Course: Computational Models and Complexity

Time and Place: Monday & Wednesday 5:00-6:45 p.m., Thimann Lab 101.

Instructor: Phokion G. Kolaitis

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Office Hours: Monday 2:30-3:30 p.m., Wednesday 3:00-4:00 p.m., and by appointment.


Overview and Goals:

The goal of this course is to present the main concepts, methods, and techniques used to analyze and classify algorithmic problems according to the intrinsic difficulty of solving them.

The first part of the course will cover some basic material on models of computation with particular emphasis on finite automata, Turing machines, and undecidability results. The second part of the course will be an introduction to computational complexity, the area of computer science that classifies algorithmic problems into complexity classes obtained by imposing resource bounds (time and/or space bounds) on models of computation. This part of the course will introduce the main complexity classes, including P, NP, and PSPACE, study the relationships between them, demonstrate the existence of natural complete problems for each of these classes (that is, problems that embody the intrinsic difficulty of the entire class), and present a number of fascinating open questions that remain unanswered thus far.

Syllabus: The following is a tentative list of topics.

- Deterministic finite automata, nondeterministic finite automata, regular expressions, closure properties of regular languages (three weeks).
- Universal models of computation, Turing machines, computability, undecidability results (two to three weeks).
- Time and space complexity classes, relations between them, hierarchy theorems, reductions between algorithmic problems (one to two weeks).
- The complexity classes NL (nondeterministic logarithmic space), P (polynomial time), NP (nondeterministic polynomial time), and PSPACE (polynomial space), complete problems for each of these classes (three weeks)
- Additional topics: Counting problems and the complexity class #P; probabilistic computation and the complexity class PP; parallel computation and the complexity class NC (time permitting); the computational complexity of approximation.

Evaluation:

- Take-home final examination.
- Written assignments consisting of homework problems and a short paper.
- Class participation.

The take-home final examination will be distributed on Wednesday, March 10, 2004 (which is the last day of classes) and will be due by 5:00 p.m. on Monday, March 15, 2004.