

# Contents

<b>1. Some Mathematical Preliminaries and Convex Sets</b>	<b>1-38</b>
1.1 Introduction	1
1.2 Matrix	1
1.3 Type of Matrices	1
1.4 Operation on Matrices	3
1.5 Properties of Matrix Addition	5
1.6 Properties of Multiplication of Matrix by a scalar	6
1.7 Multiplication of Matrices	7
1.8 Determinant of a Square Matrix	8
1.9 Properties of Determinants	8
1.10 Evolution of a Determinant by Sarrus diagram	9
1.11 Minors and Cofactors	9
1.12 Singular and Non-Singular Matrix	10
1.13 Transpose of a Matrix	10
1.14 Properties of Transpose of a Matrix	11
1.15 Symmetric Matrix	12
1.16 Skew-symmetric Matrix	12
1.17 Rank of a Matrix	12
1.18 Echelon form of a Matrix	13
1.19 Inverse of a Matrix	14
1.20 Convex Set	17
1.21 Some Related Definitions	17
1.22 Convex Hull	19
1.23 Convex Function and Convex Polyhedron	19
1.24 Feasible and Basic Feasible Solutions	30
<b>2. Linear Programming Problems: Formulation and Graphical solutions</b>	<b>39-94</b>
2.1 Introduction	39
2.2 Basic Terminology of Linear Programming	39
2.3 Basic Requirements of LPP	40
2.4 Basic Assumptions of LP model	40
2.5 Advantage of Linear Programming	40
2.6 Limitations of Linear Programming	41
2.7 Application areas of Linear Programming	41
2.8 Standard form of Linear Programming Problems	42
2.9 Matrix form of LPP	43
2.10 Mathematical Formulation of Linear Programming Problem	43
2.11 Extra Variable needed	44
2.12 Solution of Linear Programming Problem	53
2.13 Graphical solution methods of an LPP	54
<b>3. Simplex Method</b>	<b>95-160</b>
3.1 Introduction	95
3.2 Terminology and Notations	95

3.3	Fundamental Theorem of Linear Programming	96
3.4	Reduction of Feasible Solution to Basic Feasible Solution	98
3.5	To find the Improved Basic Feasible Solution (BFS) from a given BFS	110
3.6	Conditions for the Existence of Unbounded Solutions	112
3.7	Condition for Improved Basic Feasible Solution to become Optimal	113
3.8	Alternative optimal solutions	114
3.9	Inconsistency and Redundancy	114
3.10	Procedure to obtain Initial Basic Feasible Solution	114
3.11	Simplex Algorithm	116
3.12	Simplex Method : Case of minimization	130
3.13	Artificial Variable Technique	130
3.14	Two Phase Method	139
3.15	Some special Linear Programming Problems	144
3.16	Solution of Simultaneous Linear Equations by Simplex Method	153
3.17	Inverse of a Matrix by Simplex Method	155
<b>4.</b>	<b>Degeneracy in Linear Programming</b>	<b>161-174</b>
4.1	Introduction	161
4.2	Degeneracy in Linear Programming	161
4.3	The necessary and Sufficient Condition for the Existence of Non-Degeneracy	161
4.4	Occurance of Degeneracy in Linear Programming	161
4.5	Resolution of Degeneracy	161
<b>5.</b>	<b>Revised Simplex Method</b>	<b>175-216</b>
5.1	Introduction	175
5.2	Standard Form of Revised Simplex Method	175
5.3	Revised Simplex method for Standard form-I	175
5.4	Revised Simplex method for Standard form-II	193
5.5	Comparison of Simplex Method and Revised Simplex Method	213
<b>6.</b>	<b>Duality in Linear Programming</b>	<b>271-252</b>
6.1	Introduction	217
6.2	Relationship Between Prime and Dual	217
6.3	Symmetric Primal-Dual Problems	218
6.4	Dual of an LPP with Mixed Restrictions	220
6.5	Some Results on Duality	231
<b>7.</b>	<b>Dual Simplex Method and Primal-Dual Algorithm</b>	<b>253-272</b>
7.1	Introduction	253
7.2	Dual-Simplex Algorithm	253
7.3	Primal-Dual Algorithm	262
7.4	Steps of Primal-Dual Algorithm	266
<b>8.</b>	<b>Sensitivity Analysis</b>	<b>273-304</b>
8.1	Introduction	273
8.2	Change in the Objective Function Coefficients (price vectors), $c_j$	273
8.3	Variation in the Requirement Vector, $b_i$	282

8.4	Variation in the Elements $a_{ij}$ of the Coefficient Matrix A	289
8.5	Addition of a New Variable	292
8.6	Addition of a New Constraint	292
<b>9.</b>	<b>Parametric Linear Programming</b>	<b>305-332</b>
9.1	Introduction	305
9.2	Parametric Programming	305
9.3	Systematic Variation in the Objective function Coefficients, $c_j$	305
9.4	Systematic Linear variation in $b_i$	323
<b>10.</b>	<b>Integer Programming</b>	<b>333-364</b>
10.1	Introduction	333
10.2	Need of Integer Linear Programming	333
10.3	Types of Integer Linear Programming Problems	333
10.4	Methods to solve an Integer Linear Programming Problem	334
10.5	Problem on Mixed Integer Linear Programming	348
10.6	The Branch and Bound technique	354
<b>11.</b>	<b>The Transportation Problem</b>	<b>365-424</b>
11.1	Introduction	365
11.2	Mathematical Formulation of Transportation Problem	365
11.3	Solution of the Transportation Problem	369
11.4	Test for Optimality	385
11.5	Degeneracy in Transportation Problems	398
11.6	Unbalanced Transportation Problem	405
11.7	Some Miscellaneous Solved Problems	408
<b>12.</b>	<b>Assignment Problems</b>	<b>425-466</b>
12.1	Introduction	425
12.2	Mathematical Representation of Assignment Problem	425
12.3	Difference between Transportation and Assignment Problem	426
12.4	Theorems on Assignment Problem	426
12.5	Solution of Assignment Problem : Hungarian Method	427
12.6	The Maximal Assignment Problem	438
12.7	Unbalanced Assignment Problem	439
12.8	Some Miscellaneous Solved Examples	442
12.9	Travelling Salesman Problem	455
<b>13.</b>	<b>Goal Programming</b>	<b>467-506</b>
13.1	Introduction	467
13.2	Concepts of Goal Programming	467
13.3	Goal Programming Model Formulation	467
13.4	General form of Goal Programming Problem	473
13.5	Method of Solution of a GP Problem	474
<b>■</b>	<b>Bibliography</b>	<b>507</b>
<b>■</b>	<b>Index</b>	<b>509-511</b>