UMass Lowell Computer Science 91.404

Analysis of Algorithms

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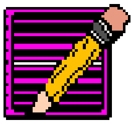
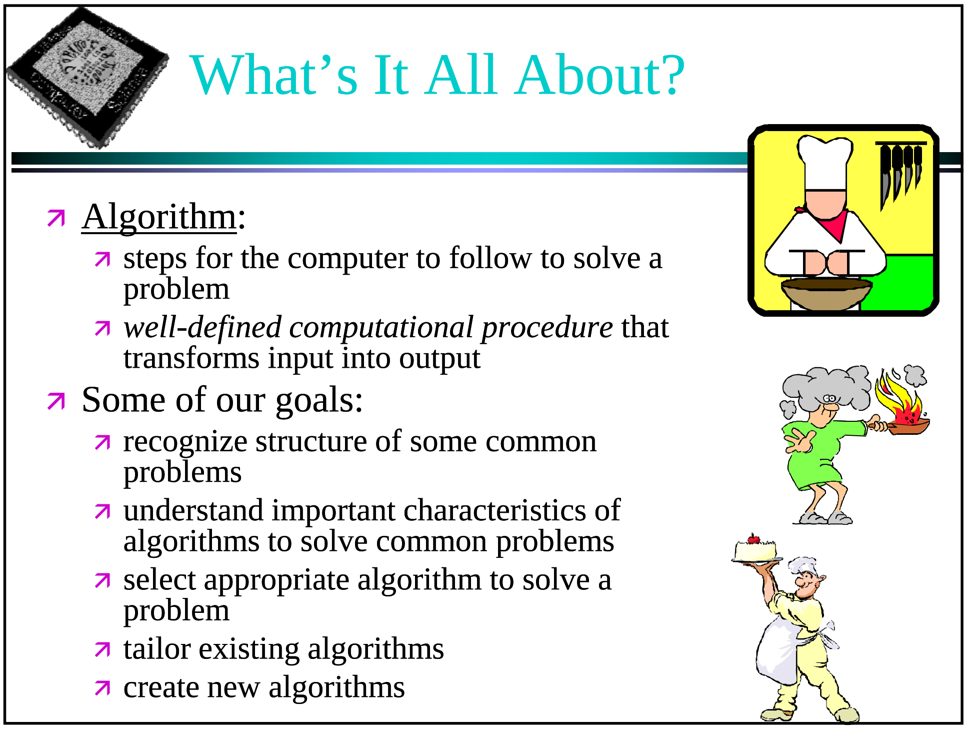
Lecture 1

Introduction/Overview

Nature of the Course

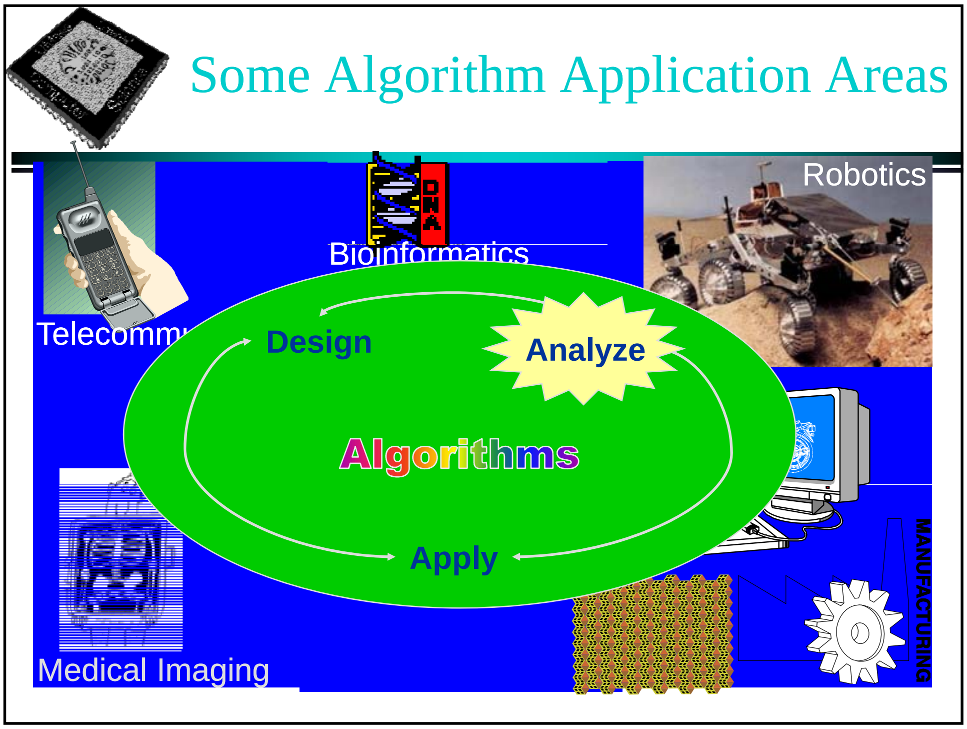
- Core course: *required for all CS majors*
- Advanced undergraduate level
  - Graduate students take separate course (91.503)
- No programming required
  - "Pencil-and-paper" exercises
  - Lectures supplemented by:
    - Programs
    - Real-world examples





What’s It All About?

