

I Algorithms

Introduction to Algorithms and Analysis

1.1	Complexity
1.2	Leading-Order Behavior
1.3	Summation
1.4	Reindexing and Changing Order of Summation
1.5	Nested Loops
1.6	*Additional Techniques of Summation
1.7	Products and Counting
1.8	Division and Divisors
1.9	Primes and Remainders
1.10	Divide and Conquer
1.11	Proof of the Master Theorem
	Exercises

Asymptotic Integrals

2.1	The Gamma Function and Stirling's Approximation
2.2	*The Beta Function and Laplace's Method
2.3	*Laplace's Method and Stirling Improved
	Exercises

Data Structures

3.1	Theory of Graphs
3.2	Trees and Tree-Based Data Structures
3.3	Search Trees
3.4	Priority Queues and Heaps
3.5	*B-Trees
	Exercises

Combinatorial Optimization

4.1	Dynamic programming
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4.2	Graph Search Algorithms
4.3	Minimum Spanning Trees
4.4	Huffman Encoding
4.5	Hard Problems
	Exercises

Probability

5.1	Probability Theory
5.2	Conditional Probability and Bayes' Rule
5.3	Independence, Paradoxes, and Pitfalls
5.4	Discrete Random Variables
5.5	Discrete Distributions
5.6	Continuous Random Variables
5.7	Multivariate Random Variables
	Exercises

Probabilistic Sampling and Estimation

6.1	Estimation
6.2	The Law of Large Numbers
6.3	The Central Limit Theorem
6.4	*Proof of the Central Limit Theorem
6.5	Bayesian Statistics
	Exercises

Random Algorithms

7.1	Monte Carlo Methods
7.2	Importance, Inversion, and Rejection Sampling
7.3	Hashing
7.4	*Simulated Annealing
7.5	*Genetic Algorithms
	Exercises

II Approximation

Harmonic Analysis

8.1	Fourier Series
8.2	*Trigonometric Fourier Series
8.3	Convergence of Fourier Series
8.4	The Discrete Fourier Transform
8.5	Convolution
8.6	Periodic Sampling Theorem
8.7	Haar Wavelets
8.8	Discrete Haar Wavelet Transform
8.9	*General Wavelets
8.10	*General Fast Wavelet Transform and Examples
	Exercises

Polynomial Approximation and Interpolation

9.1	Polynomial Approximation
9.2	Interpolation
9.3	Orthogonal Polynomials for Approximation
9.4	Interpolation and Approximation Error
9.5	Fast Chebyshev Interpolation
9.6	Integration by Interpolation
9.7	Clenshaw-Curtis and Gaussian Quadrature
	Exercises

III Interlude

Review of Multivariate Differentiation

10.1	Directional, Partial, and Total Derivatives
10.2	Properties of Derivatives
10.3	Implicit Function Theorem and Taylor's Theorem
	Exercises

Fundamentals of Numerical Approximation

11.1	Floating-point Arithmetic
11.2	A Brief Review of Conditioning
11.3	Stability of Numerical Algorithms
11.4	Computing Derivatives
	Exercises

IV Optimization

Unconstrained Optimization

12.1	Fundamentals of Unconstrained Optimization
12.2	One-dimensional Optimization
12.3	Gradient Descent
12.4	Newton and Quasi-Newton Methods
12.5	The BFGS Method
12.6	Conjugate-Gradient Methods
12.7	*Convergence of Conjugate Gradient
	Exercises

Linear Optimization

13.1	Convex and Affine Sets
13.2	Projection, Support, and Separation
13.3	Fundamentals of Linear Optimization
13.4	The Simplex Algorithm I
13.5	The Simplex Algorithm II
13.6	Duality
	Exercises

Nonlinear Constrained Optimization

14.1	Equality Constrained Optimization
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14.2	Lagrange's First-Order Condition
14.3	Lagrange's Second-Order Conditions
14.4	Karush-Kuhn-Tucker First-Order Conditions
14.5	*Second-Order KKT
14.6	Removing Constraints
14.7	Numerical Methods for Constrained Optimization
	Exercises

Convex Analysis and Optimization

15.1	Convex Functions
15.2	Jensen's Inequality
15.3	Fundamentals of Convex Optimization
15.4	Weak Duality
15.5	Strong Duality
15.6	*Interior Point Methods I: Barrier
15.7	*Interior Point Methods II: Primal-Dual
	Exercises

V Dynamic Optimization

Dynamic Optimization

16.1	Finite-Horizon Cake Eating
16.2	Dynamic Optimization Problems
16.3	Infinite-Horizon Dynamic Optimization
	Exercises

Stochastic Dynamic Optimization

17.1	Markov Decision Processes
17.2	Bandit Problems
17.3	Thompson Sampling
	Exercises