Thematic areas for the Master state exam in the subject Computer Science

I. Mathematical basics of computer science

1. Computational complexity of algorithms. Techniques of analysis of computational complexity of algorithms: analysis of recursive algorithms, amortized analysis, average-case analysis of algorithms.
2. Mathematical models of algorithms – Turing machines and Random Access Machines (RAM). Undecidable problems.
3. Complexity classes. Classes PTIME and NPTIME, NP-complete problems. Other complexity classes (PSPACE, EXPTIME, EXPSPACE, polynomial hierarchy, NLOGSPACE, LOGSPACE, ...).
4. Models of computation for parallel and distributed algorithms. Computational complexity of parallel algorithms. Communication complexity.
5. Language of first-order predicate logic. Quantifiers and equivalent transformations of formulas.
6. Relation, operations with relations, properties of binary homogeneous relations.. Equivalence and partial order and their applications.
7. Operation and algebraic structures. Algebras with one or two binary operations.
8. FCA - formal context, formal concept, concept lattice.
9. Association rules, finding frequent itemsets.
10. Metric and topological spaces – metrics and similarities. Their applications.
11. Clustering. Types of classification, methods for determining clustering quality, and applications.
12. Random Variable. Types of Random Variable. Distribution Functions of Random Variable.
13. Discrete and Continuous Probability Distributions - Binomial, Hypergeometric, Negative Binomial, Poisson, Exponential, Weibull and Normal Distribution.
14. Exploratory Data Analysis. Descriptive Statistics and Graphs for Description of Qualitative and Quantitative Variables.
15. Inferential Statistics. Confidence Intervals. Principle of Hypothesis Testing.

Test areas cover the courses Theoretical Computer Science, Probability and Statistics, Mathematics for Knowledge Processing

II. Software engineering

1. Meaning of testing, terminology, testing process, Levels of testing (V-model), Testing techniques.
2. Architectural styles.
3. Qualitative requirements and their achievement. Measurement of design quality.
4. Design principles.
5. Design patterns.
6. What is Secure Software Development Lifecycle (SSDLC)? What are its specifics and uses?
7. Describe the five basic security features that are used to ensure the security and reliability of information systems. The acronym "CIAAN" stands for "Confidentiality", "Integrity", "Availability", "Authenticity" and "Non-repudiation". Give examples of software requirements that are based on these characteristics.

8. Penetration testing of software. Descriptive and prescriptive frameworks for penetration testing. Penetration testing methods.

Test areas cover the courses: Software Quality

III. Database Systems

1. Relational data model, SQL; function dependencies, decomposition and normal forms.
2. Transactions, recovery, the log file, ACID, COMMIT and ROLLBACK operations; anomalies of concurrency, techniques and implementations: locking; isolation levels of transactions in SQL.
3. Procedural extensions of SQL: PL/SQL, triggers, functions, procedures, cursors, bind variables, bulk operations.
4. Physical implementation of database systems: tables and indices, materialized views, data partitioning.
5. Query execution plan, logical and physical operations, random and sequence accesses, tuning of the query processing.
6. Paging of the query result, compression of tables an indices, row and column storages of tables.
7. CAP theorem, NoSQL DBS, BASE, replication, MongoDB, CRUD operations.
8. Multidimensional data structures, handling of multidimensional data in DBMS.

Test areas cover the courses Database Systems I, Database Systems I, Advanced Database Systems

IV. Computer Systems and Networks

1. Architectures of universal processors (CPUs). CPU acceleration techniques.
2. Microcomputers, basic construction features. Common integrated peripherals and their characteristics. Use cases of microcomputers.
3. TCP/IP protocol family.
4. Routing in computer networks (routing protocols, common problems). IP addressing. Network Address Translation.
5. Security in TCP/IP-based computer networks: possible attacks, packet filters, stateful firewall. Encryption and authentication, virtual private networks.
6. Parallel computing and platforms: Flynn taxonomy, SIMD, MIMD, SPMD. Instruction-level, data, and task parallelism. Processes and threads.
7. Shared-memory systems and distributed memory systems. inter-process communication (race condition, deadlock, mutual exclusion). Communication by message passing. OpenMP, MPI.
8. Parallel reduction and parallel scan: basic principles and case-studies in the selected technology
9. Concurrent data structures: overview, blocking and non-blocking implementations

Test areas cover the courses Computer Architecture and Parallel Systems, Computer Networks, Parallel Algorithms I.

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