Scope of the entrance exam in Computer Science
in the recruitment process to
the Doctoral School of Exact and Natural Sciences

Format of the exam
The candidate is given 8 problems in Computer Science together with 8 problems in Mathematics. The candidate can submit solutions to any subset of the 16 problems, but the final score depends on four (4) solutions with the highest evaluation.

Scope of the 8 problems in CS:

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

2. **discrete mathematics**
   Examples of topics: combinatorics, elements of graph theory, elements of number theory, asymptotics.

3. **probability and statistics**
   Examples of topics: elementary probability theory, conditional probability, independence, random variables (both discrete and continuous), moments, tail inequalities, limit theorems, Markov chains, elementary statistics: estimators and their properties, testing hypotheses, linear regression.

4. **algorithms and data structures**
   Examples of topics: designing algorithms with provable guarantees for worst case (or expected) running time and correctness of the solution; dynamic programming, sorting and selection, basic data structures (e.g. dictionary, priority queue), graph algorithms (e.g. minimal spanning tree, maximum matching, maximum flow) and text algorithms, linear programming.

5. **logic and databases**
   Examples of topics: Propositional calculus, first- and second-order logic, relational algebra, SQL; intuitionism; expressiveness and inexpressibility; decidability and complexity of logical theories and decision problems like satisfiability and evaluation (of formulas and queries).

6. **automata and formal languages**
   Examples of topics: Finite automata, regular expressions, context-free grammars, pushdown automata; recognition and unrecognizability; closure properties, decidability and complexity of problems like membership, emptiness, and inclusion.

7. **theory of computation and computational complexity**
   Examples of topics: Turing machine, 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; approximation algorithms.

8. **concurrent and distributed programming**
   Examples of topics: models of concurrency, communication and synchronization mechanisms, distributed computation paradigms, data consistency models, fault
tolerance, proving correctness of concurrent programs, efficiency analysis of concurrent programs, fundamental concurrency problems and algorithms solving them, in particular mutual exclusion and consensus.

9. computer systems
Examples of topics: computer architecture, processes management, memory hierarchy and data storage, communication between processes and network protocols, security in computer systems.