THEORY I - CS 3500 D Spring 2003

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Tentative **Office hours:** W 10-11am or by appointment

Meeting: MTWF 2:05-2:55pm, B6A Boggs-Chemistry
Textbooks:

1. *Introduction to the Theory of Computation* by Michael Sipser, PWS Publishing, 1997, [S]
2. *Introduction to Algorithms* by T. Cormen, Ch. Leiserson, R. Rivest(2nd edition) The MIT Press, [CLR]

Assignments: Eight homework assignments will be graded. They will be due in class, normally **on Wednesdays**. You are asked first to try to solve each problem yourself. If you get stuck you are permitted to collaborate with other students enrolled in the course. List on the assignment everyone with whom you discussed the problems. You MUST write up your solution alone. You are welcome to use additional references besides the class text. Please however list such references on your assignment. To earn full credit for a problem all relevant work must be shown.

Tentative **Important Dates:**

1. Mid-term 1: Monday, February 10
2. Mid-term 2: Monday, March 24
3. Final exam: Thursday, May 1, 11:30-2:20

Grading: Homeworks: 25%, two Mid-terms: 30%, Project: 15%, Final exam: 30%.

Course Outline:

1. Introductory concepts in formal languages and automata theory: languages, operations on languages, and basic machine models. (Sipser: Chapter 0)
2. **Regular languages:** Deterministic and nondeterministic finite state automata. Closure under union, intersection, complementation, concatenation, and star operations. Equivalence of Non-deterministic finite state automata and deterministic finite state automata. Regular expressions and equivalence of regular expressions and regular languages. Pumping lemma. (Sipser: Chapter 1) (Optional: Myhill-Nerode theorem.)
3. **Context-free languages:** Context-free grammars. Ambiguity. Normal forms such as Chomsky normal form. Closure under union, concatenation, and star operations. Non-closure under intersection and complementation operations. Parse-trees. Pumping lemma. Pushdown automata. Equivalence

of pushdown automata and context-free grammars. (Sipser: Chapter 2) (Optional: Cocke-Kasami-Younger algorithm. Deterministic context-free languages. Parsing.) (Other references may have to be used for these optional topics. CKY is covered in Sipser's book (page 240).)

4. **Decidability:** Turing machines. Recursively-enumerable and recursive languages. Equivalence of varieties of models such as multi-tape and non-deterministic Turing machines with the deterministic Turing machines. Diagonalization. Undecidability of the Halting problem. (Sipser: Chapter 3)

5. Introductory concepts in algorithms: computational problems, models of computation, order notation, recurrences. (CLR: Chapters 1, 2.1, 4.3)

6. **Divide and Conquer:** Strassen's matrix multiplication (CLR: Chapter 31.2), merge sort, divide and conquer recurrences (CLR: Chapter 4.3).

7. **Sorting:** heap sort (CLR: Chapter 7), quick sort (CLR: Chapter 8), lower bound for comparison sorting (CLR: Chapter 9.1), counting sort (CLR: Chapter 9.2).

8. **Medians and order statistics:** linear time selection algorithm (CLR: Chapter 10).

9. **Searching:** Balanced binary search trees (CLR: Chapter 13).

10. **Dynamic programming:** Matrix-chain multiplication (CLR: Chapter 16) Cocke-Kasami-Younger algorithm (Sipser: page 240).

11. **Greedy algorithms:** Huffman codes (CLR: Chapter 17.3).

12. **Algorithms for elementary graph problems:**

    - Graph traversal techniques and their applications (breadth-first search, depth-first search) (CLR: Chapter 23).
    - Minimum spanning trees (Kruskal's and Prim's algorithms) (CLR: Chapter 24).
    - Shortest paths (Dijkstra's algorithm and Bellman-Ford algorithm). (CLR: Chapter 25).
    - Warshall's algorithm for transitive closure. (CLR: Chapter 26.2).

13. **String matching:** Knuth-Morris-Pratt algorithm. (CLR: Chapter 34.4).

14. **NP-Completeness:** Basic notions such as reducibility and completeness. Examples of NP-Complete problems. (CLR: Chapter 36).