PA	RTI	MATRIX THEORY	1
1	PRE	LIMINARIES FROM THE THEORY	
	OF	MATRICES	3
	1.1	Similarity and the complex Jordan form	3
	1.2	Invariant subspaces	9
	1.3	Projectors and invariant subspaces	13
	1.4	Real matrices and canonical forms	16
	1.5	Square roots of definite matrices	20
	1.6	Regular matrix pencils	22
	1.7	Functions of matrices	26
	1.8	Exercises	29
	1.9	Notes	30
2	IND	EFINITE SCALAR PRODUCTS	31
	2.1	Definitions and classifications of subspaces	31
	2.2	Selfadjoint and unitary matrices	36
	2.3	Canonical forms for H-selfadjoint and	
		H-unitary matrices	41
	2.4	Invariant nonnegative subspaces	46
	2.5	Invariant neutral subspaces	52
	2.6	H-symmetric matrices	55
	2.7	H-skew-symmetric matrices	60
	2.8	H-self-adjoint pencils	62
	2.9	H-unitary pencils	64
	2.10	Exercises	68
	2.11	Notes	70

3	SKI	EW-SYMMETRIC SCALAR PRODUCTS
	3.1	Definitions and basic properties
	3.2	H-skew-symmetric matrices
	3.3	Invariant neutral subspaces
	3.4	Connections between sign characteristics
	3.5	Skew-symmetric and orthogonal pencils
	3.6	Exercises
	3.7	Notes
4	MA	TRIX THEORY AND CONTROL
	4.1	Controllable pairs
	4.2	Observable pairs
	4.3	Two characterizations of controllable pairs
	4.4	Stabilizable and detectable pairs
	4.5	The control normal form
	4.6	Real matrix pairs
	4.7	Exercises
	4.8	Notes
5	LIN	EAR MATRIX EQUATIONS
	5.1	The Kronecker product
	5.2	Linear equations in matrices
	5.3	Lyapunov and symmetric Stein equations
	5.4	Continuous and analytic dependence
	5.5	Notes
6	RA'	TIONAL MATRIX FUNCTIONS
	6.1	Realizations of rational matrix functions
	6.2	Partial multiplicities and minimal realizations
	6.3	Locally minimal realizations
	6.4	Minimal factorization for rational matrix functions
	6.5	Nonnegative rational matrix functions
	6.6	Rational matrix functions which are hermitian on the unit circle
	6.7	The real case
	6.8	Exercises
	6.9	Notes

PART	II CONTINUOUS ALGEBRAIC RICCATI EQUATIONS	147
7 GE	COMETRIC THEORY: THE COMPLEX CASE	
7.1	Solutions and invariant subspaces	149
7.2		
	semidefinite subspaces	151
7.3	Existence of hermitian solutions and partial multiplicities	158
7.4	Special and hermitian solutions	167
7.5	Extremal solutions	168
7.6	3 Partial order	177
7.7	Continuity	184
7.8	Analyticity	189
7.9	Relaxing the controllability condition	192
7.1	0 The LQR form and matrix pencils	200
7.1	A Appendix: the metric space of subspaces	205
7.1	1 Exercises	210
7.1	2 Notes	212
8 GI	COMETRIC THEORY: THE REAL CASE	215
8.1	Solutions and invariant subspaces	215
8.2	Existence of symmetric solutions	221
8.3	Special and extremal symmetric solutions	222
8.4	Partial order, continuity, and analyticity	223
8.5	Relaxing the controllability assumption	226
8.6	The pencil approach	227
8.7	Exercises	228
8.8	8 Notes	229
	ONSTRUCTIVE EXISTENCE AND COMPARISON IEOREMS	231
9.1	Comparison theorems	231
9.2	The rate of convergence	236
9.3	Stabilizing and almost stabilizing solutions	238
9.4	The second secon	241
9.5	The real case	244
9.6		244
9.7	Notes	245

