
Contents

<i>Introduction</i>	ix
<i>Notation</i>	xii
1: Basic results	1
1.1 Classical theory	1
1.1.1 Definitions	1
1.1.2 Conditions for unconstrained variables	1
1.1.3 Equality constraints	6
1.2 Inequality constraints	12
1.2.1 General considerations	12
1.2.2 Necessary conditions, Kuhn–Tucker form	13
1.2.3 Convexity, Farkas’ Lemma	15
1.2.4 Abnormal point	18
1.2.5 Sufficient conditions	19
1.3 Duality	22
1.3.1 Saddle-point conditions and duality	23
1.4 Summary of basic results	28
Notes	29
Problems	31
2: Unconstrained optimisation	35
2.1 Line-search methods	35
2.1.1 Dissection methods	35
2.1.2 Fitted polynomial methods	38
2.2 General search methods	40
2.3 Gradient methods	41
2.3.1 Steepest descents	42
2.3.2 Gradient properties of quadratic functions	44
2.3.3 The method of conjugate gradients	46
2.3.4 Powell’s method	49

2.4	Newton and quasi Newton methods	54
2.4.1	Newton's method	54
2.4.2	Davidon–Fletcher–Powell method	56
2.4.3	General considerations on matrix updating methods: the Huang family	59
2.4.4	Common directions for the Huang family	61
2.4.5	The conjugate-gradient algorithm revisited	62
2.4.6	Other methods	63
2.5	Summary of methods	64
	Note	64
	Problems	65
3: Linear programming		70
3.1	Solution of LP problems	70
3.1.1	Statement of the problem	70
3.1.2	Theory of linear problems	71
3.1.3	Simplex method	77
3.1.4	Starting the simplex method	81
3.1.5	Revised simplex method	83
3.1.6	Degeneracy	86
3.2	Duality	86
3.2.1	Duality theorem	86
3.2.2	Lagrange multipliers	90
3.2.3	Dual simplex method	91
3.2.4	Sensitivity and duality	91
	Problems	94
4: Applications of linear programming		98
4.1	Allocation of resources	98
4.2	Transportation problems	100
4.2.1	Definitions, general properties	100
4.2.2	Transportation algorithm	102
4.2.3	Transshipment problems	106
4.2.4	Assignment problems	109
4.2.5	Assignment algorithm	111
4.3	Game theory	116
4.3.1	Definition of problem	117

4.3.2	Determination of optimal strategies	119
4.3.3	Further aspects of game theory	120
4.4	Separable programming	122
	Note	125
	Problems	125
5: Constrained optimisation		132
5.1	General properties of the solution	133
5.2	Projection methods	134
5.2.1	Some projections	134
5.2.2	Method of solution of inequality-constrained problems using projection	139
5.2.3	Projection methods – examples	142
5.3	Quadratic programming	145
5.3.1	Modified simplex method	145
5.3.2	Projected Newton method	146
5.4	Application of projection methods to nonlinear constraints	147
5.5	Penalty function and multiplier methods	150
5.5.1	Sequential unconstrained minimisation	150
5.5.2	Lagrangian methods	156
5.6	Summary of methods of constrained optimisation	163
	Problems	163
	<i>Hints and answers to problems</i>	168
	<i>References</i>	175
	<i>Index</i>	178