

CONTENTS

Chapter 1 Preliminaries	1
1.1 Lattice Random Variables	2
1.2 Addition of Random Variables: Convolutions	4
1.3 Other Useful Distributions	9
1.4 Laplace Transform	11
1.5 On Certain Functions Used in Queueing Theory	16
1.6 Partial Differential Equations	20
Problems and Complements	21
References	32
Chapter 2 Some Techniques of Queueing Theory	34
2.1 Basic Material in Queues	34
2.2 Techniques and History of Analysis	40
2.3 Basic Renewal Theory	72
2.4 Overview	84
Problems and Complements	84
Miscellaneous Problems and Complements	97
References	104
Chapter 3 Bulk-Arrival Queues	107
3.1 The System $M^X/E_J/1$	107
3.2 The System $GI^r/M/1$	116
3.3 The System $M^x/M/1$	122
3.4 The System $M^X/G_n/1$	127
3.5 The System $E_k^X/E_r/1$ with Generalized Erlang Input	133
3.6 The System $M_1^{X_1}, M_2^{X_2}/G_1, G_2/1$	140
3.7 Overview	150
Problems and Complements	151
Miscellaneous Problems and Complements	167
References	175

Chapter 4 Bulk-Service Queues	179
4.1 The System $M/G^B/1$	180
4.2 The System $M/G^B/1/M$ with Customers Served in Batches of Variable Capacity	186
4.3 The System $M/G^k/1$ with Customers Served in Batches of Exactly Size k	191
4.4 The System $GEOM/G^B/1$	193
4.5 The System $M/M^B/1/MB$	198
4.6 Overview	202
Problems and Complements	203
Miscellaneous Problems and Complements	216
References	232
Chapter 5 Multichannel Bulk Queues	237
5.1 The System $M^X(t)/M/\infty$ with the Input Rate $\lambda(t)$	237
5.2 The System $M^X/M/c$	240
5.3 The System $M^X/D/c$	252
5.4 The System $D^s/M/c$	258
5.5 The System $M/M^B/c$	261
5.6 The System $GI/M^B/c$	267
5.7 Overview	275
Problems and Complements	275
References	292
Chapter 6 Relations Among Queueing Systems	295
6.1 The System $GI^r/E/1$	296
6.2 The System $GI/E_r/1$	302
6.3 Relationship between $GI/E_r/1$ and $GI^r/E/1$	304
6.4 The System $E/G^k/1$	309
6.5 The System $E_k/G/1$	316
6.6 Relationship between $E_k/G/1$ and $E/G^k/1$	317
6.7 Expected Busy and Idle Periods	322
6.8 Overview	325
Problems and Complements	326
Miscellaneous Problems and Complements	334
References	340
Appendices	
A.1 Differentiation of a Definite Integral with Respect to a Parameter	342
A.2 Fundamental Lemma of Branching Process Theory	342
A.3 Transform Inversion and Residue Calculus	343

A.4	Generalized Argument Principle	344
A.5	Rouché's Theorem	345
A.6	Lagrange's Theorem	345
A.7	The Riemann–Stieltjes Integral and the Laplace–Stieltjes Transform	345
A.8	Some Theorems on Laplace–Stieltjes Transform and Generating Functions	349
A.9	Linear Difference Equations with Constant and Variable Coefficients	350
A.10	Inversion of a Discrete Transform	351
	References	352
B	Bulk-Arrival, Bulk-Service Queues	353
	References	353
C	Glossary of Symbols	356
	AUTHOR INDEX	363
	SUBJECT INDEX	367