Table of Contents

i Preface

iii Introduction

v About the Authors

1. Computation with *MATLAB*
   1.1. Data in *MATLAB*
      The basics: Matrices and vectors
      Setting vectors and matrices with internal *MATLAB* commands
      Simple functions and plots
      Reading data into *MATLAB*
   1.2. Mathematical operations with matrices
      Elementary operations: Addition, subtraction, and so forth
      Matrix multiplication
      Multiplication on an element-by-element basis
   1.3. Symbolic math toolbox
   1.4. Programming in *MATLAB*
      Script files
      Function files
   1.5. Summary
   1.6. Problems
   1.7. References

2. Solving Nonlinear Equations
   2.1 Nonlinear algebraic equations
   2.2. Bisection
   2.3. Newton's method and secant method
      Newton's method
      Secant method
   2.4. *MATLAB* methods for finding roots
   2.5. Example: Leonardo of Pisa's polynomial
   2.6. Iterative equations
   2.7. *MATLAB* methods for solving iterative equations
   2.8. Example: Wavelength of surface gravity waves
   2.9. Systems of linear equations
   2.10. *MATLAB* methods for solving sets of linear equations
   2.11. Gaussian elimination
   2.12. Example: Gaussian elimination
   2.13. Problems
   2.14. References

3. Numerical Differentiation and Integration
   3.1. Finite differences

3.2. Taylor series approach
3.3. Differentiation using interpolating polynomials
3.4. *MATLAB* methods for finding derivatives
3.5. Numerical integration
3.6. Trapezoidal rule
3.7. Simpson's rules
3.8. Gaussian quadrature
3.9. *MATLAB* methods
3.10. Problems
3.11. References

4. Numerical Methods for Solving First-Order Ordinary Differential Equations
   4.1. Ordinary differential equations in hydrology
   4.2. Euler and Taylor-series methods
   4.3. Modified Euler method or Euler predictor-corrector method
   4.4. Runge-Kutta methods
   4.5. Runge-Kutta-Fehlberg method
   4.6. *MATLAB* methods
        Example
   4.7. Multistep methods
   4.8. Sources of error, convergence, and stability
   4.9. Systems of equations
   4.10. Problems
   4.11. References

5. Numerical Methods for Solving Higher-Order and Boundary-Value Ordinary Differential Equations
   5.1. Introduction
   5.2. Solving higher-order initial value problems
   5.3. Example: Bessel equation
   5.4. Solving boundary value problems using the shooting method
   5.5. Solving boundary value problems using finite differences
   5.6. Derivative boundary conditions
   5.7. Problems

6. Introduction to Finite Difference Methods for Partial Differential Equations
   6.1. Classification of partial differential equations
   6.2. Finite difference approximations for derivatives
   6.3. Example: The Laplace equation
        Solving the example problem in *MATLAB*
   6.4. Example problem: The "Tóth" problem
   6.5. Solving the two-dimensional Poisson equation
   6.6. An example problem
   6.7. Problems
   6.8. References

7. Iterative Solution of Systems of Equations
   7.1. Introduction
   7.2. Fixed-point iteration revisited
   7.3. Iterative solution of a system of equations
   7.4. Vector and matrix norms
   7.5. Iterative methods for finite difference equations
   7.6. Problems
   7.7. References

8. Finite Difference Solutions for Transient Problems
   8.1. Background
   8.2. Unidirectional flow in an aquifer
   8.3. A forward-difference (or *explicit*) approximation
   8.4. Stability problems with the explicit method
   8.5. A backward-difference (or *implicit*) approximation
   8.6. The γ method
   8.7. Flow in an unsaturated soil
   8.8. Problems
   8.9. References

9. Finite Difference Methods for Transport Equations
   9.1. Background
   9.2. Numerical dispersion
   9.3. The advection-dispersion equation
   9.4. Transport of reactive solutes
   9.5. Problems
   9.6. References

10. The Finite Element Method: An Introduction
   10.1. Background
   10.2. Collocation
   10.3. Weighted residual method
   10.4. The finite-element approach: Galerkin weighted residual method
   10.5. Steady diffusion into sediment
   10.6. Problems
   10.7. References

11. The Finite Element Method: Steady Flow of Groundwater in Two Dimensions
   11.1. Background
   11.2. An example problem
   11.3. Triangular elements
   11.4. The weighted residual equation and its integral over an element
   11.5. Defining node connectivities
   11.6. Assigning *x* and *z* coordinates to the mesh
   11.7. Assembling the global conductance matrix
   11.8. The boundary conditions: Setting the right-hand side of the equation

11.9. Problems
11.10. References

12. Methods of Data Analysis: Fourier Analysis of Time Series
12.1. Periodic functions
12.2. Fourier series
12.3. Example: Square wave
12.4. Example: CO_2 time series
12.5. *MATLAB* methods
12.6. Spectral analysis and periodograms
12.7. Filtering time series
12.8. Problems
12.9. References

13. Methods of Data Analysis: Spatial Data
13.1. Background
13.2. Interpolating irregularly spaced data onto a regular grid
13.3. Contouring
13.4. Semivariance
13.5. Kriging
13.6. Problems
13.7. References

Subject Index