

CONTENTS

Chapter One. Basic Equations of Macroscopic Systems. . . .	1
1.1. The Concept of a Continuum	1
1.2. Kinematics	2
1.3. Balance Laws	8
1.4. Constitutive Laws	21
1.5. Mixtures	40
1.6. Problems for Chapter One	48
1.7. References	50
Chapter Two. Introduction to Numerical Methods.	52
2.1. Introduction	52
2.2. Partial Differential Equations	52
2.3. Boundary and Initial Conditions	55
2.4. Polynomial Approximations	56
2.5. Polynomial Approximation in Higher Dimensions	62
2.6. Finite-Difference Approximations	76
2.7. Error Estimates for Finite Differences	82
2.8. Consistency of Finite-Difference Approximations	84
2.9. Stability of Finite-Difference Approximations	85
2.10. The Method of Weighted Residuals	90
2.11. The Galerkin Finite-Element Method	94
2.12. The Galerkin Method in Two Space Dimensions	99
2.13. Error Bounds on the Galerkin Finite-Element Method	110
2.14. The Method of Collocation	114
2.15. Error Bounds on the Collocation Method	117
2.16. Boundary-Element Methods	119
2.17. Problems for Chapter Two	120
2.18. References	125
Chapter Three. Steady-State Systems.	126
3.1. Introduction	126
3.2. Laplace's Equation in Physics and Engineering	127
3.3. Well Posed Boundary-Value Problems	130
3.4. General Properties of the Laplace Operator	132
3.5. Variational Principles	134
3.6. Maximum Principles	138
3.7. Invariance Under Translation and Fundamental Solutions	141
3.8. Integral Representation Theorems	142
3.9. Finite-Difference Approximations	145
3.10. Boundary Conditions via Finite Differences	150

3.11. Matrix Form of the Finite-Difference Equations	152
3.12. Direct Methods of Solution	155
3.13. Iterative Methods	156
3.14. Convergence and Related Topics	163
3.15. Other Iterative Schemes	166
3.16. Finite-Element Methods	171
3.17. Boundary-Element Methods	179
3.18. Problems for Chapter Three	184
3.19. References	188
Chapter Four. Dissipative Systems..	191
4.1. Introduction	191
4.2. The Heat Equation	197
4.3. Finite-Difference Methods	201
4.4. Finite-Element Methods	228
4.5. Problems for Chapter Four	257
4.6. References	259
Chapter Five. Nondissipative Systems	261
5.1. Introduction	261
5.2. Well Posed Problems	266
5.3. General Properties of Nonlinear Equations	275
5.4. Finite-Difference Methods for Linear Problems	283
5.5. Finite-Difference Methods for Nonlinear Problems	293
5.6. Finite Elements for Hyperbolic Equations	309
5.7. Problems for Chapter Five	331
5.8. References	333
Chapter Six. High-Order, Nonlinear, and Coupled Systems	335
6.1. Introduction	335
6.2. The Biharmonic Equation	335
6.3. Nonlinear Problems	349
6.4. The Simulation of Solid Deformation	368
6.5. Oil Reservoir Modeling	375
6.6. Problems for Chapter Six	387
6.7. References	391
Appendix. Summary of Vector and Tensor Analysis	395
Index	408

