The scope of the exam
in enrollment to the Doctoral School of Exact and Natural Sciences
in the discipline of Computer Science

Structure of the exam: 8 problems in the discipline of Computer Science within the pool of 16 problems proposed together with the discipline of Mathematics. For the final result, 4 best evaluated problems are chosen from the 16 proposed problems.

The following list of topics is indicative only; exam problems may partly relate to other topics within the same general thematic range.

1. Programming languages

   Examples of topics: language constructs encountered in imperative, object-oriented, functional and logic programming languages, semantics of programming languages, software verification techniques, type systems.

2. Discrete mathematics

   Examples of topics: combinatorics, elements of graph theory, elements of number theory, asymptotics.

3. Probability theory and statistics

   Examples of topics: conditional probability, independence, random variables and their parameters, conditional expectation, Markov chains, types of convergence of sequences of random variables, laws of large numbers and the central limit theorem. Elements of statistics: estimators and their properties, testing hypotheses, linear regression.

4. Algorithms and data structures

   Examples of topics: knowledge and ability to create algorithms with provable guarantees on pessimistic (or expected) running time and on correctness, dynamic programming, sorting and selection, basic data structures (e.g. dictionary, priority queue), graph algorithms (e.g. minimal spanning tree, maximal matching, maximal flow) and text algorithms, linear programming.

5. Logic and databases

   Examples of topics: Propositional logic, first- and second-order logic, relational algebra, SQL, intuitionism, expressivity and non-expressivity, decidability and complexity of logical theories.

6. Automata and formal languages

   Examples of topics: Finite automata, regular expressions, context-free grammars, pushdown automata, recognizability and non-recognizability, closure properties, decidability and complexity of the problems of belonging to a language, nonemptiness, language inclusion.

7. Computation theory and computational complexity

   Examples of topics: Turing machines, decidable and undecidable problems, complexity classes P, NP, PSPACE and others, hardness and completeness, Boolean circuits and complexity classes based on them, Las Vegas and Monte Carlo randomized algorithms, approximate algorithms.

8. Concurrent and distributed programming

   Examples of topics: Models of concurrency, communication and synchronisation mechanisms, paradigms of distributed computation, data integrity models, proving correctness of concurrent programs, efficiency analysis of concurrent programs, basic problems of concurrency and algorithms to solve them, in particular mutual exclusion and consensus.

9. Computer systems

   Examples of topics: computer system architecture, processes and mechanisms of process management, memory hierarchy and data storage, process communication and network protocols, computer system security.