

Numerical Methods for Scientific Computing

Chapter 1 Basic Concepts	1
Derivative of a Function, Fundamental Theorem of Calculus, Taylor Series for Functions of a Single Variable, The Landau Symbol \mathcal{O} , Taylor Series for Functions of Two Variables, Mean Value Theorem, Mean Value Theorem for Integrals, Extreme Value Theorem, Rolle's Theorem, Intermediate Value Theorem, Number Representation, Number Conversion, Conversion Between Different Bases, Computer Storage of Numbers, Numerical Calculations, Infinite Sequence	
Exercise	18
Chapter 2 Equation Solving.....	25
Graphical Methods, Bisection Method, Linear Interpolation, Iterative Methods, Convergence of Iterative Methods, Newton-Raphson Method, Newton-Raphson Method with Multiple Roots, Modifications to Newton-Raphson Method, Secant Method, Müller's Method	
Exercise	53
Chapter 3 Linear and Nonlinear Systems	59
Preliminaries, Eigenvalues and Eigenvectors, Elementary Row Operations, Gaussian Elimination, Echelon Form and Rank, Rank and Solutions, LU Decomposition, Iterative Methods for Solving $A\bar{x} = \bar{b}$, Gauss-Seidel Method, SOR Methods, Nonlinear Systems, Newton's Method for Higher Order Systems	
Exercise	100
Chapter 4 Interpolation and Approximation.....	109
Difference Tables, Interpolating Polynomials, Equally Spaced Data, Unequally Spaced Data, Divided Differences, Error Term for Polynomial Interpolation, Interpolation with Piecewise Cubic Splines, Linearity Condition, Hermite Interpolation, Special Functions and Operators, Rational Functions, Continued Fractions, Parametric Representations, Orthogonal Functions	
Exercise	156

Table of Contents

Chapter 5 Curve Fitting 167

Special Graph Paper, Probability Graph Paper, Least Squares,
Linear Regression, Weighted Least Squares, Nonlinear Regression

Exercise 193

Chapter 6 Difference Equations and Z-transforms 197

Differences and Difference Equations, Special Differences, Finite Integrals,
Summation of Series, Difference Equations with Constant Coefficients,
Nonhomogeneous Difference Equations, Z-transforms, Properties of the Z-transform

Exercise 233

Chapter 7 Numerical Differentiation and Integration 245

Numerical Approximation for Derivative, Error Terms for Derivative
Approximations, Method of Undetermined Coefficients, Numerical Integration,
Newton-Cotes Formula, Romberg Integration, Adaptive Quadrature,
Gaussian Quadrature, Gauss-Legendre Integration, Gauss-Laguerre Integration,
Gauss-Chebyshev Integration, General Gauss Integration, Error Term,
Improper Integrals

Exercise 292

Chapter 8 Ordinary Differential Equations 303

Higher Order Equations, Numerical Solution, Single Step Methods,
Taylor Series Method, Runge-Kutta Methods, Second-order Runge-Kutta Methods,
Third-order Runge-Kutta methods, Fourth-order Runge-Kutta methods,
Implicit Runge-Kutta Methods, Multi-step Methods, Open and Closed Adams
formula, Predictor Corrector Methods, Method of Undetermined Coefficients,
Error Term, Taylor Series for Systems of Equations, Runge-Kutta for Systems
of Equations, Local and Global Error, Stability, Stability Analysis of Multi-step
Methods, Stiff Differential Equations, Variable Step Size, Runge-Kutta-Fehlberg
method, Boundary Value Problems, Shooting Methods, Differential Equations
with Singular Points

Exercise 353

Table of Contents

Chapter 9 Partial Differential Equations.....	363
Canonical Forms, Boundary and Initial Conditions, The Heat Equation, The Wave Equation. Elliptic Equation, Numerical solution of the Laplace Equation, Numerical Solution of the Heat Equation, Crank-Nicolson Method, Numerical Solution of the Wave Equation, Alternating-Direction Implicit Scheme, Systems of Partial Differential Equations	
Exercise	401
Chapter 10 Monte Carlo Methods	411
Uniformly Distributed Random Numbers, Chi-square χ^2 Goodness of Fit, Discrete and Continuous Distributions, Selected Discrete Distributions, Selected Continuous Distributions, Monte Carlo Examples, Queuing Theory	
Exercise	438
Chapter 11 Miscellaneous Numerical Methods	445
Parallel Computer Systems, Bézier Curves, B-Splines, Fredholm Integral Equation, Neumann Series, Volterra Integral Equation, Boltzmann Differential-Integral Equation	
Bibliography	472
Appendix A Units of Measurement	475
Appendix B Solutions to Selected Exercises	477
Appendix C Tables	495
Index	498