



# CONTENTS

## CHAPTER 1 INTRODUCTION

1.1 Overview . . . . .	.1
1.2 SPARKS . . . . .	8
1.3 How to Create Programs . . . . .	15
1.4 How to Analyze Programs . . . . .	27
References and Selected Readings . . . . .	35
Exercises . . . . .	36

## CHAPTER 2 ARRAYS

2.1 Axiomatization . . . . .	40
2.2 Ordered Lists . . . . .	41
2.3 Sparse Matrices . . . . .	51
2.4 Representation of Arrays . . . . .	62
Exercises . . . . .	66

## CHAPTER 3 STACKS AND QUEUES

3.1 Fundamentals . . . . .	77
3.2 A Mazing Problem . . . . .	86
3.3 Evaluation of Expressions . . . . .	91
3.4 Multiple Stacks and Queues . . . . .	97
Exercises . . . . .	100

## CHAPTER 4 LINKED LISTS

4.1 Singly Linked Lists . . . . .	106
4.2 Linked Stacks and Queues . . . . .	112
4.3 The Storage Pool . . . . .	114
4.4 Polynomial Addition . . . . .	118
4.5 More on Linked Lists . . . . .	126
4.6 Equivalence Relations . . . . .	128
4.7 Sparse Matrices . . . . .	134
4.8 Doubly Linked Lists and Dynamic Storage Management . . . . .	140
4.9 Generalized Lists . . . . .	155

4.10 Garbage Collection and Compaction . . . . . 169  
4.11 STRINGS—A Case Study . . . . . 182  
    4.11.1 Data Representations for STRINGS . . . . . 184  
    4.11.2 Pattern Matching in STRINGS . . . . . 190  
4.12 Implementing Node Structures . . . . . 197  
    References and Selected Readings . . . . . 201  
    Exercises . . . . . 202

**CHAPTER 5 TREES**

5.1 Basic Terminology . . . . . 218  
5.2 Binary Trees . . . . . 223  
5.3 Binary Tree Representations . . . . . 225  
5.4 Binary Tree Traversal . . . . . 228  
5.5 More on Binary Trees . . . . . 234  
5.6 Threaded Binary Trees . . . . . 239  
5.7 Binary Tree Representation of Trees . . . . . 243  
5.8 Applications of Trees . . . . . 248  
    5.8.1 Set Representation . . . . . 248  
    5.8.2 Decision Trees . . . . . 257  
    5.8.3 Game Trees . . . . . 259  
5.9 Counting Binary Trees . . . . . 270  
    References and Selected Readings . . . . . 275  
    Exercises . . . . . 276

**CHAPTER 6 GRAPHS**

6.1 Terminology and Representations . . . . . 282  
    6.1.1 Introduction . . . . . 282  
    6.1.2 Definitions and Terminology . . . . . 283  
    6.1.3 Graph Representations . . . . . 287  
6.2 Traversals, Connected Components and Spanning Trees . . . . . 292  
6.3 Shortest Paths and Transitive Closure . . . . . 301  
6.4 Activity Networks, Topological Sort and Critical Paths . . . . . 310  
6.5 Enumerating All Paths . . . . . 324  
    References and Selected Readings . . . . . 327  
    Exercises . . . . . 328

**CHAPTER 7 INTERNAL SORTING**

7.1 Searching . . . . . 335  
7.2 Insertion Sort . . . . . 345  
7.3 Quicksort . . . . . 347

7.4	How Fast Can We Sort? . . . . .	350
7.5	2-Way Merge Sort . . . . .	352
7.6	Heap Sort . . . . .	357
7.7	Sorting on Several Keys . . . . .	359
7.8	Practical Considerations for Internal Sorting . . . . .	368
	References and Selected Readings . . . . .	377
	Exercises . . . . .	378

**CHAPTER 8 EXTERNAL SORTING**

8.1	Storage Devices . . . . .	382
	8.1.1 Magnetic Tapes . . . . .	382
	8.1.2 Disk Storage . . . . .	386
8.2	Sorting With Disks . . . . .	388
	8.2.1 K-Way Merging . . . . .	392
	8.2.2 Buffer Handling for Parallel Operation . . . . .	397
	8.2.3 Run Generation . . . . .	406
8.3	Sorting with Tapes . . . . .	407
	8.3.1 Balanced Merge Sorts . . . . .	411
	8.3.2 Polyphase Merge . . . . .	415
	8.3.3 Sorting with Fewer Than 3 Tapes . . . . .	418
	References and Selected Readings . . . . .	419
	Exercises . . . . .	419

**CHAPTER 9 SYMBOL TABLES**

9.1	Static Tree Tables . . . . .	423
9.2	Dynamic Tree Tables . . . . .	438
9.3	Hash Tables . . . . .	456
	9.3.1 Hashing Functions . . . . .	458
	9.3.2 Overflow Handling . . . . .	462
	9.3.3 Theoretical Evaluation of Overflow Techniques . . . . .	469
	References and Selected Readings . . . . .	471
	Exercises . . . . .	473

**CHAPTER 10 FILES**

10.1	Files, Queries and Sequential Organizations . . . . .	478
10.2	Index Techniques . . . . .	485
	10.2.1 Cylinder-Surface Indexing . . . . .	486
	10.2.2 Hashed Indexes . . . . .	491
	10.2.3 Tree Indexing— <i>B</i> -Trees . . . . .	496

**xii Contents**

10.2.4	Trie Indexing . . . . .	517
10.3	File Organizations . . . . .	525
10.3.1	Sequential Organizations . . . . .	525
10.3.2	Random Organizations . . . . .	525
10.3.3	Linked Organization . . . . .	528
10.3.4	Inverted Files . . . . .	531
10.3.5	Cellular Partitions . . . . .	533
10.4	Storage Management . . . . .	533
	References and Selected Readings . . . . .	535
	Exercises . . . . .	536
<b>APPENDIX A: SPARKS . . . . .</b>		<b>543</b>
<b>APPENDIX B: ETHICAL CODE IN INFORMATION PROCESSING . . . . .</b>		<b>553</b>
<b>APPENDIX C: ALGORITHM INDEX BY CHAPTER . . . . .</b>		<b>558</b>
<b>INDEX . . . . .</b>		<b>562</b>

