prepare you to study more complex topics in statistical thinking and machine learning. Topics include descriptive statistics, sampling and randomized controlled experiments, probability, sample distributions and the central theorem, regression, general significance tests, re-sampling, and multiple comparisons.
Probability Theory: Foundation for Data Science.	https://www.coursera.org/learn/probability-theory-foundation-for-data-science	This course provides a foundational understanding of probability theory and its applications in statistics and data science. We'll explore key concepts like probability calculations, independent and dependent events, and conditional probabilities, along with discrete and continuous random variables. The course culminates with a focus on the Gaussian (normal) distribution, the Central Limit Theorem, and their essential role in statistical analysis and data science.
Combinatorics and Probability.	https://www.coursera.org/learn/combinatorics	This online course explores a wide range of combinatorial problems, emphasizing the ability to identify and apply these concepts in real-world scenarios and algorithmic tasks. You'll gain hands-on experience with the recursive counting technique and develop a solid foundation in probability theory, fostering both theoretical knowledge and practical intuition.
To p or not to p?	https://www.coursera.org/learn/probability-statistics	This course equips you with essential tools for dealing with uncertainty and making informed decisions. You'll learn about quantifying uncertainty using probability, descriptive statistics, and methods for estimating averages and proportions. The course also covers the fundamentals of hypothesis testing and explores multidimensional applications of key

		concepts, empowering you to make confident decisions in various real-world scenarios.

Computer science, artificial intelligence

Online courses in English	**Link**	**Summary**
Machine Learning	https://openedu.ru/course/mephi/mephi_mo/	Students of the course will learn what big data looks like, learn how to process it: restore missing values, remove anomalies, and predict feature values. Students will also learn how to analyze artificial intelligence models, find their strengths and weaknesses, and argue their point of view on issues related to artificial intelligence.
Neural Networks	https://openedu.ru/course/mephi/mephi_ns/	This course explores the fundamental concepts of neural networks, including their architecture, algorithms for configuration, and effective methods for presenting problems to these networks. You'll learn how to identify solvable problems and gain insights into the limits of neural network applications.
Supervised Machine Learning: Regression and Classification	https://www.coursera.org/learn/machine-learning	This course covers machine learning methods such as decision trees and neural networks. The practical part of the course will be devoted to getting acquainted with the most popular libraries for data analysis using the Python programming language — Pandas and Scikit-learn.
Online courses in Russian	**Link**	**Summary**
Машинное обучение	https://stepik.org/course/8057/info	The Machine Learning course is dedicated to the study of one of the most popular sections of machine learning – machine learning with a teacher. A brief history and paradigms of machine learning, the basic principles of machine learning with a teacher are given, regression and classification tasks are considered, models used to solve them, teaching methods and quality assessment of trained models are considered, the features of the organization of the learning process with a teacher and the application of machine learning methods to solve practical problems are considered. The presentation is conducted in strict mathematical language, accompanied by a variety of formulas and mathematical calculations. To study this course, knowledge of university courses in mathematical analysis, linear algebra, probability theory and mathematical statistics is required. Basic knowledge of

		optimization methods and applied statistical data analysis is desirable.
Нейронные сети и компьютерное зрение	https://stepik.org/course/50352/promo	The course "Neural networks" is devoted to the study of the mathematical foundations of the theory of neural networks, provides a brief history of the theory of neural networks, mathematical models of neural network architectures, formulation of the learning task and methods of its solution, discusses the features of the organization of the learning process and the use of neural networks to solve practical problems. The presentation is conducted in strict mathematical language, accompanied by a variety of formulas and mathematical calculations. To study this course, knowledge of university courses in mathematical analysis, linear algebra, probability theory and mathematical statistics is required. Basic knowledge of optimization methods and applied statistical data analysis is desirable.
Введение в Data Science и машинное обучение	https://stepik.org/course/4852/promo	The course will teach you how to build machine learning models in Python using popular machine learning libraries NumPy and sci-kit-learn. Build and train supervised machine learning models for prediction and binary classification tasks, including linear regression and logistic regression The Machine Learning Specialization is a foundational online program created in collaboration between DeepLearning.AI and Stanford Online. In this beginner-friendly program, you will learn the fundamentals of machine learning and how to use these techniques to build real-world AI applications. This Specialization is taught by Andrew Ng, an AI visionary who has led critical research at Stanford University and groundbreaking work at Google Brain, Baidu, and Landing.AI to advance the AI field.

Computer science, cybernetics

Online courses in English	**Link**	**Summary**
Planning and Control	https://www.classcentral.com/classroom/youtube-planning-and-control-141805	This brief course with Alfredo Canziani dives into planning and control strategies, covering state transition equations, numerical examples, and practical implementation of optimal control problems using PyTorch.

