

CONTENTS

| | |
|---|-----------|
| CHAPTER ONE. SYSTEMS: ORIGIN AND EVOLUTION, TERMS AND CONCEPTS | 1 |
| 1.1. Introduction | 1 |
| 1.2. The Origin and Evolution of Systems Science | 2 |
| 1.3. Systems Terms and Concepts | 6 |
| 1.3.1. Introduction | 6 |
| 1.3.2. Terms and Concepts | 7 |
| 1.4. Conclusion | 16 |
| Problems | 16 |
| | |
| CHAPTER TWO. SYSTEMS AND COMPLEXITY | 19 |
| 2.1. Introduction | 19 |
| 2.2. Coming to Grips with Complexity | 20 |
| 2.2.1. Systems and People | 20 |
| 2.2.2. Parts and Relationships, Notions and Perceptions | 21 |
| 2.2.3. Nonlinearity, Asymmetry, and Nonholonomic Constraints | 25 |
| 2.2.4. Hierarchy and Emergence | 28 |
| 2.2.5. Aesthetic Measures—An Illustrative Example | 29 |
| 2.3. Two-Dimensional Science | 31 |

| | |
|--|----|
| 2.4. One Dimension beyond Three Ranges of Complexity | 31 |
| 2.5. Conclusion | 32 |
| Problems | 33 |

**CHAPTER THREE. SYSTEMS AND MODELING I:
DIAGRAMS AND IDENTIFICATION 35**

| | |
|---|----|
| 3.1. Introduction | 35 |
| 3.2. Misuse and Abuse | 38 |
| 3.3. System Diagrams | 39 |
| 3.3.1. Graphs | 39 |
| 3.3.2. Block Diagrams | 44 |
| 3.3.3. Soft System Diagrams | 45 |
| 3.4. Other Useful Diagrams | 46 |
| 3.4.1. Unit Diagrams | 46 |
| 3.4.2. Rich Pictures | 48 |
| 3.4.3. Decision Flow Diagrams | 51 |
| 3.4.4. Hierarchical Representations | 51 |
| 3.5. Hard System Diagrams and Messy Situations | 53 |
| 3.6. Element, Relationship, and Boundary Identification | 54 |
| 3.6.1. Introduction | 54 |
| 3.6.2. Data Filtering for Information Production | 55 |
| 3.6.3. System Identification | 56 |
| 3.7. Conclusion | 59 |
| Problems | 60 |

CHAPTER FOUR. SYSTEMS AND MEASUREMENT 63

| | |
|---|----|
| 4.1. Introduction | 63 |
| 4.2. The Nature of Measurement | 64 |
| 4.2.1. Numerals, Numbers, and Other Symbols | 64 |
| 4.2.2. Assignment | 64 |
| 4.2.3. Rules | 64 |
| 4.3. Scales of Measurement | 65 |
| 4.3.1. Introduction | 65 |
| 4.3.2. The Scales | 66 |
| 4.4. Problems Associated with Measurement | 68 |
| 4.4.1. Introduction | 68 |
| 4.4.2. Content Validity | 69 |
| 4.4.3. Empirical Validity | 69 |
| 4.4.4. Construct Validity | 70 |
| 4.4.5. The Experiential Approach | 70 |
| 4.5. Conclusion | 71 |
| Problems | 71 |

