Table of Contents

Chapter 1. The World of Scientific Computing	1
1.1 What is Scientific Computing?	1
1.2 Mathematical Modeling	3
1.3 The Process of Numerical Solution	6
1.4 The Computational Environment	11
Chapter 2. Letting It Fly: Initial Value Problems	15
2.1 Examples of Initial Value Problems	15
2.2 One-Step Methods	20
2.3 Polynomial Interpolation	37
2.4 Multistep Methods	45
2.5 Stability, Instability, and Stiff Equations	55
Chapter 3. Pinning It Down: Boundary Value Problems	67
3.1 The Finite Difference Method for Linear Problems	67
3.2 Solution of the Discretized Problem	80
Chapter 4. More on Linear Systems of Equations	89
4.1 Introduction and Least Squares Problems	89
4.2 Gaussian Elimination	101
4.3 Interchanges	112
4.4 Ill-conditioning and Error Analysis	122
4.5 Other Factorizations	133

viii	CONTENTS
Chapter 5. Life Is Really Nonlinear	145
5.1 Nonlinear Problems and Shooting	145
5.2 Solution of a Single Nonlinear Equation	149
5.3 Systems of Nonlinear Equations	166
Chapter 6. Is There More Than Finite Differences?	179
6.1 Introduction to Projection Methods	179
6.2 Spline Approximation	187
6.3 Numerical Integration	193
6.4 The Discrete Problem Using Splines	202
Chapter 7. N Important Numbers	211
7.1 Eigenvalue Problems	211
7.2 The QR Method	224
7.3 Other Iterative Methods	234
Chapter 8. Space and Time	247
8.1 Partial Differential Equations	247
8.2 Explicit Methods and Stability	253
8.3 Implicit Methods	262
8.4 Semidiscrete Methods	267
Chapter 9. The Curse of Dimensionality	273
9.1 Two and Three Space Dimensions	273
9.2 Direct Methods	283
9.3 Iterative Methods	292
Appendix 1. Analysis and Differential Equations	309
Appendix 2. Linear Algebra	315
Bibliography	321

329

333

Author Index

Subject Index