- Algorithm:
  - steps for the computer to follow to solve a problem
  - *well-defined computational procedure* that transforms input into output
- Some of our goals:
  - recognize structure of some common problems
  - understand important characteristics of algorithms to solve common problems
  - select appropriate algorithm to solve a problem
  - tailor existing algorithms
  - create new algorithms



Some Algorithm Application Areas

Robotics

Bioinformatics

Telecommu

Design

Analyze

Algorithms

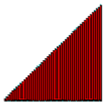
Apply

Medical Imaging

MANUFACTURING

Some Typical Problems

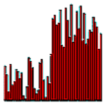
Sorting



Input: Set of items

Problem: Arrange items “in order”

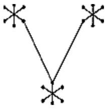
Median finding



Input: Set of numbers or keys

Problem: Find item smaller than half of items and bigger than half of items

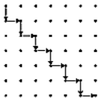
Minimum Spanning Tree



Input: Graph G = (V,E) with weighted edges

Problem: Find subset of E of G of minimum weight which forms a tree on V

Shortest Path



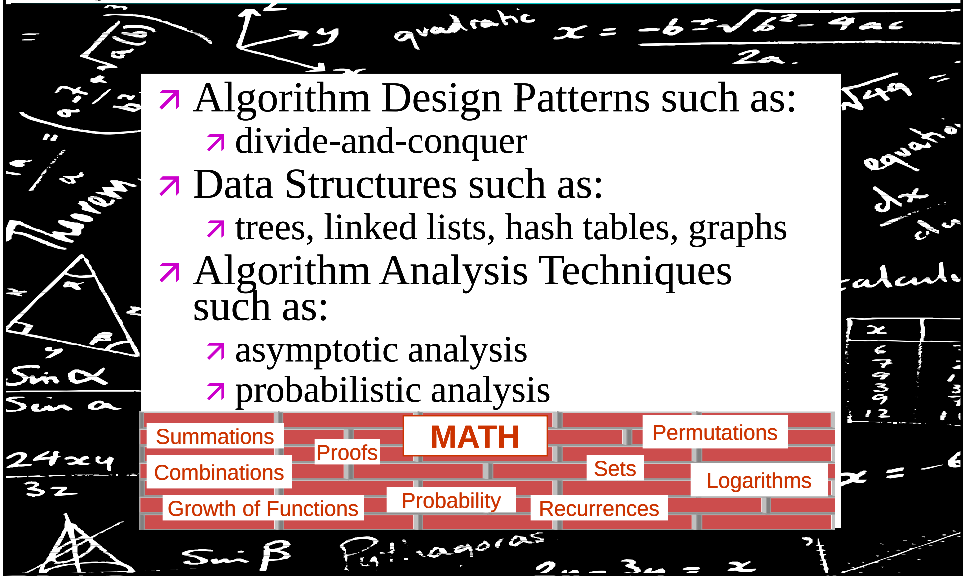
Input: Edge-weighted graph G , with start vertex s and end vertex t

Problem: Find the shortest path from s to t in G

SOURCE*: Steve Skiena’s Algorithm Design Manual*

(for problem descriptions, see graphics gallery at http://www.cs.sunysb.edu/~algorith)

Tools of the Trade



- Algorithm Design Patterns such as:
  - divide-and-conquer
- Data Structures such as:
  - trees, linked lists, hash tables, graphs
- Algorithm Analysis Techniques such as:
  - asymptotic analysis
  - probabilistic analysis

