Algorithms (CS4102) Syllabus
University of Virginia, Fall 2015
Gabriel Robins

Course description: Algorithm design and analysis, problem solving strategies, proof techniques, asymptotic complexity analysis, upper and lower bounds, sorting and searching, graph algorithms, geometric algorithms, probabilistic algorithms, amortized analysis, intractability and NP-completeness, reductions between problems, and approximation algorithms.

Special emphasis will be placed on problem solving, unifying ideas, proof techniques, the “scientific method”, as well as striving for elegance, insights, and generalizability in developing algorithms and proofs.

Prerequisites: Discrete mathematics or equivalent


Supplemental reading: “How to Solve It”, by George Polya, Princeton University Press

Selected papers at: http://www.cs.virginia.edu/~robins/CS_readings.html

Office hours: Tues & Thur 10:45am-12:15pm (after every class lecture), and other times by appointment
Also Email Q&A, and a running course-related blog

Class structure: two exams (midterm and final), several problem sets, with problems taken from the textbook and other sources, and a term project (involving implementing and demoing some algorithms and/or related concepts and ideas). Extra credit will be given throughout the semester for solving challenging problems.

We will cover most of the following topics, as time permits:

Fundamentals:
- History of algorithms
- Problem solving
- Pigeon-hole principle
- Occam's razor
- Uncomputability
- Universality
- Asymptotic complexity

Data structures:
- Arrays
- Stacks and queues
- Linked lists
- Binary trees
- Height-balanced trees
- Heaps
- Hash tables
Sorting and searching:
• Classical sorting methods
• Specialized sorting techniques
• Finding max & min
• Median finding and K\textsuperscript{th} selection
• Majority detection
• Meta algorithms

Computational geometry:
• Convex hulls
• Lower bounds
• Line segment intersection
• Planar subdivision search
• Voronoi diagrams
• Nearest neighbors
• Geometric minimum spanning trees
• Delaunay triangulations
• Distance between convex polygons
• Triangulation of polygons
• Collinear subsets

Graph algorithms:
• Depth-first search
• Breadth-first search
• Minimum spanning trees
• Shortest paths trees
• Radius-cost tradeoffs
• Steiner trees
• Degree-constrained trees

Other topics in algorithms:
• Linear programming
• Matrix multiplication
• String matching
• Minimum matchings
• Network flows
• Distributed algorithms
• Amortized analysis
• Zero knowledge proofs

NP-completeness:
• Polynomial time and intractability
• Space and time complexity
• Problem reductions
• The satisfiability problem
• Independent sets
• Graph colorability
• Travelling salesperson problem
• Approximation heuristics