

Contents

1 Vectors 1

- 1 Coordinate Vectors *1*
- 2 Geometric Vectors *7*
- 3 Lines and Planes *13*
- 4 Dot Products *21*
- 5 Euclidean Geometry *28*

2 Equations and Matrices 34

- 1 Systems of Linear Equations *34*
- 2 Matrices *40*
- 3 Matrix Algebra *48*
- 4 Inverse Matrices *56*

3 Linearity 63

- 1 Linear Functions *64*
- 2 Linear Functions on \mathbb{R}^n *69*
- 3 Vector Spaces and Subspaces *79*

- 4 Examples of Linear Functions 87
- 5 Image and Null-Space 95
- 6 Complex Vector Spaces 101

- 4 Coordinates and Dimension 108**
 - 1 Bases 108
 - 2 Coordinates 115
 - 3 Rank and Nullity 123
 - 4 Theorems on Dimension 128

- 5 Determinants 132**
 - 1 Basic Properties 133
 - 2 Geometric Properties 144

- 6 Eigenvectors 155**
 - 1 Eigenvalues and Eigenvectors 155
 - 2 Bases of Eigenvectors 160

- 7 Orthogonality 168**
 - 1 Inner Products 168
 - 2 Orthogonal Bases 176

- 8 Derivatives 184**
 - 1 Functions of One Variable 185
 - 2 Graphs 195
 - 3 Partial Derivatives 201
 - 4 Vector Partial Derivatives 208
 - 5 Limits and Continuity 213
 - 6 Differentiability 222
 - 7 Directional Derivatives 234

- 9 Vector Differential Calculus 240**
 - 1 Gradient Vectors 240
 - 2 The Chain Rule 247
 - 3 Implicit Differentiation 259
 - 4 Extreme Values 267
 - 5 Curvilinear Coordinates 279

10 Multiple Integration 288

- 1 Iterated Integrals 288
- 2 Multiple Integrals 299
- 3 Integration Theory 314
- 4 Change of Variable 317

11 Integration on Curves 330

- 1 Line Integrals 331
- 2 Arc Length 338

12 Vector Field Theory 348

- 1 Green's Theorem 348
- 2 Conservative Vector Fields 360
- 3 Surface Integrals 367
- 4 Stokes's Theorem 378
- 5 Gauss's Theorem 388
- 6 The Operators ∇ , ∇_x , and $\nabla \cdot$ 393

13 First-Order Differential Equations 401

- 1 Direction Fields 402
- 2 Applications 408
- 3 Linear Equations 419

14 Constant-Coefficient Equations 427

- 1 Differential Operators 428
- 2 Complex Solutions 437
- 3 Nonhomogeneous Equations 445
- 4 Oscillations 451
- 5 Laplace Transforms 459
- 6 Convolution 467

15 First-Order Systems 473

- 1 Vector Fields 474
- 2 Linear Systems 482
- 3 Applications 490
- 4 Numerical Methods 500

16 Linear Systems 508

- 1 Eigenvalues and Eigenvectors 508
- 2 Matrix Exponentials 517
- 3 Nonhomogeneous Systems 523
- 4 Autonomous Systems 529

Answers and Hints 537**Index 571**