

Contents

Notation	ix
1 Extrema of a Function of One Variable	
1.1 Extreme points	1
1.2 Necessary and sufficient conditions	2
1.3 Taylor's formula for one variable	3
1.4 Necessary condition for an extremum	4
1.5 Sufficient condition for an extremum	5
1.6 Necessary and sufficient condition for an extremum	10
1.7 Remarks	11
Exercises	11
2 Extrema of a Function of Two or More Variables (without Constraint)	
2.1 Necessary condition	13
2.2 Taylor's formula for a function of two variables— necessary condition	13
2.3 Sufficient condition for a function of two variables	15
2.4 Sufficient condition for a function $f(x_1, x_2, \dots, x_n)$ of n variables	21
Exercises	27
3 Functions of Two or More Variables (with Constraint)	
3.1 Preliminary	29
3.2 Necessary condition	30
3.3 Sufficient condition	32
3.4 Examples	37
Exercises	49
4 Simultaneous Maxima of Several Functions	
4.1 Statement of the problem	51
4.2 Graphic interpretation	53
4.3 Necessary conditions for Pareto optimality in production, consumption, and the economy	56

4.4 Pareto optimality in general	60
Exercises	62
5 Linear Programming	
5.1 General nature of linear programming problems	64
5.2 Some geometric and algebraic interpretations	69
5.3 The simplex method	81
5.4 Complications and adjustments	88
5.5 Solving a minimization problem	97
5.6 Assumptions of linear programming	99
Exercises	100
6 Linear Programming—Duality and Sensitivity Analysis	
6.1 Duality	102
6.2 Proofs of some theorems	112
6.3 Economic interpretation of duality	114
6.4 Dual simplex method	117
6.5 Sensitivity analysis	118
Exercises	127
7 Nonlinear Programming	
7.1 General nonlinear programming problems	128
7.2 The Kuhn–Tucker conditions	131
7.3 Further look at the Kuhn–Tucker conditions	134
7.4 Quadratic programming	142
7.5 Separable functions	152
7.6 Some economic applications of the Kuhn–Tucker conditions	159
Exercises	165
8 Optimal Control	
8.1 The control problem and some terminology	167
8.2 The classical calculus of variations	171
8.3 The maximum principle (modern calculus of variations)	183
8.4 Maximum principle—the costate variables and constraints	191
8.5 Dynamic programming	193
8.6 Dynamic programming and the calculus of variations	201
8.7 Stochastic and adaptive controls	204
Exercises	204
Appendix I	
Quadratic Forms and Characteristic Roots	208
Appendix II	
Convexity and Quasiconvexity	210
Bibliography	212
Index	217