

Contents

Preface *xi*

To the Student *xvii*

Suggested Lecture Schedule *xix*

1 The Geometry of the Plane and 3-Space **1**

- 1.1 Vectors *1*
- 1.2 Length and Direction *16*
- 1.3 Lines, Planes, and the Cross Product of Vectors *26*
- 1.4 Projections *45*
- 1.5 Euclidean n -Space *54*
 - Review Exercises *66*

2 Matrices and Linear Equations **69**

- 2.1 The Algebra of Matrices *69*
- 2.2 The Inverse and Transpose of a Matrix *88*
- 2.3 Systems of Linear Equations *98*
- 2.4 Homogeneous Systems and Linear Independence *117*
- 2.5 The LU Factorization of a Matrix *125*
- 2.6 LDU Factorizations *144*
- 2.7 Finding the Inverse of a Matrix *152*
 - Review Exercises *163*

3 Determinants, Eigenvalues, Eigenvectors 167

- 3.1 The Determinant of a Matrix 167
- 3.2 Properties of Determinants 177
- 3.3 The Eigenvalues and Eigenvectors of a Matrix 193
- 3.4 Similarity and Diagonalization 203
- Review Exercises 214

4 Vector Spaces 217

- 4.1 The Theory of Linear Equations 217
- 4.2 Basic Terminology and Concepts 233
- 4.3 Basis and Dimension; Rank and Nullity 253
- 4.4 One-Sided Inverses 274
- Review Exercises 282

5 Linear Transformations 285

- 5.1 Linear Transformations of R^n 285
- 5.2 Matrix Multiplication Revisited 301
- 5.3 The Matrices of a Linear Transformation 308
- 5.4 Changing Coordinates 321
- Review Exercises 331

6 Orthogonality 335

- 6.1 Projection Matrices and Least Squares Approximation 335
- 6.2 The Gram–Schmidt Algorithm and QR Factorization 353
- 6.3 Orthogonal Subspaces and Complements 371
- 6.4 The Pseudoinverse of a Matrix 387
- Review Exercises 398

7 The Spectral Theorem **401**

- 7.1 Complex Numbers and Vectors *401*
- 7.2 Complex Matrices *415*
- 7.3 Unitary Diagonalization *423*
- 7.4 Real Symmetric Matrices *441*
- 7.5 The Singular Value Decomposition *448*
Review Exercises *455*

8 Applications **457**

- 8.1 Data Fitting *457*
- 8.2 Linear Recurrence Relations *462*
- 8.3 Markov Processes *468*
- 8.4 Quadratic Forms and Conic Sections *474*
- 8.5 Graphs *479*

Appendix: Show and Prove *A-1*

**Solutions to True/False Questions
and Selected Exercises** *S-1*

Glossary *G-1*

Index *I-1*