List of Figures

Figure 1.1 Model of a Simple Queue	1
Figure 2.1 State Transition from State A	10
Figure 2.2 Classification of States for a Markov Chain	13
Figure 2.3 State Transition Diagram for a Birth-Death	16
Process	
Figure 2.4 Graphical Verification of Little's Result	22
Figure 2.5 Arrival/Departure of a Customer of Interest	37
from a FCFS M/M/1 Queue	
Figure 2.6 A Network of M/M/m Queues with Probabilistic	39
Routing	
Figure 2.7 Single Sever Queue with Two Stages of Service	42
Figure 2.8 State Transition Diagram for Single Sever Queue	42
with Two Stages of Service	
Figure 2.9 Generalised Service in Stages of a Single Server	44
Queue	
Figure 3.1 A M/G/1 Queue	57
Figure 3.2 Residual Service Time $r(t)$ as a Function of t	58
Figure 3.3 Arrival Process Illustrating the Paradox of	61
Residual Life	
Figure 3.4a Departure Leaves System Non-Empty	64
Figure 3.4b Departure Leaves System Empty	65
Figure 3.5 Time Instants of Arrival and Departure for a	71
Customer in a FCFS M/G/1 Queue	
Figure 3.6 Unfinished Work in a M/G/1 Queue	73
Figure 3.7 Customer Arrival and Departure from a LCFS	77
M/G/1 Queue	
Figure 3.8 Actual Lifetime and Residual Lifetime	83

Figure 4.1 Residual Time $r(t)$ for a M/G/1 Queue with Vacations	91
Figure 4.2 M/G/1 Oueue with Head of Line Priority	106
Figure 4.3 Server Available/Unavailable Intervals for	115
Class 1 Customers	
Figure 4.4 Class 1 Departure Leaving Class 1 Queue	118
Figure 4.5 Class 1 departure Leaving Class 1 Queue Empty	122
Figure 4.6 Late Arrivel Model of a Discrete Time Queue	122
Figure 4.0 Late Arrival Model of a Discrete Time Queue	129
Figure 4.7 Early Annual Model of a Discrete Time Queue	129
Figure 5.1 An Open Queueing Network	144
Figure 5.2 A Closed Quedeling Network	144
Figure 5.3 Probabilistic Routing in a Queueing Network	148
Figure 5.4 Probabilistically Splitting a Poisson Process	149
Figure 5.5 Combining Poisson Processes	150
Figure 5.6 A Feedforward Open Network of M/M/m Queues	151
Figure 5.7 Immediate Feedback to a Queue	154
Figure 5.8 Open Queueing Network of Example 1	157
Figure 5.9 Open Queueing Network of Example 2	158
Figure 5.10 Open Queueing Network of Example 3	160
Figure 5.11 A Closed Network with <i>M</i> Jobs	167
Figure 5.12 A Closed Queueing Network of Single	181
Server Queues, M=4	
Figure 5.13 Original Queueing Network Before Reduction	185
Figure 5.14 Equivalent Network with Flow Equivalent	186
Server	
Figure 5.15 Network to Obtain the Flow Rate $T(j)$	186
of the FES with <i>j</i> Jobs in the Network	
Figure 5.16 Open Queueing Network of Problem 3	189
Figure 5.17 Closed Oueueing Network for Problem 8	191
Figure 5.18 Closed Queueing Network of Problem 9	192
Figure 6.1 Superposition and Splitting in a Queueing	199
Network	
Figure 6.2 Queue with Immediate Feedback	201
Figure 6.3 Queue after Removal of Immediate Feedback	202
Figure 6.4 Internal Flow Parameter Calculations	202
Figure 6.5 Fork/Join Node without Synchronising Oueues	204
Figure 6.6 Fork/Join Node with Synchronising Queues	212
Figure 6.7 Blocking in a Queueing Network with	212 210
Figure 0.7 Diocking in a Queueing Network with	219
Finite Capacity Queues	222
Figure 0.6 Wrapping the State Space for Closed	223
Network with Transfer Blocking	

Figure 6.9 Open Queueing Network with Transfer	246
Blocking	
Figure 6.10 Queueing Network with Transfer Blocking	248
Figure 6.11 Holding Nodes for Jobs	249
Figure 7.1 Simulation Model of a Real System	258
(Continuous or Discrete States)	
Figure 7.2 Continuous State, Continuous Time	262
Simulations (Level of Water in a Tank)	
Figure 7.3 Discrete State, Continuous Time System	262
(Number of Jobs in a Queue)	
Figure 7.4 Inserting a New Event in the Event List	264
Figure 7.5 An Example of an Open Queueing Network	266
Figure 7.6 Example of an Observation-Based Random	269
Variable (Time W_i Spent in a Queue by the Job i)	
Figure 7.7 Example of an Time-Weighted Random Variable	271
(Number in a Queue as a Function of Time)	
Figure 7.8 Confidence Estimation with Confidence	272
Intervals and Confidence Levels	
Figure 7.9 Transient Behaviour in a Simulation Run	274
Figure 7.10 The Subinterval Method or The Method	276
of Batch Means	
Figure 7.11 The Regenerative Method of Choosing	277
Independent Batches	
Figure 7.12 The Replication Method	278