

Contents

1	REVIEW OF PROBABILITY	1
1.1	Introduction	1
1.2	Sample Space, Events, and Basic Concepts of Probability	1
1.3	Conditional Probability, Total Probability, Bayes' Theorem, and Statistical Independence	2
1.4	Random Variables and Probability Distribution and Density Functions	4
1.5	Functions of Random Variables	10
1.6	Some Useful Definitions and Concepts	16
1.7	Normal Distributions and Characteristic Equations	25
1.8	The Characteristic Function	29
1.9	Definition Extended to Random Vectors	30
	Exercises	33
2	STOCHASTIC PROCESSES	36
2.1	Introduction	36
2.2	Definitions and Examples	36
2.3	First-Order Statistics	40
2.4	Second and Higher Order Statistics	45
2.5	Stationary Processes	48
2.6	Continuity and Differentiability	53
2.7	Ergodicity and Stochastic Integrals	56
2.8	Stochastic Integrals in Quadratic Mean	56
2.9	Definition of Ergodicity	63
2.10	Special Processes with Independent Increments	64
	Exercises	70
3	POWER SPECTRUM OF STATIONARY PROCESSES	74
3.1	Classification of Systems	74
3.2	Frequency Spectra and Fourier Transforms	80

3.3	Power Spectra	83
3.4	Major Result	93
3.5	Input-Output Relations	95
3.6	Input-Output of Multiple Terminals	97
3.7	Sampling Theorem	100
3.8	Summary of Some Useful Results	107
3.9	Ideal Low-Pass Signals	108
3.10	Representation of Band-Pass Processes	110
	Exercises	117
4	ESTIMATION THEORY	120
4.1	Introduction	120
4.2	Systems and Modeling	121
4.3	Mean-Square Estimation	123
4.4	Linear Estimate	126
4.5	Orthogonality Principle	128
4.6	Linear Mean-Square Estimate of Continuous Stochastic Signals	134
4.7	The Wiener-Kolmogorov Theory	135
4.8	Optimum Causal Systems	145
4.9	Matched Filtering	154
4.10	Kalman-Bucy Filtering	157
4.11	Combination of Unbiased Estimators	183
4.12	Discrete Smoothing	184
4.13	Nonlinear Estimation	185
4.14	Reformulation of Kalman Filtering	190
4.15	Discussion and Concluding Remarks	191
	Exercises	193
5	APPLICATION OF ESTIMATION THEORY TO IMAGE RESTORATION	202
5.1	Introduction	202
5.2	Spectral Factorization	204
5.3	Recursive Image Estimation	208
5.4	Partial Randomization	228
5.5	Conclusions	243
APPENDICES		
A.	Dirac Delta Function	244
B.	Vector Spaces and Matrices	249

C.	Fourier and Bilateral Laplace Transforms and Their Inversions	263
D.	A Special Vector Space	271
E.	State Variables	276
REFERENCES		283
INDEX		289