Programming and Simulink	https://www.classcentral.com/course/swayam-advanced-linear-continuous-control-systems-applications-with-matlab-programming-and-simulink-13887	This 8-week course from IIT Roorkee delves into advanced linear continuous control systems. You'll master state space modelling, stability analysis, controllability, and observability, gaining practical skills with MATLAB and Simulink to confidently tackle real-world control challenges.
An Informational Perspective on Uncertainty in Control	https://www.classcentral.com/classroom/youtube-an-informational-perspective-on-uncertainty-in-control-180472	This short course from the Simons Institute, led by Gireeja Ranade of Microsoft Research, examines uncertainty in control systems from an information-theoretic perspective.
Online courses in Russian	**Link**	**Summary**
Кибернетика	https://stepik.org/course/200842/promo#toc	This is a course that studies the fundamentals of information theory and control in systems.
Основы кибернетики	https://teach-in.ru/course/fundamentals-of-cybernetics	This course explores various classes of control systems, focusing on their discrete mathematical models. These models represent diverse types of electronic circuits, information processing and control systems, algorithms, and programs, providing a comprehensive understanding of their underlying structure and behaviour.
Теория кибернетических систем	https://openedu.ru/course/spbu/CYBERSYS/	This course helps students understand issues of linear theory, discrete systems and discretization, features of nonlinear problems

Computer science, software engineering

Online courses in English	**Link**	**Summary**

IBM: Software Engineering Basics for Everyone	https://www.edx.org/learn/software-engineering/ibm-software-engineering-basics-for-everyone	This course is suitable for anyone willing to start in a software development-related role, including those aspiring to be Software Engineers, IT Product and Project Managers, Scrum Masters, Information Developers, UI/UX Designers, QA Engineers, as well as Sales Executives, and Marketing Managers in the Tech industry. No prior programming experience or degree is required.
UBCx: Software Engineering: Introduction	https://www.edx.org/learn/software-engineering/university-of-british-columbia-software-engineering-introduction	This course introduces how teams design, build, and test multi-version software systems. You will learn software engineering principles that apply to the breadth of large-scale software systems. The course explores topics such as agile development, REST and Async programming, software specification, design, refactoring, information security, and more.
DevOps and Software Engineering	https://www.edx.org/certificates/professional-certificate/ibm-devops-and-software-engineering	This self-paced certificate program of online courses, built for beginners, will equip you with the key DevOps concepts and technical know-how to build your Software Development skills and knowledge with DevOps practices, tools, and technologies. By the end of this program, you will be prepared for an entry-level role in Software Engineering with an organization of DevOps practitioners.
Online courses in Russian	**Link**	**Summary**
Программная инженерия. Анализ, моделирование, проектирование	https://stepik.org/175415	The purpose of the course is to form a comprehensive understanding of the activities that form the "core" and the basis of the working outlook of a software engineer. Each chapter examines activities that represent self-sufficient professional fields of knowledge.

Основы Agile	https://stepik.org/183476	This is a course that allows you to delve deeply into the values, principles and practices of Agile (agile), as well as understand their connection with the methods used in popular methodologies such as Scrum, XP (extreme programming) and Kanban.
Современный Agile для Разработчиков [и Менеджеров]	https://stepik.org/203018	This course provides a balanced and accessible approach to the subject matter, combining concise theory with clear illustrations and practical examples. Each lesson includes self-assessment tests to ensure a thorough understanding of the material.

Informatics and information systems

Online courses in English	**Link**	**Summary**
Databases: Modeling and Theory	https://www.edx.org/learn/databases/stanford-university-databases-modeling-and-theory?index=product&queryID=34124529d88149b80e288b13698e5e20&position=1&linked_from=autocomplete&c=autocomplete	This course covers underlying principles and design considerations related to databases. It can be taken either before or after taking other courses in the Databases series.
Information Systems Foundations	https://www.coursera.org/specializations/information-systems-foundations#credits	The Information Systems Foundations specialization provides an immersive experience in software development and information systems across four courses. Throughout this specialization, you'll master the art of modelling significant business applications swiftly and effectively, preparing you for challenges in the professional world of information systems.
The Nature of Data and Relational Database Design	https://www.coursera.org/learn/nature-of-data-relational-	This course provides a comprehensive understanding of data, different types of data, designing databases to store them, and creating and manipulating data in databases using SQL.

	database-design#modules	
Online courses in Russian	**Link**	**Summary**
Проектирование информационных систем	https://intuit.ru/studies/courses/2195/55/info	The course is aimed at studying modern methods and means of designing information systems in the field of economics. The scientific basis of the course is the methodologies of system analysis and modelling.
Введение в реляционные базы данных	https://intuit.ru/studies/courses/74/74/info	The course outlines the basic concepts and methods of organizing and manipulating relational databases and also describes basic approaches to designing relational databases. The concept of a relational data model is introduced, and the structural, manipulation and holistic components of the model are discussed.
Хранение и обработка данных	https://openedu.ru/course/ITMOUniversity/DATST/?session=self_2024	The purpose of the course is to show the practical aspects of technologies related to storage, processing and approaches to analyzing large volumes of data. Practical exercises of the course can be performed using MS Excel, programming languages (not required), relational and NoSQL DBMS.