

Contents

Preface	xi
Acknowledgments	xv
1 Sorting and Associated Concepts	1
1.1 Sorting	1
1.2 Selection	2
1.3 Jargon	4
1.4 Algorithmic Conventions	6
1.5 Order	7
1.6 Binary Trees	10
1.7 Decision Trees	18
1.8 Bounds on Sorting	21
1.8.1 Lower Bounds on Sorting	22
1.8.2 Upper Bounds on Sorting	24
1.9 Bounds on Selection	25
1.9.1 Lower Bounds on Selection	26
1.9.2 Upper Bounds on Selection	33
1.10 Random Permutations	36
1.10.1 Records	41
1.10.2 Inversions	44
1.10.3 Cycles	46
1.10.4 Runs	48
1.11 An Analytic Toolkit	53
1.11.1 The Saddle Point Method	54
1.11.2 The Mellin Transform	56
1.11.3 Poissonization	61
1.11.4 The Dirichlet Transform	67
1.11.5 Rice's Method	74
2 Insertion Sort	83
2.1 A General Framework	84
2.2 A Sufficient Condition for Normality	87

2.3	Linear Insertion Sort	88
2.4	Binary Insertion Sort	95
3	Shell Sort	103
3.1	The Algorithm	103
3.2	Streamlined Stochastic Analysis	105
3.2.1	The Empirical Distribution Function	106
3.2.2	The Brownian Bridge	106
3.2.3	Using the Stochastic Tools	114
3.3	Other Increment Sequences	122
4	Bubble Sort	129
4.1	The Algorithm	129
4.2	A limit Law for Passes	131
4.3	A Limit Law for Comparisons	136
5	Selection Sort	139
5.1	The Algorithm	139
5.2	Analysis	140
6	Sorting by Counting	144
6.1	COUNT SORT	144
6.2	Sorting by Counting Frequencies	146
7	Quick Sort	148
7.1	The Partitioning Stage	148
7.2	Bookkeeping	151
7.3	Quick Sort Tree	152
7.4	Probabilistic Analysis of QUICK SORT	153
7.5	Quick Selection	166
7.5.1	Hoare's FIND	167
7.5.2	MULTIPLE QUICK SELECT	177
8	Sample Sort	199
8.1	The Small Sample Algorithm	199
8.2	The Large Sample Algorithm	205
9	Heap Sort	212
9.1	The Heap	212
9.2	Sorting via a Heap	217

10 Merge Sort	220
10.1 Merging Sorted Lists	220
10.1.1 LINEAR MERGE	222
10.1.2 BINARY MERGE	227
10.1.3 The HWANG-LIN Merging Algorithm	228
10.2 The Merge Sort Algorithm	230
10.3 Distributions	239
10.4 Bottom-Up Merge Sort	243
11 Bucket Sorts	250
11.1 The Principle of Bucket Sorting	250
11.1.1 Distributive Sorts	253
11.1.2 Radix Sorting	259
11.2 Bucket Selection	269
11.2.1 Distributive Selection	271
11.2.2 Radix Selection	276
12 Sorting Nonrandom Data	283
12.1 Measures of Presortedness	284
12.2 Data Randomization	284
12.3 Guaranteed Performance	286
12.3.1 The FORD-JOHNSON Algorithm	286
12.3.2 Linear-Time Selection	294
12.4 Presorting	298
13 Epilogue	304
Answers to Exercises	307
Appendix: Notation and Standard Results from Probability Theory	367
A.1 Logarithms	367
A.2 Asymptotics	367
A.3 Harmonic Numbers	368
A.4 Probability	368
Bibliography	373
Index	389