

Contents

Preface	ix
1 Mathematical Preliminaries and Error Analysis	1
1.1 Introduction	1
1.2 Review of Calculus	1
1.3 Round-off Error and Computer Arithmetic	17
1.4 Errors in Scientific Computation	25
1.5 Computer Software	34
2 Solutions of Equations of One Variable	39
2.1 Introduction	39
2.2 The Bisection Method	39
2.3 The Secant Method	47
2.4 Newton's Method	55
2.5 Error Analysis and Accelerating Convergence	64
2.6 Müller's Method	70
2.7 Survey of Methods and Software	77
3 Interpolation and Polynomial Approximation	79
3.1 Introduction	79
3.2 Lagrange Polynomials	81
3.3 Divided Differences	95
3.4 Hermite Interpolation	104
3.5 Spline Interpolation	111
3.6 Parametric Curves	124
3.7 Survey of Methods and Software	131
4 Numerical Integration and Differentiation	133
4.1 Introduction	133
4.2 Basic Quadrature Rules	134
4.3 Composite Quadrature Rules	144
4.4 Romberg Integration	155
4.5 Gaussian Quadrature	164
4.6 Adaptive Quadrature	170

4.7	Multiple Integrals	178
4.8	Improper Integrals	191
4.9	Numerical Differentiation	198
4.10	Survey of Methods and Software	210
5	Numerical Solution of Initial-Value Problems	213
5.1	Introduction	213
5.2	Taylor Methods	216
5.3	Runge-Kutta Methods	229
5.4	Predictor-Corrector Methods	239
5.5	Extrapolation Methods	248
5.6	Adaptive Techniques	255
5.7	Methods for Systems of Equations	265
5.8	Stiff Differential Equations	277
5.9	Survey of Methods and Software	283
6	Direct Methods for Solving Linear Systems	285
6.1	Introduction	285
6.2	Gaussian Elimination	285
6.3	Pivoting Strategies	298
6.4	Linear Algebra and Matrix Inversion	307
6.5	Matrix Factorization	320
6.6	Techniques for Special Matrices	327
6.7	Survey of Methods and Software	337
7	Iterative Methods for Solving Linear Systems	339
7.1	Introduction	339
7.2	Convergence of Vectors	340
7.3	Eigenvalues and Eigenvectors	350
7.4	The Jacobi and Gauss-Seidel Methods	358
7.5	The SOR Method	365
7.6	Error Bounds and Iterative Refinement	371
7.7	The Conjugate Gradient Method	379
7.8	Survey of Methods and Software	394
8	Approximation Theory	397
8.1	Introduction	397
8.2	Discrete Least Squares Approximation	397
8.3	Continuous Least Squares Approximation	408
8.4	Chebyshev Polynomials	417
8.5	Rational Function Approximation	424
8.6	Trigonometric Polynomial Approximation	431
8.7	Fast Fourier Transforms	438
8.8	Survey of Methods and Software	444

9	Approximating Eigenvalues	445
9.1	Introduction	445
9.2	Isolating Eigenvalues	445
9.3	The Power Method	453
9.4	Householder's Method	467
9.5	The QR Method	473
9.6	Survey of Methods and Software	481
10	Solutions of Systems of Nonlinear Equations	483
10.1	Introduction	483
10.2	Newton's Method for Systems	486
10.3	Quasi-Newton Methods	497
10.4	The Steepest Descent Method	505
	10.5 Homotopy and Continuation Methods	512
10.6	Survey of Methods and Software	521
11	Boundary-Value Problems for Ordinary Differential Equations	523
11.1	Introduction	523
11.2	The Linear Shooting Method	524
11.3	Linear Finite Difference Methods	531
11.4	The Nonlinear Shooting Method	540
11.5	Nonlinear Finite-Difference Methods	547
11.6	Variational Techniques	552
11.7	Survey of Methods and Software	568
12	Numerical Methods for Partial-Differential Equations	571
12.1	Introduction	571
12.2	Finite-Difference Methods for Elliptic Problems	573
12.3	Finite-Difference Methods for Parabolic Problems	583
12.4	Finite-Difference Methods for Hyperbolic Problems	598
12.5	Introduction to the Finite-Element Method	607
12.6	Survey of Methods and Software	623
	Bibliography	627
	Answers for Numerical Methods	633
	Index	755