Master's entrance examination program in "Applied Mathematics and Informatics"

1. Limit and continuity of functions of one and several variables. Properties of functions that are continuous on a segment.

2. Derivative and differential of functions of one and several variables. Sufficient conditions for differentiability.

3. A definite integral, its properties. The basic formula of integral calculus. Basic methods of integration.

4. Improper integrals. Absolute and conditional convergence. Convergence criteria.

5. Numerical series. Absolute and conditional convergence. Convergence criteria.

6. Functional sequences and series. Uniform convergence. Uniform convergence criteria for functional series.

7. Multiple, curvilinear and surface integrals. Green, Ostrogradsky-Gauss and Stokes' formulas.

8. Derivative of a function of a complex variable. Cauchy-Riemann conditions. Analytical function.

9. Power series in the real and complex domain. Convergence radius. Expansion of functions in power series.

10. Systems of linear algebraic equations. The Kronecker-Capelli theorem, a criterion for the uniqueness of a solution. General solution of a system of linear algebraic equations and methods of its construction.

11. A straight line on a plane, a plane and a straight line in space; their equations. Mutual arrangement of straight lines and planes, basic metric problems. Linear subspaces, linear affine manifolds.

12. Algebraic lines and surfaces of the second order, canonical equations, classification. Quadratic forms in real linear space, reduction to principal axes.

13. Linear operator in a finite-dimensional space, its matrix, kernel and image. The norm of a linear operator.

14. Characteristic polynomial of a linear operator. Eigenvalues and eigenvectors.

15. Linear operators in Euclidean space. Orthogonal, self-adjoint and sign-definite operators.

16. The concept of an algorithm and its formalization (Turing machines, normal Markov algorithms). Equivalence of algorithms. Algorithmic undecidability. Time and space algebraic complexity of the algorithm. O-, Ω-, and Θ-notation in asymptotic estimates of complexity. Basic algorithms and data structures. Sorting and searching algorithms.

17. Computer architecture. Von Neumann principles. The main components of a computer: processor, computer memory, bus, external devices, and controllers. Virtual memory addressing and its main models.

18. Parallelism and pipelining in computer architecture. Amdahl's Law. Classification of parallel computing systems. Parallelization of algorithms. Information graph of algorithm. Critical path in information graph.

19. Operating system, its structure and functions (on the example of Unix family of OS). Processes and threads. Memory management. Input/Output. External devices. Interprocess communication in Unix family of OS.

20. Languages and programming paradigms. Imperative programming (for example Pascal or C). Object-oriented programming (by the example of C++).

21. Formal grammars and languages. Chomsky classification of grammars and languages. Backus - Naur form. Regular expressions. Compiler operation diagram. Lexical and syntactic analysis.

22. Databases. Basic concepts of the relational data model. Relational algebra. Functional dependencies. Normalization of relations. Normal forms. Lossless decomposition of a relation, Heath's theorem. SQL query language tools.

23. First order ordinary differential equations. Linear ordinary differential equations and systems. Fundamental system of solutions. The Wronskian.

24. Determination of stability according to Lyapunov. Lyapunov's first method. Lyapunov's second method. Singular points.

25. Boolean functions. Formulas. Completeness of systems of Boolean functions. Disjunctive normal forms and their synthesis. Zhegalkin polynomials. Synthesis of circuits from functional elements.

26. Graphs. Trees. Graph isomorphism, graph connectivity. Planarity of graphs. Chromatic numbers of graphs.

27. Codes. Alphabetic coding. Unambiguity of encoding. Macmillan's inequality. Optimal coding. Huffman method. Error correcting codes. Hamming codes.

28. Automata. Moore's Theorem.

29. Probability space. Classical and geometric definitions of probability. Conditional probabilities.

30. Random variables and their numerical characteristics. Discrete and absolutely continuous distributions.

31. The law of large numbers and the central limit theorem.

32. Methods of Newton and secants for solving nonlinear equations.

33. Interpolation by polynomials. Lagrange and Newton interpolation formulas.

34. Quadrature formulas for rectangles, trapezoids, parabolas and Gauss.

35. Numerical solution of the Cauchy problem for ordinary differential equations. Euler and Runge-Kutta methods.

36. Basic concepts of the theory of difference schemes: approximation, convergence, stability. Maximum principle, monotone difference schemes. Difference schemes for the first boundary value problem of the heat equation.

37. The method of separation of variables for solving boundary value problems for linear partial differential equations of the second order on the plane and in three-dimensional space.

38. Properties of harmonic functions. Statement of the Dirichlet and Neumann problems for the Poisson equation, existence and uniqueness of the solution. Green's function, methods of its construction. Poisson's integral.

39. The Cauchy problem for the heat equation and the wave equation. The method of continuation of the initial data of the solution of initial-boundary value problems for the these equations on the half-line.

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28. Voronenko A.A., Fedorova V.S. Discrete Math. Problems and exercises with solutions.
29. Gnedenko B.V. Probability theory course.

30. Sevastyanov B.A. Course in Probability Theory and Mathematical Statistics.
31. Feller V. Introduction to the theory of probability and its applications, v.1,2.
32. Samarskiy A.A., Gulin A.V. Numerical methods.
33. Tikhonov A.N., Samarsky A.A. Equations of mathematical physics.
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2. Ilyin V.A., Sadovnichy V.A., Sendov Bl.Kh. Mathematical analysis. Continuation of the course. - M .: Publishing house of Moscow State University, 1987.

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5. Ilyin V.A., Poznyak E.G. Linear algebra. - M .: Fizmatlit, 2004.
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