

CONTENTS

Preface / vii

1. INTRODUCTION

Perspective / 1
Formulation of Optimization Problems / 2
Topics in Optimization / 3
Method of Attack / 6
Summary / 8
References / 8

2. CLASSICAL THEORY OF MAXIMA AND MINIMA

Introduction / 10
Locating Local Maxima and Minima (Necessary Conditions) / 12
Evaluating Local Maxima and Minima (Sufficient Conditions) / 12
Sufficient Conditions for One Independent Variable / 13
Sufficient Conditions for Two Independent Variables / 15
Sign of a Quadratic Form / 16
Sufficient Conditions for N Independent Variables / 16
Analytical Methods Applicable for Constraints / 20
Direct Substitution / 22
Constrained Variation / 22
Lagrange Multipliers / 26
Method of Steepest Ascent / 31
Economic Interpretation of the Lagrange Multipliers / 35
Inequality Constraints / 36
Necessary and Sufficient Conditions for Constrained Problems / 39
Closure / 51
References / 52
Problems / 53

3. GEOMETRIC PROGRAMMING

Introduction / 58
Optimization of Posynomials / 59
Optimization of Polynomials / 68
Closure / 73

References / 74

Problems / 75

4. LINEAR PROGRAMMING

Introduction / 80

Concepts and Geometric Interpretation / 81

General Statement of the Linear Programming Problem / 84

Slack and Surplus Variables / 86

Basic and Basic Feasible Solutions of the Constraint Equations / 86

Optimization with the Simplex Method / 87

Simplex Tableau / 94

Mathematics of Linear Programming / 96

Degeneracy / 99

Artificial Variables / 103

Formulating the Linear Programming Problem—A Simple Refinery / 106

Solving the Linear Programming Problem for the Simple Refinery / 115

Sensitivity Analysis / 123

Changes in the Right Hand Side of the Constraint Equation / 127

Changes in the Coefficients of the Objective Function / 129

Changes in the Coefficients of the Constraint Equations / 134

Addition of New Variables / 140

Addition of More Constraint Equations / 140

Closure / 144

Selected List of Texts on Linear Programming and Extensions / 145

References / 146

Problems / 146

5. SINGLE-VARIABLE SEARCH TECHNIQUES

Introduction / 160

Search Problems and Search Plans / 160

Unimodality / 162

Reducing the Interval of Uncertainty / 163

Measuring Search Effectiveness / 164

Minimax Principle / 168

Simultaneous Search Methods / 170

Sequential Search Methods / 176

Fibonacci Search / 176

Golden Section Search / 185

Lattice Search / 188

Open Initial Interval / 190

Other Methods / 194

Closure / 196

References / 197

Problems / 198

6. MULTIVARIABLE OPTIMIZATION PROCEDURES

Introduction / 203

Multivariable Search Methods Overview / 205

Unconstrained Multivariable Search Methods / 207

Quasi-Newton Methods / 209

Conjugate Gradient and Direction Methods / 222

Logical Methods / 232

Constrained Multivariable Search Methods / 235

Successive Linear Programming / 236

Successive Quadratic Programming / 244

Generalized Reduced Gradient Method / 252

Penalty, Barrier and Augmented Lagrangian Functions / 263

Other Multivariable Constrained Search Methods / 271

Comparison of Constrained Multivariable Search Methods / 278

Stochastic Approximation Procedures / 282

Closure / 284

FORTTRAN Program for BFGS Search of an Unconstrained
Function / 285

References / 292

Problems / 295

7. DYNAMIC PROGRAMMING

Introduction / 303

Variables, Transforms, and Stages / 316

Serial System Optimization / 318

Initial Value Problem / 319

Final Value Problem / 320

Two-Point Boundary Value Problem / 323

Cyclic System Optimization / 324

Branched Systems / 327

Diverging Branches / 327

Converging Branches / 329

Procedures and Simplifying Rules / 334

Application to the Contact Process—A Case Study / 336

Brief Description of the Process / 336

Dynamic Programming Analysis / 338

Results / 342

Optimal Equipment Replacement—Time as a Stage / 343

Optimal Allocation by Dynamic Programming / 350

Closure / 354

References / 355

Problems / 355

8. CALCULUS OF VARIATIONS

Introduction / 365

Functions, Functionals and Neighborhoods / 365

Euler Equation / 366

More Complex Problems / 374

Functional with Higher Derivatives in the Integrand / 374

Functional with Several Functions in the Integrand / 377

Functional with Several Functions and Higher Derivatives / 379

Functional with More than One Independent Variable / 380

Constrained Variational Problems / 384

Algebraic Constraints / 384

Integral Constraints / 386

Differential Equation Constraints / 387

Closure / 391

References / 394

Problems / 395

Answers to Exercises / 400

Author Index / 409

Subject Index / 413

