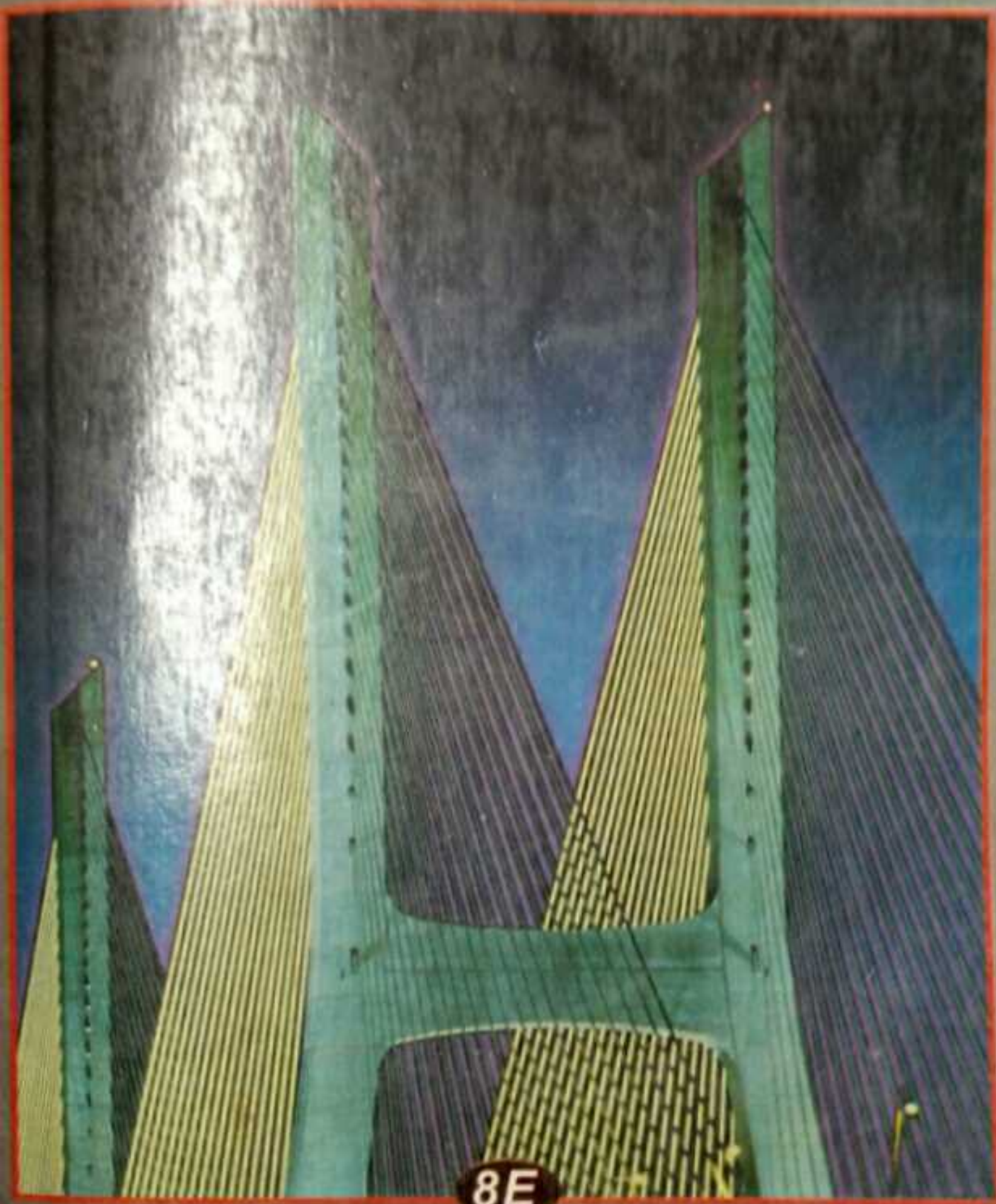


# ANTON • RORRES

FORTUNE TELLER  
BOOK CENTRE  
18, New York Road,  
Kolkata - 700001



8E

## Elementary Linear Algebra

APPLICATIONS VERSION

# Contents

## CHAPTER 1

### SYSTEMS OF LINEAR EQUATIONS AND MATRICES

1

- 1.1 Introduction to Systems of Linear Equations 2
- 1.2 Gaussian Elimination 4
- 1.3 Matrices and Matrix Operations 23
- 1.4 Inverse: Rules of Matrix Arithmetic 37
- 1.5 Elementary Matrices and a Method for Finding  $A^{-1}$  50
- 1.6 Further Results on Systems of Equations and Invertibility 54
- 1.7 Diagonal, Triangular, and Symmetric Matrices 66