Summations

Proofs

MATH

Permutations

Combinations

Sets

Logarithms

Growth of Functions

Probability

Recurrences

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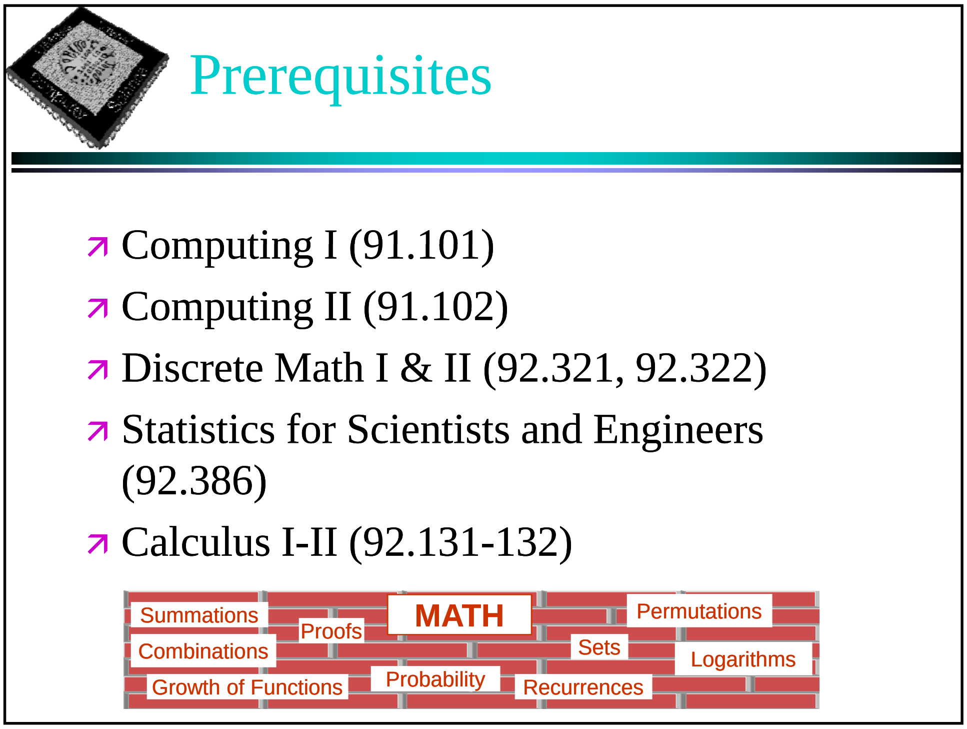
Tools of the Trade: (continued) Algorithm Animation

http://www.sorting-algorithms.com/

http://www.site.uottawa.ca/~stan/csi2514/applets/sort/sort.html

What are we measuring?

- Some Analysis Criteria:
  - Scope
    - The problem itself?
    - A particular algorithm that solves the problem?
  - “Dimension”
    - Time Complexity? Space Complexity?
  - Type of Bound
    - Upper? Lower? Both?
  - Type of Input
    - Best-Case? Average-Case? Worst-Case?
  - Type of Implementation
    - Choice of Data Structure

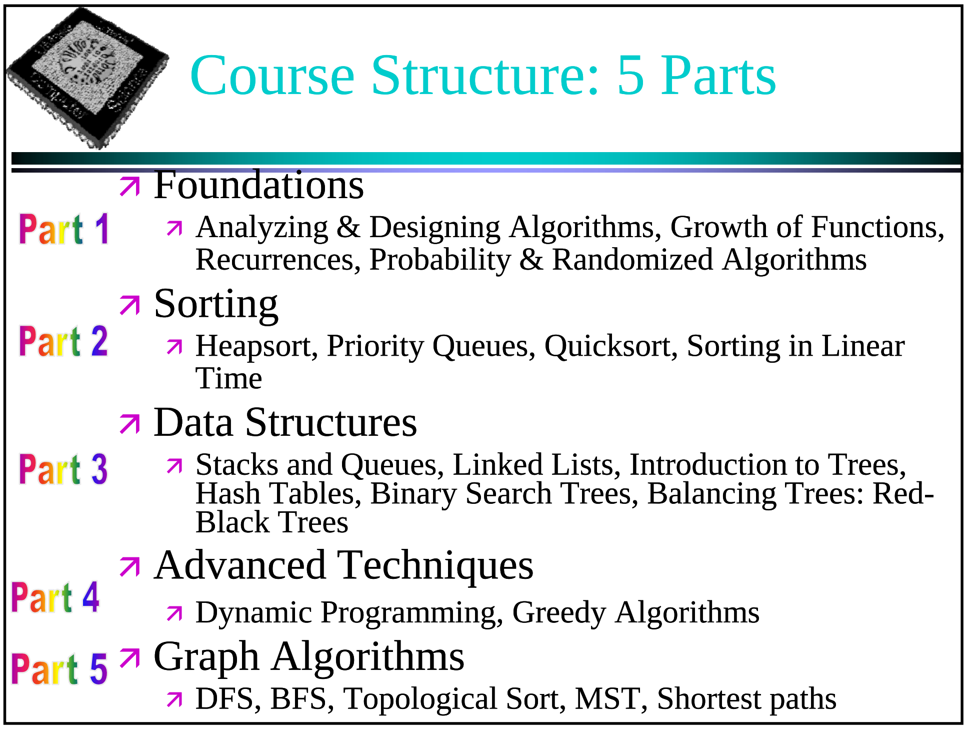


Prerequisites

- Computing I (91.101)
- Computing II (91.102)
- Discrete Math I & II (92.321, 92.322)
- Statistics for Scientists and Engineers (92.386)
- Calculus I-II (92.131-132)

MATH

Summations
Proofs
Permutations
Combinations
Sets
Logarithms
Growth of Functions
Probability
Recurrences



Course Structure: 5 Parts

Part 1
- Foundations
  - Analyzing & Designing Algorithms, Growth of Functions, Recurrences, Probability & Randomized Algorithms

Part 2
- Sorting
  - Heapsort, Priority Queues, Quicksort, Sorting in Linear Time

Part 3
- Data Structures
  - Stacks and Queues, Linked Lists, Introduction to Trees, Hash Tables, Binary Search Trees, Balancing Trees: Red-Black Trees

Part 4
- Advanced Techniques
  - Dynamic Programming, Greedy Algorithms

Part 5
- Graph Algorithms
  - DFS, BFS, Topological Sort, MST, Shortest paths

Textbook

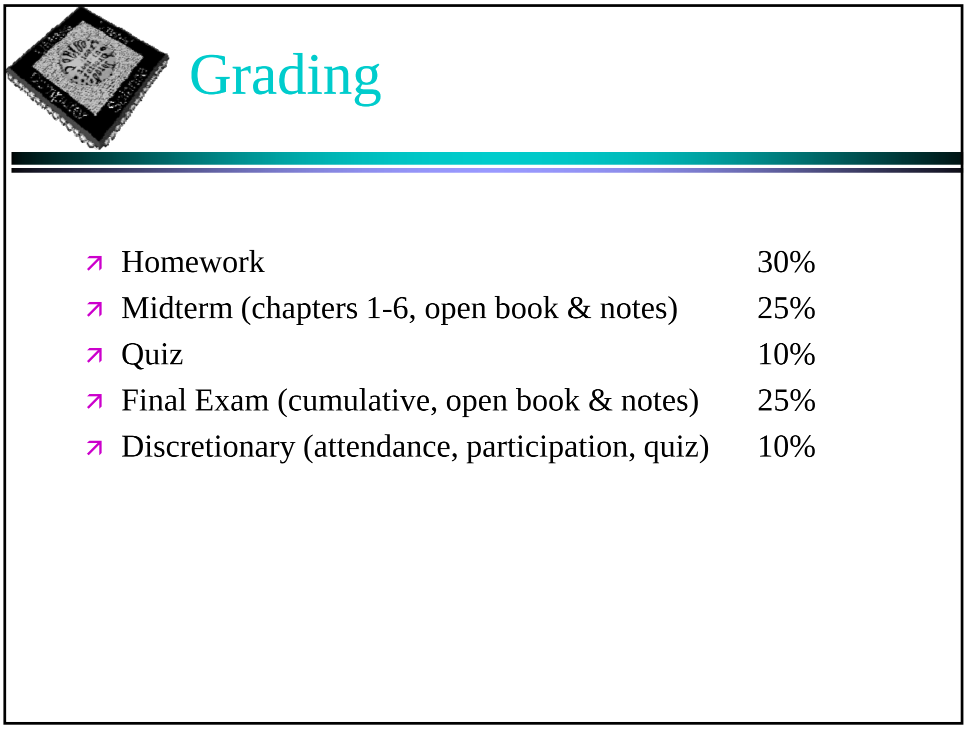
- Required:
  - *Introduction to Algorithms*
    - by T.H. Corman, C.E. Leiserson, R.L. Rivest, Clifford Stein
    - McGraw-Hill
    - 2009
    - ISBN 978-0-262-03384-8
    - See course website for recommended texts

Third Edition

CS Theory Math Review Sheet The Most Relevant Parts...

- p. 1
  - O, Θ, Ω definitions
  - Series
  - Combinations
- p. 2 Recurrences & Master Method
- p. 3
  - Probability
  - Factorial
  - Logs
  - Stirling's approx
- p. 4 Matrices
- p. 5 Graph Theory
- p. 6 Calculus
  - Product, Quotient rules
  - Integration, Differentiation
  - Logs
- p. 8 Finite Calculus
- p. 9 Series

Math fact sheet (courtesy of Prof. Costello) is on our web site.



Grading

Homework	30%
Midterm (chapters 1-6, open book & notes)	25%
Quiz	10%
Final Exam (cumulative, open book & notes)	25%
Discretionary (attendance, participation, quiz)	10%