THE LIST OF EXAMINATION QUESTIONS
for Master Program
Machine learning and data analysis

Computer Technology Department

Math

1. Definite and indefinite integrals. Integral of one variable and two variables.

2. Approximating integral: rectangular method, trapezoidal rule, error estimation. Multiple integral evaluation.

3. The number series. Absolute and conditional convergence. Convergence tests of numerical series.

4. Functional series, properties of uniformly convergent functional series. Power series. Taylor Series.

5. Determinants and their properties. System of linear algebraic equations, solving methods.

6. Linear operators and their matrix representation. Characteristic polynomial, eigenvalues and eigenvectors of a linear operator.

7. Projection of vector on axis and its properties. Linear dependence and independence of vectors. The criterion for linear dependence of two vectors. Concept of basis.

8. Scalar product of vectors: definition and properties. The criterion of vector orthogonality. Cross product, its properties and geometric meaning. The criterion of vector collinearity (using cross product). Calculation of vector products in Cartesian coordinate system.

9. The general, canonical and parametric equation of a line. The general equation of plane, the equation of plane passing through three points, the equation of plane passing through the point parallel to two given non-collinear vectors. The angle between the straight line and plane. The surface of the second order.

10. Definition of probability, random events, elementary outcomes, probability properties. Compatible and incompatible events. Addition of probabilities. Dependent and independent events. Multiplication of probabilities.

11. Conditional probability. The formula of total probability, Bayes' formula. The probability distribution of random events. The scheme of independent tests. The formula Of Bernoulli.

12. Distribution function of a random variable and its properties, independent random variables. Mathematical expectation, variance, mode, median, central and raw moments. Properties of mathematical expectation and dispersion.

13. Continuous random variable. Mathematical expectation and variance for a uniformly and normally distributed random variables. Distribution function of continuous random variable and its properties. Density function distribution. Mode, median. The raw and central

moments.

14. Population, sample, sample characteristics. Selection methods selection. Unbiased, efficient and consistent sample.

15. Point and interval estimation of distribution parameters. Method of moments and maximum likelihood estimation. The likelihood function for the discrete and continuous cases. Confidence intervals and reliability.

Applied math and numerical analysis

16. Numerical analysis: numerical stability and well-posed problems, examples of numerically stable and unstable problems, well-conditioned and ill-conditioned problems.

17. Numerical methods for nonlinear equations solving: problem conditioning, simple iterations method and Newton's method.

18. Direct methods for solving systems of linear equations: problem conditioning, Gaussian elimination and its modifications, tridiagonal matrix algorithm.

19. Numerical methods for solving systems of linear equations: fixed point iteration, Gauss--Seidel method, successive over-relaxation method, methods of descent.

20. Numerical methods for solving systems of nonlinear equations: fixed point iteration, Newton's method, methods of descent, combined method.

21. Function interpolation and approximation. Lagrange polynomial and Newton-Cotes method. Interpolation strategies, spline interpolation. Least squares method.

22. Difference schemes: Taylor series, finite volume method.

Computer Science

23. Mathematical sets and their basic operations. Boolean function, conjunctive normal form, disjunctive normal form.

24. Linear data structures: list, queue, deque, stack, vector. Priority queue. Search tree.

25. Graph algorithms. Graph search. Shortest path. Spanning tree.

26. Routes, chains, cycles. Connectivity. Trees. Eulerian path, Hamiltonian path. Graph coloring. Planar graph.

27. Graph maximum flow, maximum bipartite matching. Maximum flow in a flow network.

28. Computational geometry on the plane. Equations of point, line, circle. Convex hull algorithms. Triangulation algorithms.

29. Finite-state machine, regular language. Regular language equivalent formalisms.

30. Context-free grammar. Chomsky normal form. Halting problem.

31. Computational theory. Time and memory complexity. P, NP, PS classes. NP-completeness.

32. Cooperative and preemptive multitasking. Process and thread. Scalability, Amdahl’s law.

Software Engineering

33. Structured programming. Common features.

34. Procedural programming. Procedures and functions. Direct and indirect recursion. Modular programming.

35. Object-oriented programming. Encapsulation, abstract data types. Modules. Parametric and ad hoc polymorphism. Inheritance. Liskov Substitution Principle.

36. Metaprogramming. Templates and Generics. Explicit template specialization.

37. Database types. Relational databases. Database normalization. SQL language.

38. Relational database implementation. Transactions and their properties. Locks and their types.

39. Stored procedures. Comparison with functions. Data indexing. Types of indexes. Hash index.

40. Hierarchical database: nested set model, adjacency list model. Temporal database: intervals model, events model.

41. Test-driven development cycle. Pros and cons of test-driven development. Test-driven development tools

42. Software design patterns and their applications. Patterns classification. Examples.