Lecture 1

Introduction/Overview

Text: Chapters 1, 2

Tuesday 1/20/2015
CS 91.404 (Section 201)
Analysis of Algorithms
Spring, 2015

General Information

Announcements: in PDF format
Level: Advanced Undergraduate
Category: Required for Computer Science Majors
Credits: 3
Location: OS 401
Time: TR 9:30-10:45

Instructor: Prof. Karen Daniels
Email: kdaniels@cs.uml.edu
Office Hours: TR 11:00 - 12:00 pm
or by appointment in Olsen Hall 216

TA: ?
Email: ?@student.uml.edu
Office Hours: ? in OS 212A
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
- Geographic Information Systems
- Bioinformatics
- Medical Imaging
- Voice Recognition
- Telecommunications
- Computer Graphics
Some Typical Problems

**Sorting**

**Input**: Set of items  
**Problem**: Arrange items “in order”

**Searching**

**Input**: Set of keys & query key  
**Problem**: Check if query key is in the set of keys

**Topological Sorting**

**Input**: Directed acyclic graph  
**Problem**: Find linear ordering of vertices

**SOURCE**: *Steve Skiena’s Algorithm Design Manual*  
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
Tools of the Trade: (continued) Algorithm Animation

Formerly http://www.cs.brockport.edu/cs/java/apps/sorters/insertsortaniminp.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)
Course Structure: 4 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 • Graph Algorithms
  • DFS, BFS, Topological Sort, MST, Shortest paths
Required:

- *Introduction to Algorithms*
  - by T.H. Corman, C.E. Leiserson, R.L. Rivest, C. Stein
  - MIT Press
  - 2009
  - see course web site (Related Links) for textbook web site
    - includes solutions to selected exercises

*Ordered for UML bookstore*

See course web site for recommended texts.
# Syllabus (current plan)

<table>
<thead>
<tr>
<th>Lecture Date</th>
<th>Topic</th>
<th>Reading</th>
<th>Homework</th>
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<tbody>
<tr>
<td>T 1/20</td>
<td><strong>Foundations</strong></td>
<td>Chapters 1-5</td>
<td>assign #1 (Ch 1, 2)</td>
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<tr>
<td>R 1/22, T 1/27</td>
<td>Introduction/Overview</td>
<td>Chapter 1</td>
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<tr>
<td>R 1/29, T 2/3</td>
<td>Analyzing &amp; Designing</td>
<td>Chapter 2</td>
<td></td>
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<tr>
<td>R 2/5, T 2/10</td>
<td>Algorithms</td>
<td>Chapter 3</td>
<td>1/29: #1 due; assign #2 (Ch 3)</td>
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<tr>
<td>R 2/12, R 2/19</td>
<td>Growth of Functions</td>
<td>Chapter 4</td>
<td>2/5: #2 due; assign #3 (Ch 4)</td>
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<tr>
<td>T 2/24, R 2/26</td>
<td>Recurrences</td>
<td>Chapter 5</td>
<td>2/12: #3 due; assign #4 (Ch 5)</td>
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<td>T 3/3, R 3/5</td>
<td>Probability &amp;</td>
<td>Chapters 6-8</td>
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<td>T 3/10, T 3/24</td>
<td>Randomized Algorithms</td>
<td>Chapter 6</td>
<td>2/24: #4 due; assign #5 (Ch 6)</td>
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<td><strong>Sorting</strong></td>
<td>Chapter 7</td>
<td>3/3: #5 due; assign #6 (Ch 7)</td>
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<td>Heapsort/ Priority</td>
<td>Chapter 8</td>
<td>3/10: #6 due; assign #7 (Ch 8)</td>
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<td>Queues</td>
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<td>Quicksort</td>
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<td>Sorting in Linear Time</td>
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<td><strong>Review (outside class)</strong></td>
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<td><strong>Midterm Exam (in class)</strong></td>
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<td><strong>Chapters 1-7</strong></td>
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Syllabus (current plan, continued)

<table>
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<th>Task</th>
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<tr>
<td>R 4/2, T 4/7</td>
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<td>R 4/9, T 4/14</td>
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<td>R 4/16, T 4/21</td>
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<td>R 4/23, T 4/28, R 4/30</td>
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**Data Structures**
- Stacks, Queues, Linked Lists, Trees
- Hash Tables
- Binary Search Trees
- Balancing Trees: Red-Black Trees

**Graph Algorithms**
- Elementary Graph Algorithms

**Review (outside class)**
- Final Exam

**Chapters 10-13**
- Chapter 10
- Chapter 11
- Chapter 12
- Chapter 13

**Chapters 22**
- Chapter 22

**Notes**
- 3/26: #7 due; assign #8 (Ch 10-11)
- 4/9: #8 due; assign #9 (Ch 12-13)
- 4/23: #9 due; assign #10 (Ch 22)
- 5/1: #10 due at 5:00 p.m.


*Note that we are using the third edition of the textbook. This schedule may be revised during the semester if needed.*
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.
Important Dates

- **Midterm Exam** (Chapters 1-7): Thursday, 3/12
  - Closed book, with 1 double-sided note sheet
- **Final Exam** (Chapters 1-8, 10-13, 22): TBA
  - Closed book, with 2 double-sided note sheets
  - Cumulative
Grading

- Homework 32%
- Midterm 33%
- Discretionary (e.g. attendance, participation) 2%
- Final Exam 33%