**CHAPTER FIVE. SYSTEMS VIEW OF MANAGEMENT
AND THE ORGANIZATION 73**

5.1. Introduction 73

5.2. Evolution of Management Theory 73

 5.2.1. Introduction 73

 5.2.2. Traditional Management Theory and Industrial Psychology . 74

 5.2.3. The Birth of Human Relations Theory 74

 5.2.4. Sociotechnical Systems 75

 5.2.5. Equilibrium Theories 75

 5.2.6. Structural Functionalism 75

 5.2.7. Open Systems 75

 5.2.8. Empirical Studies 76

 5.2.9. Contingency Theory 76

 5.2.10. Summary 77

5.3. A Cybernetic View of Management and Organization Theory . 77

 5.3.1. Introduction 77

 5.3.2. Three Schools of Thought 77

 5.3.3. Cybernetics in the Three Schools of Thought 78

 5.3.4. Summary 79

5.4. Administrative Management 80

 5.4.1. Introduction 80

 5.4.2. Planning 80

 5.4.3. Organizing 82

 5.4.4. Directing 83

 5.4.5. Controlling 84

 5.4.6. Summary 86

5.5. The Viable System Model: A Structuralist Alternative 86

 5.5.1. Introduction 86

 5.5.2. The Need for Change 87

 5.5.3. The Model 88

 5.5.4. Operationalizing the Model 90

 5.5.5. The Chilean Experience 94

 5.5.6. Summary 95

5.6. Management and Organizational Cybernetics 96

 5.6.1. Introduction 96

 5.6.2. Distinctions 96

 5.6.3. The Cybernetic Model on Trial 97

 5.6.4. Summary 100

5.7. The Interpretive Alternatives 101

 5.7.1. Introduction 101

 5.7.2. The Fundamental Tenets of the Paradigm 101

 5.7.3. The Empirical Dilemma and Other Issues 102

 5.7.4. Summary 103

5.8. Conclusion 103

 Problems 103

| | |
|---|------------|
| CHAPTER SIX. SYSTEMS VIEW OF PROBLEMS AND PROBLEMATIC SITUATIONS | 105 |
| 6.1. Introduction | 105 |
| 6.2. Setting the Scene | 105 |
| 6.3. Hard Systems Methodologies | 107 |
| 6.3.1. Introduction | 107 |
| 6.3.2. Systems Analysis | 108 |
| 6.3.3. Systems Engineering | 110 |
| 6.3.4. Operations Research | 113 |
| 6.3.5. Summary | 116 |
| 6.4. Soft Systems Methodology (SSM) | 116 |
| 6.4.1. Introduction | 116 |
| 6.4.2. The Methodology | 117 |
| 6.4.3. Summary | 124 |
| 6.5. Teaching and Learning Methodologies | 125 |
| 6.5.1. Introduction | 125 |
| 6.5.2. Rules of Checkland's Methodology | 125 |
| 6.5.3. Rules of Jenkins's Methodology | 126 |
| 6.5.4. Summary | 127 |
| 6.6. Which Methodology When? | 127 |
| 6.6.1. Introduction | 127 |
| 6.6.2. Architecture of Systems Problem Solving | 128 |
| 6.6.3. Toward a System of Systems Methodologies | 131 |
| 6.6.4. Toward a Problem Management Tool Kit for Pragmatists | 135 |
| 6.6.5. Summary | 138 |
| 6.7. Three Case Studies | 139 |
| 6.7.1. Introduction | 139 |
| 6.7.2. Case Study 1 | 139 |
| 6.7.3. Case Study 2 | 147 |
| 6.7.4. Case Study 3 | 152 |
| 6.7.5. Summary | 156 |
| 6.8. Conclusion | 156 |
| Problems | 157 |

**CHAPTER SEVEN. SYSTEMS THEORY IN
INTERNATIONAL RELATIONS 159**

| | |
|--|-----|
| 7.1. Introduction | 159 |
| 7.2. Systems and International Relations | 159 |
| 7.2.1. The Current Position | 159 |
| 7.2.2. The International System | 160 |

| | |
|---------------------------|-----|
| 7.3. Conclusion | 166 |
| Problems | 167 |

**CHAPTER EIGHT. SYSTEMS QUANTIFICATION:
FROM STONE AGE TO SPACE AGE . . . 169**

| | |
|---|-----|
| 8.1. Introduction | 169 |
| 8.2. Using Letters Instead of Numbers | 170 |
| 8.3. Rate of Change | 172 |
| 8.4. Drawing up Differential Equations | 175 |
| 8.5. Computer Simulation | 179 |
| 8.5.1. Introduction | 179 |
| 8.5.2. Simulation by Analog, Hybrid, and Digital Methods | 179 |
| 8.5.3. Solving Differential Equations Using Digital Computers | 180 |
| 8.5.4. Constructing a Program | 182 |
| 8.5.5. Simulation Languages | 183 |
| 8.5.6. Summary | 184 |
| 8.6. Quantitative Cybernetics | 184 |
| 8.6.1. Introduction | 184 |
| 8.6.2. Dynamics and Feedback | 184 |
| 8.6.3. Summary | 190 |
| 8.7. