

	Preface	xiii
<b>Chapter 1</b>	<b>Basic Concepts</b>	<b>1</b>
1-1	Introduction	1
1-2	Optimization Concepts	4
1-3	General Problem Statement	9
1-4	The Iterative Optimization Procedure	10
1-5	Existence and Uniqueness of an Optimum Solution	12
	1-5.1 Unconstrained Problems	12
	1-5.2 Constrained Problems	14
	1-5.3 The Kuhn-Tucker Conditions	17
1-6	Concluding Remarks	19
	1-6.1 Advantages of Using Numerical Optimization	20
	1-6.2 Limitations of Numerical Optimization	20
	1-6.3 Summary	20
	References	21
	Problems	21
<b>Chapter 2</b>	<b>Functions of One Variable</b>	<b>24</b>
2-1	Introduction	24
2-2	Polynomial Approximations	26
	2-2.1 Polynomial Coefficients	30
	2-2.2 The Zero of a Polynomial	32
	2-2.3 The Minimum or Maximum of a Polynomial	36
2-3	Golden Section Method	41
	2-3.1 The Golden Section Algorithm	43
	2-3.2 The Maximum or Zero of a Function	45
2-4	Finding Bounds on the Solution	49
	2-4.1 Bounds on $F = 0$	50
	2-4.2 Bounds on the Minimum of $F$	52

2-5	Constrained Functions of One Variable	54
2-5.1	The Direct Approach	55
2-5.2	The Indirect Approach	56
2-6	A General Strategy for Minimizing Functions of One Variable	58
2-6.1	Unconstrained Functions	59
2-6.2	Constrained Functions—Initially Feasible	62
2-6.3	Constrained Functions—Initially Infeasible	62
2-7	Summary	64
	References	68
	Problems	68
<b>Chapter 3</b>	<b>Unconstrained Functions of <math>N</math> Variables</b>	<b>71</b>
3-1	Introduction	71
3-1.1	Search Methods	73
3-1.2	General Optimization Strategy	75
3-1.3	The Optimization Algorithm	78
3-2	Zero-Order Methods	79
3-2.1	Random Search	80
3-2.2	Powell's Method	84
3-2.3	Other Zero-Order Methods	87
3-3	First-Order Methods	88
3-3.1	Steepest Descent	88
3-3.2	The Conjugate Direction Method	89
3-3.3	Variable Metric Methods	92
3-4	Second-Order Methods: Newton's Method	93
3-5	Scaling of the Variables	97
3-6	Convergence Criteria	100
3-6.1	Maximum Number of Iterations	100
3-6.2	Absolute or Relative Change in the Objective Function	100
3-6.3	The Kuhn-Tucker Conditions	101
3-6.4	The Convergence Algorithm	101
	References	102
	Problems	103
<b>Chapter 4</b>	<b>Constrained Functions of <math>N</math> Variables: Linear Programming</b>	<b>104</b>
4-1	Introduction	104
4-2	Standard Linear Programming Form	105
4-2.1	Matrix Form of the Linear Programming Problem	106
4-3	Possible Solutions to the Linear Programming Problem	108
4-4	The Simplex Method	110
4-4.1	The Simplex Algorithm	115
4-5	Some Applications of Linear Programming	116
	References	119
	Problems	119

<b>Chapter 5</b>	<b>Constrained Functions of <math>N</math> Variables: Sequential Unconstrained Minimization Techniques</b>	121
5-1	Introduction	121
5-2	The Exterior Penalty Function	123
5-3	The Interior Penalty Function	128
5-4	The Extended Interior Penalty Function	132
5-4.1	The Linear Extended Penalty Function	132
5-4.2	The Quadratic Extended Penalty Function	132
5-4.3	The Variable Penalty Function	134
5-5	Scaling of the Constraints	136
5-6	Picking the Initial Penalty Parameter	137
5-7	A Note on the One-Dimensional Search	138
5-8	The Augmented Lagrange Multiplier Method	140
5-8.1	Equality-Constrained Problems	140
5-8.2	Inequality-Constrained Problems	145
5-8.3	The General Constrained Optimization Problem	146
	References	150
	Problems	151
<b>Chapter 6</b>	<b>Constrained Functions of <math>N</math> Variables: Direct Methods</b>	153
6-1	Introduction	153
6-2	Random Search	153
6-3	Sequential Linear Programming	155
6-4	The Method of Centers	157
6-5	The Method of Feasible Directions	163
6-5.1	Dealing with Initially Infeasible Designs	171
6-5.2	Search Direction Modification	172
6-5.3	Equality Constraints	175
6-6	The Generalized Reduced Gradient Method	177
6.6.1	Dealing with Initially Infeasible Designs	184
6.6.2	Discussion	185
6-7	A Robust Feasible Directions Method	186
6-7.1	The Search Direction	187
6-7.2	Equality Constraints	189
6-7.3	The One-Dimensional Search	191
6-7.4	Initially Infeasible Designs	192
6-7.5	Infrequent Gradient Calculations	193
6-7.6	Discussion	195
6-8	Sequential Quadratic Programming	195
	References	201
	Problems	202
<b>Chapter 7</b>	<b>Approximation Techniques</b>	204
7-1	Introduction	204
7-2	Design Variable Linking	205

7-3	The Reduced Basis Concept	208
7-4	Formal Approximations	211
7-5	Constraint Deletion	215
7-6	Sensitivity of the Optimum Design to Problem Parameters	217
7-6.1	Sensitivity Analysis Using the Kuhn-Tucker Conditions	217
7-6.2	Sensitivity Analysis Using the Concept of a Feasible Direction	220
	References	225
	Problems	225
<b>Chapter 8</b>	<b>Duality</b>	<b>227</b>
8-1	Introduction	227
8-2	Basic Concepts	227
8-2.1	Convex Sets	228
8-2.2	Convex and Concave Functions	230
8-2.3	The Lagrangian and the Kuhn-Tucker Conditions	233
8-2.4	Saddle Points	233
8-2.5	The Max-Min Problem	235
8-3	The Primal and Dual Problems	236
8-4	Computational Considerations	237
8-5	Applications of Duality	238
8-5.1	Duality in Linear Programming	238
8-5.2	Duality Applied to Structural Optimization	241
8-5.3	General Use of Duality in Nonlinear Optimization	246
	References	248
	Problems	249
<b>Chapter 9</b>	<b>Structural Optimization</b>	<b>250</b>
9-1	Introduction	250
9-2	The Finite-Element Method	251
9-3	Gradient Computations	255
9-4	Structural Design	258
9-4.1	Fully-Stressed Design	258
9-4.2	Approximation Techniques	260
9-5	Truss Structures	263
9-5.1	Design of Trusses of Specified Geometry	264
9-5.2	Design of Trusses, Including Configuration Variables	267
9-6	Design of General Structures of Fixed Configuration	271
9-6.1	Membrane and Shear Structures	272
9-6.2	Continuum Structures	274
9-6.3	Composite Structures	277
9-7	Summary	279
	References	279
<b>Chapter 10</b>	<b>General Design Applications</b>	<b>283</b>
10-1	Introduction	283
10-2	Aerodynamic Shape Optimization	283
10-2.1	Wing Aerodynamic Optimization	291

10-3	Machine Components	293
	10-3.1 Design of Isotropic and Composite Driveshafts	293
	10-3.2 Design of Internal-Expanding Brakes	296
	10-3.3 Design of Helical Gears	298
10-4	Probabilistic Design	300
10-5	Optimization Using Experimental Data	304
10-6	Design of Heat Exchangers and Steam Condensers	306
10-7	Aircraft and Ship Synthesis	309
	10-7.1 Aircraft Synthesis	310
	10-7.2 Ship Synthesis	316
10-8	Summary	317
	References	317
	<b>Indexes</b>	321
	Name Index	
	Subject Index	