10	HERMITIAN SOLUTIONS AND FACTORIZATIONS OF RATIONAL MATRIX FUNCTIONS	247
	10.1 Nonnegative rational matrix functions	247
	10.2 The real case	253
	10.3 Notes	256
11	PERTURBATION THEORY	257
	11.1 Existence of hermitian solutions	257
	11.2 Extremal solutions: continuous dependence	260
	11.3 Extremal solutions: analytic dependence	263
	11.4 The real case	266
	11.5 Exercises	266
	11.6 Notes	267
PA	RT III DISCRETE ALGEBRAIC	
	RICCATI EQUATIONS	269
12	GEOMETRIC THEORY FOR THE DISCRETE	
12	ALGEBRAIC RICCATI EQUATION	271
	12.1 Preliminaries	271
	12.2 Hermitian solutions and invariant Lagrangian subspaces	273
	12.3 Description of solutions in terms of invariant subspaces	280
	12.4 Positive definiteness of Ψ and existence of hermitian solutions	283
	12.5 Relaxing the controllability condition	291
	12.6 A more general DARE	295
. 610	12.7 The real case	301
	12.8 Exercises	303
	12.9 Notes	306
	the family integral was leading to the family of the famil	HA
13	CONSTRUCTIVE EXISTENCE AND COMPARISON	207
	THEOREMS	307
	13.1 Existence of maximal hermitian solutions	307
	13.2 The rate of convergence	313
	13.3 Comparison theorems	315
	13.4 Inequalities for partitioned matrices	319
	13.5 Stabilizing and positive semidefinite solutions	324
	13.6 Exercises 13.7 Notes	327 327
	10.4 NOLES	321

14	PERTURBATION THEORY FOR DISCRETE	
	ALGEBRAIC RICCATI EQUATIONS	329
	14.1 Existence of hermitian solutions	329
	14.2 Extremal solutions	330
	14.3 Notes	332
15		to h
	AND MATRIX PENCILS	333
	15.1 The DARE and a symplectic matrix pencil	333
	15.2 The DARE and a dilated matrix pencil	336
	15.3 Stabilizing solutions	339
	15.4 The real case	342
	15.5 Exercises	344
	15.6 Notes	345
PA	RT IV APPLICATIONS AND CONNECTIONS	347
16	LINEAR-QUADRATIC REGULATOR PROBLEMS	349
10	16.1 The optimization problem	349
	16.2 Properties of the cost functional	351
	16.3 Finding an optimal control	357
	16.4 The differential and algebraic Riccati equations	359
	16.5 The cost functional for the discrete LQR problem	362
	16.6 Solution of the discrete LQR problem	366
	16.7 Exercises	369
	16.8 Notes	369
	terest vasing legicity	10
17	THE DISCRETE KALMAN FILTER	371
	17.1 Some concepts and results concerning random vectors	372
	17.2 Statement of the problem	375
	17.3 The recursive process	377
	17.4 Discussion	379
	17.5 Time-invariant filters and a Riccati equation	380
	17.6 Properties of the observer system	384
	17.7 Exercises	385
	17.8 Notes	385

18	THE TOTAL LEAST SQUARES TECHNIQUE	387
	18.1 The total least squares problem	388
	18.2 Total least squares with a symmetry constraint	391
	18.3 Notes	395
19	CANONICAL FACTORIZATION	397
	19.1 Canonical factorization in geometric terms	397
	19.2 The real case	403
	19.3 Spectral factorization	404
	19.4 Notes	407
20	H [∞] CONTROL PROBLEMS	409
	20.1 The bounded real lemma	410
	20.2 An H^{∞} control problem with state feedback	412
	20.3 H^{∞} filtering using state estimation	417
258	20.4 Notes	418
21	CONTRACTIVE RATIONAL MATRIX FUNCTIONS	421
	21.1 Realizations of strict contractions	421
	21.2 Inertia of solutions of a "CARE" and poles of strict contractions	426
	21.3 Relaxing the minimality of realizations	428
	21.4 Minimal unitary completions	430
	21.5 The real case	433
	21.6 Notes	435
22	THE MATRIX SIGN FUNCTION	437
	22.1 Matrix sign function: definition and basic properties	438
	22.2 Connection with the Riccati equation	440
	22.3 The sign function and the DARE	444
	22.4 The real case	445
	22.5 Exercises	446
	22.6 Notes	446

23 STRUCTURED STABILITY RADIUS	447
23.1 Basic properties of the structured stability radius	448
23.2 The Hamiltonian matrix	451
23.3 Connection with the Riccati equation	453
23.4 Exercises	457
23.5 Notes	457
BIBLIOGRAPHY	459
LIST OF NOTATION AND CONVENTIONS	473
INDEX	477