CONTENTS

31

INTRODUCTION xv

ONE | MATHEMATICAL PRELIMINARIES 1

- 1.1 Review of Calculus 2
- 1.2 Round-Off Errors and Computer Arithmetic 10
- 1.3 Algorithms and Convergence 21

TWO | SOLUTIONS OF EQUATIONS IN ONE VARIABLE

- 2.1 The Bisection Method 32
- 2.2 Fixed-Point Iteration 38
- 2.3 The Newton-Raphson Method 47
- 2.4 Error Analysis for Iterative Methods 60
- 2.5 Accelerating Convergence 68
- 2.6 Zeros of Polynomials and Müller's Method 73

THREE INTERPOLATION AND POLYNOMIAL APPROXIMATION 85

- 3.1 The Taylor Polynomials 86
- 3.2 Interpolation and the Lagrange Polynomial 91
- 3.3 Iterated Interpolation 101
- 3.4 Divided Differences 106
- 3.5 Hermite Interpolation 117
- 3.6 Cubic Spline Interpolation 126

FOUR | NUMERICAL DIFFERENTIATION AND INTEGRATION 145

- 4.1 Numerical Differentiation 146
- 4.2 Richardson's Extrapolation 157
- 4.3 Elements of Numerical Integration 163
- 4.4 Composite Numerical Integration 173
- 4.5 Adaptive Quadrature Methods 184
- 4.6 Romberg Integration 191

CONTENTS

- 4.7 Gaussian Quadrature 198
- 4.8 Multiple Integrals 204



- 8.5 Trigonometric Polynomial Approximation 466
- 8.6 Fast Fourier Transforms 471

NINE APPROXIMATING EIGENVALUES 483

- 9.1 Linear Algebra and Eigenvalues 484
 - 9.2 The Power Method 492
 - 9.3 Householder's Method 508
 - 9.4 The QR Algorithm 515

TEN NUMERICAL SOLUTIONS OF NONLINEAR SYSTEMS OF EQUATIONS 527

- 10.1 Fixed Points for Functions of Several Variables 528
- 10.2 Newton's Method 536
- 10.3 Quasi-Newton Methods 544
- 10.4 Steepest Descent Techniques 551

ELEVEN BOUNDARY-VALUE PROBLEMS FOR ORDINARY DIFFERENTIAL EQUATIONS 559

- 11.1 The Linear Shooting Method 560
- 11.2 The Shooting Method for Nonlinear Problems 567
- 11.3 Finite-Difference Methods for Linear Problems 574
- 11.4 Finite-Difference Methods for Nonlinear Problems 580
- 11.5 Rayleigh-Ritz Method 587

TWELVENUMERICAL SOLUTIONS TO
PARTIAL DIFFERENTIAL EQUATIONS605

- 12.1 Physical Problems Involving Partial-Differential Equations 606
- 12.2 Elliptic Partial-Differential Equations 610
- 12.3 Parabolic Partial-Differential Equations 620
- 12.4 Hyperbolic Partial-Differential Equations 635
- 12.5 An Introduction to the Finite-Element Method 644

BIBLIOGRAPHY 659

ANSWERS TO SELECTED EXERCISES 667

INDEX 723

xiii