

# CONTENTS IN DETAIL

<b>FOREWORD</b>	<b>xix</b>
-----------------	------------

<b>ACKNOWLEDGMENTS</b>	<b>xxi</b>
------------------------	------------

<b>INTRODUCTION</b>	<b>xxiii</b>
---------------------	--------------

What We'll Do .....	xxiii
New to the Second Edition .....	xxiv
Who This Book Is For .....	xxv
Our Programming Language .....	xxvi
Why Use C? .....	xxvi
Static Keyword .....	xxvi
Include Files .....	xxvii
Freeing Memory .....	xxvii
Topic Selection .....	xxvii
Programming Judges .....	xxviii
Anatomy of a Problem Description .....	xxx
Starter Problem: Food Lines .....	xxx
The Problem .....	xxx
Solving the Problem .....	xxxii
Online Resources .....	xxxiv
Notes .....	xxxiv

<b>1</b>	
<b>HASH TABLES</b>	<b>1</b>

Problem 1: Unique Snowflakes .....	1
The Problem .....	2
Simplifying the Problem .....	4
Solving the Core Problem .....	5
Solution 1: Pairwise Comparisons .....	8
Solution 2: Doing Less Work .....	12
Hash Tables .....	17
Hash Table Design .....	17
Why Use Hash Tables? .....	20
Problem 2: Login Mayhem .....	20
The Problem .....	20
Solution 1: Looking at All Passwords .....	21
Solution 2: Using a Hash Table .....	23

Problem 3: Spelling Check .....	29
The Problem .....	29
Thinking About Hash Tables .....	30
An Ad Hoc Solution .....	32
Summary .....	35
Notes .....	35

## **2 TREES AND RECURSION 37**

Problem 1: Halloween Haul .....	37
The Problem .....	38
Binary Trees .....	39
Solving the Sample Instance .....	41
Representing Binary Trees .....	41
Collecting All the Candy .....	46
A Completely Different Solution .....	51
Walking the Minimum Number of Streets .....	56
Reading the Input .....	59
Why Use Recursion? .....	65
Problem 2: Descendant Distance .....	66
The Problem .....	66
Reading the Input .....	68
Number of Descendants from One Node .....	72
Number of Descendants from All Nodes .....	73
Sorting Nodes .....	74
Outputting the Information .....	75
The main Function .....	75
Summary .....	76
Notes .....	76

## **3 MEMOIZATION AND DYNAMIC PROGRAMMING 77**

Problem 1: Burger Fervor .....	78
The Problem .....	78
Forming a Plan .....	78
Characterizing Optimal Solutions .....	80
Solution 1: Recursion .....	81
Solution 2: Memoization .....	86
Solution 3: Dynamic Programming .....	91
Memoization and Dynamic Programming .....	94
Step 1: Structure of Optimal Solutions .....	95
Step 2: Recursive Solution .....	96
Step 3: Memoization .....	96
Step 4: Dynamic Programming .....	97

Problem 2: Moneygrubbers .....	98
The Problem .....	98
Characterizing Optimal Solutions .....	99
Solution 1: Recursion .....	101
The main Function .....	105
Solution 2: Memoization .....	106
Problem 3: Hockey Rivalry .....	108
The Problem .....	109
About Rivalries .....	110
Characterizing Optimal Solutions .....	111
Solution 1: Recursion .....	114
Solution 2: Memoization .....	117
Solution 3: Dynamic Programming .....	119
A Space Optimization .....	122
Summary .....	123
Notes .....	123

## **4 ADVANCED MEMOIZATION AND DYNAMIC PROGRAMMING 125**

Problem 1: The Jumper .....	125
The Problem .....	126
Working Through an Example .....	127
Solution 1: Backward Formulation .....	128
Solution 2: Forward Formulation .....	133
Problem 2: Ways to Build .....	137
The Problem .....	138
Working Through an Example .....	139
Solution 1: Using “Exactly” Subproblems .....	140
Solution 2: Adding More Subproblems .....	144
Summary .....	149
Notes .....	149

## **5 GRAPHS AND BREADTH-FIRST SEARCH 151**

Problem 1: Knight Chase .....	151
The Problem .....	152
Moving Optimally .....	153
Best Knight Outcome .....	163
The Knight Flip-Flop .....	165
A Time Optimization .....	168
Graphs and BFS .....	169
What Are Graphs? .....	169
Graphs vs. Trees .....	170
BFS on Graphs .....	172
Graphs vs. Dynamic Programming .....	173



