

INTERNATIONAL EDITION



Kenneth H. Rosen



**Discrete
Mathematics
and Its
Applications**

FIFTH EDITION

M c G R A W - H I L L

Contents

Preface vii

The Companion Website xvii

To the Student xix

1 The Foundations: Logic and Proof, Sets, and Functions 1

1.1	Logic	1
1.2	Propositional Equivalences	20
1.3	Predicates and Quantifiers	28
1.4	Nested Quantifiers	44
1.5	Methods of Proof	56
1.6	Sets	77
1.7	Set Operations	86
1.8	Functions	97
	End-of-Chapter Material	111

2 The Fundamentals: Algorithms, the Integers, and Matrices 119

2.1	Algorithms	120
2.2	The Growth of Functions	131
2.3	Complexity of Algorithms	144
2.4	The Integers and Division	153
2.5	Integers and Algorithms	169
2.6	Applications of Number Theory	181
2.7	Matrices	196
	End-of-Chapter Material	206

3 Mathematical Reasoning, Induction, and Recursion 213

3.1	Proof Strategy	214
3.2	Sequences and Summations	225
3.3	Mathematical Induction	238
3.4	Recursive Definitions and Structural Induction	256
3.5	Recursive Algorithms	274
3.6	Program Correctness	284
	End-of-Chapter Material	290

4 Counting 301

4.1	The Basics of Counting	301
4.2	The Pigeonhole Principle	313
4.3	Permutations and Combinations	320
4.4	Binomial Coefficients	327
4.5	Generalized Permutations and Combinations	335
4.6	Generating Permutations and Combinations	344
	End-of-Chapter Material	349

5 Discrete Probability 355

5.1	An Introduction to Discrete Probability	355
5.2	Probability Theory	362
5.3	Expected Value and Variance	379
	End-of-Chapter Material	394

6 Advanced Counting Techniques 401

6.1	Recurrence Relations	401
6.2	Solving Recurrence Relations	413
6.3	Divide-and-Conquer Algorithms and Recurrence Relations	425
6.4	Generating Functions	435
6.5	Inclusion–Exclusion	451
6.6	Applications of Inclusion–Exclusion	457
	End-of-Chapter Material	465

7 Relations 471

7.1	Relations and Their Properties	471
7.2	n -ary Relations and Their Applications	482
7.3	Representing Relations	489
7.4	Closures of Relations	496
7.5	Equivalence Relations	507
7.6	Partial Orderings	516
	End-of-Chapter Material	530

8 Graphs 537

8.1	Introduction to Graphs	537
8.2	Graph Terminology	545
8.3	Representing Graphs and Graph Isomorphism	557
8.4	Connectivity	567
8.5	Euler and Hamilton Paths	577
8.6	Shortest-Path Problems	593

8.7	Planar Graphs	603
8.8	Graph Coloring	613
	End-of-Chapter Material	622

9 Trees 631

9.1	Introduction to Trees	631
9.2	Applications of Trees	644
9.3	Tree Traversal	660
9.4	Spanning Trees	674
9.5	Minimum Spanning Trees	688
	End-of-Chapter Material	694

10 Boolean Algebra 701

10.1	Boolean Functions	701
10.2	Representing Boolean Functions	709
10.3	Logic Gates	712
10.4	Minimization of Circuits	719
	End-of-Chapter Material	734

11 Modeling Computation 739

11.1	Languages and Grammars	739
11.2	Finite-State Machines with Output	751
11.3	Finite-State Machines with No Output	758
11.4	Language Recognition	765
11.5	Turing Machines	775
	End-of-Chapter Material	783

Appendixes

A.1	Exponential and Logarithmic Functions	A-1
A.2	Pseudocode	A-4

Suggested Readings B-1

Answers to Odd-Numbered Exercises S-1

Photo Credits C-1

Index of Biographies I-1

Index I-2