

Contents

Symbols	xvii
1. Introduction	1
1.1 System Models	1
1.2 Approach	4
1.3 Portable Concepts	5
1.4 System Modeling	9
1.5 Solution of Linear Algebraic Equations	17
1.6 Problems and Comments	28
1.7 References	32
2. System Models: Transformations on Vector Spaces	33
2.1 The Condition of a System	33
2.2 Relations among Vectors	45
2.3 System Models	55
2.4 Linear Transformations	62
2.5 Matrices of Linear Transformations	72
2.6 Problems and Comments	81
2.7 References	92
3. Linear Differential Operators	93
3.1 A Differential Operator and Its Inverse	94
3.2 Properties of n th-Order Systems and Green's Functions	103

3.3	Inversion of n th-Order Differential Systems	112
3.4	Time-Invariant Dynamic Systems	124
3.5	Problems and Comments	135
3.6	References	142
4.	Spectral Analysis of Linear Systems	144
4.1	System Decomposition	145
4.2	Spectral Analysis in Finite-Dimensional Spaces	153
4.3	Spectral Analysis in Function Spaces	168
4.4	Nondiagonalizable Operators and Jordan Form	179
4.5	Applications of Generalized Eigendata	198
4.6	Functions of Matrices and Linear Operators	205
4.7	Problems and Comments	222
4.8	References	235
5.	Hilbert Spaces	237
5.1	Inner Products	237
5.2	Orthogonality	246
5.3	Infinite-Dimensional Spaces	264
5.4	Adjoint Transformations	279
5.5	Spectral Decomposition in Infinite-Dimensional Spaces	298
5.6	Problems and Comments	318
5.7	References	330
6.	Least-Square Minimization	332
6.1	Least-Error Problems by Orthogonal Projection	333
6.2	Least-Effort Problems by Orthogonal Projection	347
6.3	Problem 1—Resolution of Incompatibility by Adjoints	356
6.4	Problem 2—Resolution of Nonuniqueness by Adjoints	360

<i>Contents</i>	<i>xc</i>
6.5 The Pseudoinverse	365
6.6 Practical Computation of Least-Square Solutions	378
6.7 Problems and Comments	385
6.8 References	393
7. Characterizing the Optimum: Linearization in a Hilbert Space	395
7.1 Local Linearization and Unconstrained Extrema	396
7.2 Optimization with Equality Constraints	412
7.3 Optimization with Inequality Constraints	430
7.4 Mathematical Programming	441
7.5 Problems and Comments	464
7.6 References	470
8. Computing the Optimum: Iteration in a Hilbert Space	472
8.1 Solving Nonlinear Equations by Newton's Method	474
8.2 Steepest Descent	487
8.3 Other Descent Methods	501
8.4 The Gradient Projection Method	521
8.5 Penalty Functions	538
8.6 Summary	549
8.7 Problems and Comments	550
8.8 References	556
Appendix 1: Matrices and Determinants	559
Appendix 2: Delta Functions and Linear System Equations	566
Appendix 3: Decomposition Theorems	578
Answers to Selected Problems	582
Index	593