Binary Search .....	240
Runtime of Binary Search .....	241
Determining Feasibility .....	242
Searching a Sorted Array .....	242
Problem 2: River Jump .....	243
The Problem .....	243
A Greedy Idea .....	244
Testing Feasibility .....	246
Searching for a Solution .....	250
Reading the Input .....	253
Problem 3: Living Quality .....	254
The Problem .....	254
Sorting Every Rectangle .....	256
Using Binary Search .....	259
Testing Feasibility .....	260
A Quicker Way to Test Feasibility .....	261
Problem 4: Cave Doors .....	267
The Problem .....	267
Solving a Subtask .....	268
Using Linear Search .....	270
Using Binary Search .....	272
Summary .....	274
Notes .....	275

## **8 HEAPS AND SEGMENT TREES 277**

Problem 1: Supermarket Promotion .....	277
The Problem .....	277
Solution 1: Maximum and Minimum in an Array .....	278
Max-Heaps .....	282
Min-Heaps .....	293
Solution 2: Heaps .....	295
Heaps .....	298
Two More Applications .....	298
Choosing a Data Structure .....	300
Problem 2: Building Treaps .....	300
The Problem .....	300
Recursively Outputting Treaps .....	302
Sorting by Label .....	303
Solution 1: Recursion .....	303
Range Maximum Queries .....	307
Segment Trees .....	308
Solution 2: Segment Trees .....	316
Segment Trees .....	317

Problem 3: Two Sum .....	318
The Problem .....	318
Filling the Segment Tree .....	319
Querying the Segment Tree .....	323
Updating the Segment Tree .....	324
The main Function .....	328
Summary .....	329
Notes .....	329

## 9

### **UNION-FIND 331**

Problem 1: Social Network .....	332
The Problem .....	332
Modeling as a Graph .....	333
Solution 1: BFS .....	336
Union-Find .....	340
Solution 2: Union-Find .....	343
Optimization 1: Union by Size .....	346
Optimization 2: Path Compression .....	350
Union-Find .....	352
Relationships: Three Requirements .....	353
Choosing Union-Find .....	353
Optimizations .....	353
Problem 2: Friends and Enemies .....	354
The Problem .....	354
Augmenting Union-Find .....	355
The main Function .....	359
Find and Union .....	360
SetFriends and SetEnemies .....	361
AreFriends and AreEnemies .....	363
Problem 3: Drawer Chore .....	364
The Problem .....	364
Equivalent Drawers .....	365
The main Function .....	370
Find and Union .....	372
Summary .....	373
Notes .....	373

## 10

### **RANDOMIZATION 375**

Problem 1: Yōkan .....	376
The Problem .....	376
Randomly Choosing a Piece .....	376

Generating Random Numbers .....	378
Determining Number of Pieces .....	379
Guessing Flavors .....	381
How Many Attempts Do We Need? .....	384
Filling the Flavor Arrays .....	385
The main Function .....	386
Randomization .....	387
Monte Carlo Algorithms .....	387
Las Vegas Algorithms .....	388
Deterministic vs. Randomized Algorithms .....	389
Problem 2: Caps and Bottles .....	390
The Problem .....	390
Solving a Subtask .....	391
Solution 1: Recursion .....	393
Solution 2: Adding Randomization .....	396
Quicksort .....	398
Implementing Quicksort .....	398
Worst-Case and Expected Runtime .....	400
Summary .....	402
Notes .....	402

**AFTERWORD** **403**

**A**  
**ALGORITHM RUNTIME** **405**

The Case for Timing ... and Something Else .....	405
Big O Notation .....	407
Linear Time .....	407
Constant Time .....	408
Another Example .....	409
Quadratic Time .....	409
Big O in This Book .....	410

**B**  
**BECAUSE I CAN'T RESIST** **411**

Unique Snowflakes: Implicit Linked Lists .....	411
Burger Fervor: Reconstructing a Solution .....	414
Knight Chase: Encoding Moves .....	416
Dijkstra's Algorithm: Using a Heap .....	418
Mice Maze: Tracing with Heaps .....	418
Mice Maze: Implementation with Heaps .....	421

Compressing Path Compression . . . . .	422
Step 1: No More Ternary If . . . . .	423
Step 2: Cleaner Assignment Operator . . . . .	423
Step 3: Understand the Recursion . . . . .	424
Caps and Bottles: In-Place Sorting . . . . .	424

**C**  
**PROBLEM CREDITS** **427**

**INDEX** **431**