CONTENTS

Preface	vii
1. Introduction to Operations Research	1
1.1 The Nature and History of Operations Research	1
1.2 The Main Elements of Operations Research	4
1.3 The Modeling Process	ç
2. Linear Programming	13
2.1 Introduction to Linear Programming	13
2.2 Applications of Linear Programming	18
2.2.1 Production Planning	18
2.2.2 Diet Problems	20
2.2.3 Allocation Problems	28
2.2.4 Employee Scheduling	32
2.2.5 Dynamic Production-Inventory Models	35
2.2.6 Blending Problems	39
2.2.7 Transportation and Assignment Problems	43
Exercises	50
2.3 Graphical Representation and Solution	60
2.3.1 The Graphical Solution Method	60
2.3.2 Special Cases of Linear Programming Problems	70
Exercises	76
2.4 Postoptimality Analyses	78
2.4.1 Graphical Sensitivity Analyses	78
2.4.2 Economic Analysis of an Optimal Solution	92
Exercises	100
2.5 Duality	105
Exercises	112

3. Multiobjective Programming	115
3.1 Vector Optimization	116
3.2 Solution Approaches to Vector Optimization Problems	121
3.3 Goal Programming	124
Exercises	129
A YeArman Day and the	
4. Integer Programming	135
4.1 Definitions and Basic Concepts	135
4.2 Applications of Integer Programming	140
4.2.1 Cutting Stock Problems	142
4.2.2 Diet Problems Revisited	146
4.2.3 Land Use	148
4.2.4 Modeling Fixed Charges	150
4.2.5 Workload Balancing	152
4.3 Solution Methods for Integer Programming Problems	154
4.3.1 Cutting Plane Methods	154
4.3.2 Branch-and-Bound Methods	155
4.3.3 Heuristic Methods	162
Exercises	165
5. Network Models	177
5.1 Definitions and Conventions	177
5.2 Network Flow Problems	179
5.3 Shortest Path Problems	189
5.4 Spanning Tree Problems	198
5.5 Routing Problems	200
Exercises	205
6. Location Models	217
6.1 The Major Elements of Location Problems	217
6.2 Covering Problems	220
6.2.1 The Location Set Covering Problem	221
6.2.2 The Maximal Covering Location Problem	227
6.3 Center Problems	230
6.3.1 1-Center Problems	231
6.3.2 <i>p</i> -Center Problems	233
6.4 Median Problems	235
6.4.1 Minisum Problems in the Plane	235
6.4.2 Minisum Problems in Networks	240
6.5 Other Location Problems	244
Exercises	247
LACICISCS	2.,
7. Project Networks	257
7.1 The Critical Path Method	258
7.2 Project Acceleration	266

Contents xi

7.3 Project Planning with Resources	272
7.4 The PERT Method	275
Exercises	280
8. Machine Scheduling	287
8.1 Basic Concepts of Machine Scheduling	288
8.2 Single Machine Scheduling	290
8.3 Parallel Machine Scheduling	294
8.4 Dedicated Machine Scheduling	297
Exercises	301
9. Decision Analysis	305
9.1 Introduction to Decision Analysis	305
9.2 Visualizations of Decision Problems	307
9.3 Decision Rules Under Uncertainty and Risk	310
9.4 Sensitivity Analyses	316
9.5 Decision Trees and the Value of Information	319
9.6 Utility Theory	327
Exercises	328
10. Inventory Models	339
10.1 Basic Concepts in Inventory Planning	339
10.2 The Economic Order Quantity (EOQ) Model	343
10.3 The Economic Order Quantity with Positive Lead Time	346
10.4 The Economic Order Quantity with Backorders	349
10.5 The Economic Order Quantity with Quantity Discounts	352
10.6 The Production Lot Size Model	355
10.7 The Economic Order Quantity with Stochastic	
Lead Time Demand	357
10.7.1 A Model that Optimizes the Reorder Point	359
10.7.2 A Stochastic Model with Simultaneous Computation	
of Order Quantity and Reorder Point	360
10.8 Extensions of the Basic Inventory Models	362
Exercises	363
11. Stochastic Processes and Markov Chains	367
11.1 Basic Ideas and Concepts	367
11.2 Steady-State Solutions	372
11.3 Decision Making with Markov Chains	373
Exercises	376
12. Waiting Line Models	379
12.1 Basic Queuing Models	380
12.2 Optimization in Queuing	388
Exercises	392

xii	Contents
13. Simulation	395
13.1 Introduction to Simulation	395
13.2 Random Numbers and their Generation	397
13.3 Examples of Simulations	402
13.3.1 Simulation of a Waiting Line System	402
13.3.2 Simulation of an Inventory System	405
Exercises	410
Appendices	
A. Heuristic Algorithms	417
B. Vectors and Matrices	427
C. Systems of Simultaneous Linear Equations	429
D. Probability and Statistics	433
References	441
Subject Index	443