## CHAPTER 2

### DETERMINANTS

81

- 2.1 The Determinant Function 82
- 2.2 Evaluating Determinants by Row Reduction 89
- 2.3 Properties of the Determinant Function 95
- 2.4 Cofactor Expansion, Cramer's Rule 104

## CHAPTER 3

### VECTORS IN 2-SPACE AND 3-SPACE

119

- 3.1 Introduction to Vectors (Geometry) 120
- 3.2 Norm of a Vector, Vector Arithmetic 126
- 3.3 Dot Product, Projections 130
- 3.4 Cross Product 138
- 3.5 Lines and Planes in 3-Space 149

## CHAPTER 4

### EUCLIDEAN VECTOR SPACES

161

- 4.1 Euclidean  $n$ -Space 162
- 4.2 Linear Transformations from  $R^n$  to  $R^n$  173
- 4.3 Properties of Linear Transformations from  $R^n$  to  $R^n$  189



**CHAPTER 5****GENERAL VECTOR SPACES****203**

- 5.1 Real Vector Spaces 204
- 5.2 Subspaces 211
- 5.3 Linear Independence 221
- 5.4 Basis and Dimension 231
- 5.5 Row Space, Column Space, and Nullspace 246
- 5.6 Rank and Nullity 259

**CHAPTER 6****INNER PRODUCT SPACES****275**

- 6.1 Inner Products 276
- 6.2 Angle and Orthogonality in Inner Product Spaces 287
- 6.3 Orthonormal Bases; Gram-Schmidt Process; QR-Decomposition 298
- 6.4 Best Approximation; Least Squares 311
- 6.5 Orthogonal Matrices; Change of Basis 320

**CHAPTER 7****EIGENVALUES, EIGENVECTORS****337**

- 7.1 Eigenvalues and Eigenvectors 338
- 7.2 Diagonalization 347
- 7.3 Orthogonal Diagonalization 357

**CHAPTER 8****LINEAR TRANSFORMATIONS****365**

- 8.1 General Linear Transformations 366
- 8.2 Kernel and Range 376
- 8.3 Inverse Linear Transformations 382
- 8.4 Matrices of General Linear Transformations 390
- 8.5 Similarity 402

**CHAPTER 9****ADDITIONAL TOPICS****419**

- 9.1 Application to Differential Equations 420
- 9.2 Geometry of Linear Operators on  $\mathbb{R}^2$  426
- 9.3 Least Squares Fitting to Data 437
- 9.4 Approximation Problems; Fourier Series 442
- 9.5 Quadratic Forms 447
- 9.6 Diagonalizing Quadratic Forms; Conic Sections 454
- 9.7 Quadric Surfaces 463

9.8	Comparison of Procedures for Solving Linear Systems	468
9.9	LU-Decompositions	477

## CHAPTER 10

### COMPLEX VECTOR SPACES

487

10.1	Complex Numbers	488
10.2	Division of Complex Numbers	494
10.3	Polar Form of a Complex Number	500
10.4	Complex Vector Spaces	506
10.5	Complex Inner Product Spaces	513
10.6	Unitary, Normal, and Hermitian Matrices	520

## CHAPTER 11

### APPLICATIONS OF LINEAR ALGEBRA

531

11.1	Constructing Curves and Surfaces Through Specified Points	532
11.2	Electrical Networks	538
11.3	Geometric Linear Programming	542
11.4	The Assignment Problem	554
11.5	Cubic Spline Interpolation	565
11.6	Markov Chains	576
11.7	Graph Theory	587
11.8	Games of Strategy	598
11.9	Leontief Economic Models	608
11.10	Forest Management	618
11.11	Computer Graphics	626
11.12	Equilibrium Temperature Distributions	636
11.13	Computed Tomography	647
11.14	Fractals	659
11.15	Chaos	678
11.16	Cryptography	692
11.17	Genetics	705
11.18	Age-Specific Population Growth	716
11.19	Harvesting of Animal Populations	727
11.20	A Least Squares Model for Human Hearing	735
11.21	Warps and Morphs	742

## ANSWERS TO EXERCISES

753

## PHOTO CREDITS

811

## INDEX

813