

- Preface p. xvii
- Part I
  - 1 Meet the Finite Element Method p. 3
  - 1.1 What Is the Finite Element Method? p. 3
  - 1.2 How the Finite Element Method Works p. 5
  - 1.3 A Brief History of the Method p. 8
  - 1.4 Range of Applications p. 11
  - 1.5 Commercial Finite Element Software p. 13
  - 1.6 The Future of the Finite Element Method p. 14
  - References p. 15
- 2 The Direct Approach: A Physical Interpretation p. 17
  - 2.1 Introduction p. 17
  - 2.2 Defining Elements and Their Properties p. 18
  - 2.3 Assembling the Parts p. 40
  - 2.4 Solver Technology p. 56
  - 2.5 Closure p. 63
  - References p. 63
  - Problems p. 64
- 3 The Mathematical Approach: A Variational Interpretation p. 74
  - 3.1 Introduction p. 74
  - 3.2 Continuum Problems p. 75
  - 3.3 Some Methods for Solving Continuum Problems p. 79
  - 3.4 The Finite Element Method p. 85
  - 3.5 Closure p. 108
  - References p. 108
  - Problems p. 109
- 4 The Mathematical Approach: A Generalized Interpretation p. 113
  - 4.1 Introduction p. 113
  - 4.2 Deriving Finite Element Equations from the Method of Weighted Residuals p. 114
  - 4.3 Closure p. 131
  - References p. 131
  - Problems p. 132
- 5 Elements and Interpolation Functions p. 137
  - 5.1 Introduction p. 138
  - 5.2 Basic Element Shapes p. 139
  - 5.3 Terminology and Preliminary Considerations p. 144
  - 5.4 Generalized Coordinates and the Order of the Polynomial p. 146
  - 5.5 Natural Coordinates p. 151
  - 5.6 Interpolation Concepts in One Dimension p. 161
  - 5.7 Internal Nodes--Condensation/Substructuring p. 166
  - 5.8 Two-Dimensional Elements p. 170
  - 5.9 Three-Dimensional Elements p. 184
  - 5.10 Isoparametric Elements for C<sup>0</sup> Problems p. 189
  - 5.11 Numerical Integration p. 197

- 5.12 Closure p. 210
- References p. 211
- Problems p. 213
- Part II
- 6 Elasticity Problems p. 223
- 6.1 Introduction p. 224
- 6.2 General Formulation for Three-Dimensional Problems p. 224
- 6.3 Application to Plane Stress and Plane Strain p. 238
- 6.4 Application to Axisymmetric Stress Analysis p. 246
- 6.5 Application to Plate-Bending Problems p. 254
- 6.6 Three-Dimensional Problem p. 262
- 6.7 Introduction to Structural Dynamics p. 264
- 6.8 Closure p. 278
- References p. 279
- Problems p. 281
- 7 General Field Problems p. 288
- 7.1 Introduction p. 289
- 7.2 Equilibrium Problems p. 289
- 7.3 Eigenvalue Problems p. 303
- 7.4 Propagation Problem p. 311
- 7.5 Solving the Discretized Time-Dependent Equations p. 320
- 7.6 Closure p. 335
- References p. 335
- Problems p. 337
- 8 Heat Transfer Problems p. 348
- 8.1 Introduction p. 349
- 8.2 Conduction p. 349
- 8.3 Conduction with Surface Radiation p. 379
- 8.4 Convective-Diffusion Equation p. 390
- 8.5 Free and Forced Convection p. 398
- 8.6 Closure p. 403
- References p. 406
- Problems p. 410
- 9 Fluid Mechanics Problems p. 422
- 9.1 Introduction p. 422
- 9.2 Inviscid Incompressible Flow p. 423
- 9.3 Viscous Incompressible Flow without Inertia p. 434
- 9.4 Viscous Incompressible Flow with Inertia p. 441
- 9.5 Compressible Flow p. 459
- 9.6 Closure p. 479
- References p. 480
- Problems p. 486
- 10 Boundary Conditions, Mesh Generation, and Other Practical Considerations p. 495
- 10.1 Introduction p. 496

- 10.2 Physical Singularities p. 496
- 10.3 Benchmark Problems p. 498
- 10.4 Symmetry p. 502
- 10.5 Dimensional Analysis p. 517
- 10.6 Mesh Generation p. 519
- 10.7 Lumped Mass versus Consistent Mass p. 541
- 10.8 Modeling Fasteners p. 543
- 10.9 Connecting Rod Analysis p. 546
- 10.10 Crankshaft and Flywheel Analysis p. 549
- 10.11 Disc Brake Analysis p. 551
- 10.12 Closure p. 558
- References p. 559
- Problems p. 565
- 11 Finite Elements in Design p. 570
- 11.1 Introduction p. 571
- 11.2 Design Optimization p. 571
- 11.3 Finite Element-Based Optimal Design p. 582
- 11.4 Design Sensitivity Analysis p. 594
- 11.5 Examples of Design Sensitivity Analysis p. 606
- 11.6 Case Study: Finite Element-Based Design p. 626
- 11.7 Closure p. 628
- References p. 628
- Problems p. 632
- Appendix A Matrices p. 636
- A.1 Definitions p. 637
- A.2 Special Types of Square Matrices p. 637
- A.3 Matrix Operations p. 638
- A.4 Special Matrix Products p. 640
- A.5 Matrix Transpose p. 641
- A.6 Quadratic Forms p. 641
- A.7 Matrix Inverse p. 643
- A.8 Matrix Partitioning p. 643
- A.9 The Calculus of Matrices p. 645
- A.10 Norms p. 646
- Appendix B Variational Calculus p. 648
- B.1 Introduction p. 648
- B.2 Calculus--The Minima of a Function p. 648
- B.3 Variational Calculus--The Minima of Functionals p. 650
- Appendix C Basic Equations from Linear Elasticity Theory p. 657
- C.1 Introduction p. 657
- C.2 Stress Components p. 658
- C.3 Strain Components p. 658
- C.4 Generalized Hooke's Law (Constitutive Equations) p. 659
- C.5 Static Equilibrium Equations p. 662

- C.6 Compatibility Conditions p. 663
- C.7 Differential Equations for Displacements p. 664
- C.8 Minimum Potential Energy Principle p. 665
- C.9 Plane Strain and Plane Stress p. 667
- C.10 Thermal Effects p. 670
- C.11 Thin-Plate Bending p. 671
- References p. 673
- Appendix D Basic Equations from Fluid Mechanics p. 674
- D.1 Introduction p. 674
- D.2 Definitions and Concepts p. 675
- D.3 Laws of Motion p. 677
- D.4 Stream Functions and Vorticity p. 683
- D.5 Potential Flow p. 685
- D.6 Viscous Incompressible Flow p. 686
- D.7 Boundary Layer Flow p. 689
- References p. 690
- Appendix E Basic Equations from Heat Transfer p. 691
- E.1 Introduction p. 691
- E.2 Conduction p. 692
- E.3 Convection p. 696
- E.4 Radiation p. 701
- E.5 Heat Transfer Units p. 707
- References p. 708
- Index p. 709