

INTERNATIONAL EDITION

INTRODUCTORY

LINEAR ALGEBRA

An Applied First Course

8/E



Bernard Kolman ■ David R. Hill

CONTENTS

Preface xi

To the Student xix

1 Linear Equations and Matrices 1

- 1.1 Linear Systems 1
- 1.2 Matrices 10
- 1.3 Dot Product and Matrix Multiplication 21
- 1.4 Properties of Matrix Operations 39
- 1.5 Matrix Transformations 52
- 1.6 Solutions of Linear Systems of Equations 62
- 1.7 The Inverse of a Matrix 91
- 1.8 LU-Factorization (Optional) 107

2 Applications of Linear Equations and Matrices (Optional) 119

- 2.1 An Introduction to Coding 119
- 2.2 Graph Theory 125
- 2.3 Computer Graphics 135
- 2.4 Electrical Circuits 144
- 2.5 Markov Chains 149
- 2.6 Linear Economic Models 159
- 2.7 Introduction to Wavelets 166

3 Determinants 182

- 3.1 Definition and Properties 182
- 3.2 Cofactor Expansion and Applications 196
- 3.3 Determinants from a Computational Point of View 210

4 Vectors in R^n 214

- 4.1 Vectors in the Plane 214
- 4.2 n -Vectors 229
- 4.3 Linear Transformations 247

5 Applications of Vectors in R^2 and R^3 (Optional) 259

- 5.1 Cross Product in R^3 259
- 5.2 Lines and Planes 264

6 Real Vector Spaces 272

- 6.1 Vector Spaces 272
- 6.2 Subspaces 279
- 6.3 Linear Independence 291
- 6.4 Basis and Dimension 303
- 6.5 Homogeneous Systems 317
- 6.6 The Rank of a Matrix and Applications 328
- 6.7 Coordinates and Change of Basis 340
- 6.8 Orthonormal Bases in R^n 352
- 6.9 Orthogonal Complements 360

7 Applications of Real Vector Spaces (Optional) 375

- 7.1 QR-Factorization 375
- 7.2 Least Squares 378
- 7.3 More on Coding 390

8 Eigenvalues, Eigenvectors, and Diagonalization 408

- 8.1 Eigenvalues and Eigenvectors 408
- 8.2 Diagonalization 422
- 8.3 Diagonalization of Symmetric Matrices 433

9 Applications of Eigenvalues and Eigenvectors (Optional) 447

- 9.1 The Fibonacci Sequence 447
- 9.2 Differential Equations (Calculus Required) 451
- 9.3 Dynamical Systems (Calculus Required) 461
- 9.4 Quadratic Forms 475
- 9.5 Conic Sections 484
- 9.6 Quadric Surfaces 491

10 Linear Transformations and Matrices 502

- 10.1 Definition and Examples 502
- 10.2 The Kernel and Range of a Linear Transformation 508
- 10.3 The Matrix of a Linear Transformation 521
- 10.4 Introduction to Fractals (Optional) 536

Cumulative Review of
Introductory Linear Algebra 555

11 Linear Programming (Optional) 558

- 11.1 The Linear Programming Problem; Geometric Solution 558
- 11.2 The Simplex Method 575
- 11.3 Duality 591
- 11.4 The Theory of Games 598

12 MATLAB for Linear Algebra 615

- 12.1 Input and Output in MATLAB 616
- 12.2 Matrix Operations in MATLAB 620
- 12.3 Matrix Powers and Some Special Matrices 623
- 12.4 Elementary Row Operations in MATLAB 625
- 12.5 Matrix Inverses in MATLAB 634
- 12.6 Vectors in MATLAB 635
- 12.7 Applications of Linear Combinations in MATLAB 637
- 12.8 Linear Transformations in MATLAB 640
- 12.9 MATLAB Command Summary 643

APPENDIX **A** Complex Numbers A1

- A.1 Complex Numbers A1
- A.2 Complex Numbers in Linear Algebra A9

APPENDIX **B** Further Directions A19

- B.1 Inner Product Spaces (Calculus Required) A19
- B.2 Composite and Invertible Linear Transformations A30

Glossary for Linear Algebra A39

Answers to Odd-Numbered Exercises and Chapter Tests A45

Index I1