CIS 303 Algorithm Analysis and Design
Spring 2022
Final Exam Study Guide

Exam Day/Time: Friday, May 20, 2022, 10:15 AM – 12:15 PM, Dunn 208

The Final Exam is COMPREHENSIVE. That means that you are responsible for all material we have covered in the course. The list below is a summary, NOT an exhaustive list of topics or material.

Chapter 2 – Mathematical Preliminaries
* Sets and Relations
-- Definitions
-- Properties (reflexive, symmetric, antisymmetric, transitive)
-- Equivalence relations
* Logarithms (be able to use them; know the basic properties)
* Summations and Recurrences
-- Expand simple recurrence relations
-- Prove correctness of recurrence relations closed form
* Recursion
* Mathematical Proof Techniques
-- Focus on induction

Chapter 3 – Algorithm Analysis
* Preliminaries (from the Introduction)
-- Basic operations
-- Running time
-- Growth rates
* Best, Worst, and Average Cases
* A Faster Computer, or a Faster Algorithm?
-- Be able to calculate speedup based on hardware changes
* Asymptotic Analysis
-- Upper Bounds
-- Lower Bounds
-- Θ Notation
-- Simplifying Rules
--Classifying Functions
--Use definitions of bounds; describe what the bounds mean and why they are important
--Differentiate between bounds and cases
* Calculating the Running Time for a Program
* Analyzing Problems
* Multiple Parameters
* Space Bounds

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Chapter 4 – Lists, Stacks, and Queues
* Lists
-- Array-based implementation, linked list implementation, comparison of the two (basic operations, storage requirements/overhead/break-even point)
-- Doubly linked lists
* Stacks
-- Performance in basic operations
-- Comparison of array-based and linked implementations of a stack
-- Implementing recursion with a stack
* Queues
-- Array-based, linked implementations
-- Performance in basic operations
-- Dictionary ADT

Chapter 5 – Binary Trees
*Binary search trees
-- Full binary trees
-- Full binary tree theorem (be able to do the proof using induction)
-- Overhead fractions for full binary trees (calculate overhead fraction; describe what it means)
-- Enumerating tree traversals
-- Inserting/deleting elements in binary search trees
*Heaps (maxHeaps)
-- Heap property
-- Building heaps (2 methods: with all data up front, sfitdown; elements as they arrive, siftup)
-- removeMax operation
-- Analysis of performance of general binary trees, BSTs (including effect of balance), heaps

Chapter 13 – Advanced Tree Structures (Section 13.2.1 ONLY)
* AVL Trees: rules of AVL trees; rotations (single and double)

Chapter 7 – Internal Sorting
* $\Theta(n^2)$ sorting algorithms
-- Cost of exchange sorting – comparisons, swaps (best, average, worst cases)
*Divide and conquer sorts – MergeSort, QuickSort
-- Compare costs of algorithms – comparisons, swaps (best, average, worst cases)
* Heapsort
-- Demonstrate Heapsort
-- Costs of Heapsort – comparisons, swaps (best, average, worst cases)
* Radix Sort
-- Complexity
* Proof of lower bounds for the sorting problem (**guaranteed** to be on the exam)

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Chapter 9 – Searching
* Searching Sorted and Unsorted Lists
* Hashing
-- Terminology
-- Hash Functions
-- Open Hashing
-- Closed Hashing (with various collision resolution policies – linear probing, quadratic probing, pseudo-random probing, double hashing)
-- Analysis of Closed Hashing
-- Deletion from Hash Tables

Chapter 11: Graphs – not covered

Chapter 17: Limits to Computation
Focus on definitions, descriptions, connections
* Reductions
* Hard problems: P, NP, NP-Complete, NP-Hard
-- Definitions
-- Why do these things matter? What does it mean?
-- Relationships between problem classes
-- How we prove a problem is in NP; how we prove a problem is NP-Complete (the process; you will not have to do a proof)
-- Discuss the importance of problem classes, what the classes tell us, what characterizes problems in the different classes