Spring 2006
Georgia Tech, CS 6505
Tu/Th 9:35am - 10:55am
Classroom: CCB Room 102

CS 6505: Computability, Algorithms, and Complexity

http://www.cc.gatech.edu/~bader/COURSES/GATECH/CS6505-Spring2006/

Instructor: Prof. David A. Bader, CCB 257, 404-385-0004, bader@cc
Course Assistant: TBD
Office Hours: Tuesday/Thursday 11:00am-12:00pm, or by appointment
Textbooks:

1. **[Sipser]:** *Introduction to the Theory of Computation*, Second edition, 2005.
2. **[CLRS]:** Cormen, Leiserson, Rivest, and Stein, *Introduction to Algorithms*, Second edition, MIT Press, 2001.

Course Description: This course will cover: (a) important concepts from computability theory; (b) techniques for designing efficient algorithms for combinatorial, algebraic, and number-theoretic problems; and (c) basic concepts such as NP-Completeness from computational complexity theory.

Pre-requisites: Finite automata, regular languages, pushdown automata, context-free languages, basic algorithm design techniques.

This course can be taken for satisfying the theory breadth requirement by graduate students (M.S. and non-theory Ph.D. students). This course cannot be taken by theory/ACO Ph.D. students to satisfy the breadth/core requirement. Students who are interested in theory and are well prepared are advised to take CS 6550 rather than this course.

Grading:

(25 %) Exam I
(25 %) Exam II
(25 %) Exam III
(20 %) Homework
(5 %) Class participation

CS 6505 CLASS POLICIES

1. Please let me know as soon as possible if you will need to re-schedule an exam, or have any special needs during the semester.

2. Each student must read and abide by the Georgia Tech Academic Honor Code, see www.honor.gatech.edu.

3. Plagiarizing is defined by Websters as "to steal and pass off (the ideas or words of another) as one's own: use (another's production) without crediting the source." If caught plagiarizing, you will be dealt with according to the GT Academic Honor Code.

4. When working on homework, you may work with other students in the class. However; you must turn in separate copies of the homework with the following written on it: your name and the names of everyone you collaborated with.

5. Homework is due by NOON on the given due date. Late homeworks will not be accepted without a legitimate excuse and approval from the instructor.

6. No collaboration is permitted on exams. Exams I, II, and III, will be in-class, closed-book exams. You will be allowed to take a "cheat sheet" (double-sided 8.5 x 11 sheet of paper) into each exam.

7. Unauthorized use of any previous semester course materials, such as tests, quizzes, homework, projects, and any other coursework, is prohibited in this course. Using these materials will be considered a direct violation of academic policy and will be dealt with according to the GT Academic Honor Code.

8. For any questions involving these or any other Academic Honor Code issues, please consult me, my teaching assistants, or www.honor.gatech.edu.

CS 6505 Coverage of Topics

Computability theory

1. multi-tape Turing machines definitions;
2. non-deterministic Turing machines; simulation of an NTM decider by a DTM decider;
3. The Halting Problem is undecidable.
4. Reducibility: simple examples
5. Reducibility: Computation history method (show that ALL(CFG) is undecidable); undecidability of Post correspondence problem; Reductions from post correspondence problem to show the undecidability of problems pertaining to context-free languages (such as the ambiguity problem).
6. Rice's theorem and simple applications.

Complexity theory

1. NP-Completeness: Definition of NP in terms of verification machines; Cook/Levin theorem and its proof.
2. Reductions from satisfiability: 3cnfsat, clique, vertex cover, Hamiltonian path, 3-coloring, subset sum.
3. Decision versus computation: self-reducibility.
4. BPP, amplification of acceptance probability, NP is in BPP iff NP=RP.

Algorithms

1. Fibonacci heaps; amortized analysis.
2. Dynamic programming: Sequence alignment, Bellman-ford shortest path algorithm, finding negative cycles, Floyd-Warshall algorithm.
3. Max-flow: Ford-Fulkerson algorithm, max-flow min-cut theorem, Edmond-Karp algorithm, scaling algorithm.
4. Bipartite maximum matching: reduction to network flow.
5. Fast Fourier transform: multiplication of single variable polynomials; finite-field arithmetic.
6. Basic randomized algorithms: polynomial identity testing, read-once branching program equivalence problem, and other examples.
7. Basic approximation algorithms: matchings and vertex covers

CS 6505 Spring 2006, Tentative Course Schedule

Week	Date	Lec	Topic	Read
1	10 Jan	1	Syllabus; Review: Key abstractions	Sipser Ch. 0,1,2
	12 Jan	2	multi-tape Turing machines	Sipser Ch. 3
2	17 Jan	3	Deterministic Turning machines	
	19 Jan	4	Non-deterministic Turning machines	
3	24 Jan	5	The Halting Problem	Sipser Ch. 4
	26 Jan	6	Reducibility	Sipser Ch. 5
4	31 Jan	7	Reducibility; computation history meth.	
	2 Feb	8	Reducibility; Post correspondence prob.	
5	7 Feb	9	Rice's Theorem and examples	Sipser Ch. 6
	9 Feb	10	Complexity Theory, NP-completeness	Sipser Ch. 7
6	14 Feb	11	**Exam 1**	
	16 Feb	12	Reductions from SAT: 3cnfsat, clique, vertex cover	CLRS Ch. 34
7	21 Feb	13	Decision versus computation: self-reducibility	
	23 Feb	14	Reductions from SAT: Ham. path, 3-coloring, subset sum	
8	28 Feb	15	Fibonacci heaps; amortized analysis	CLRS Ch. 20
	2 Mar	16	Dynamic programming I	CLRS Ch. 15
9	7 Mar	17	Dynamic programming II	
	9 Mar	18	Max-flow I	CLRS Ch. 26
10	14 Mar	19	Max-flow II	
	16 Mar	20	**Exam II**	
11	21 Mar	-	*Spring Break*	
	23 Mar	-	*Spring Break*	
12	28 Mar	21	Bipartite maximum matching	
	30 Mar	22	Fast Fourier Transform	CLRS Ch. 30
13	4 Apr	23	Randomized Algorithms I	
	6 Apr	24	Randomized Algorithms II	
14	11 Apr	25	Approximation Algorithms I	CLRS Ch. 35
	13 Apr	26	Approximation Algorithms II	
15	18 Apr	27	Current topics: Quantum Computing	
	20 Apr	28	Current topics: Cache-aware algorithms	
16	25 Apr	29	Current topics: Parallel algorithms	
	27 Apr	30	**Exam III**	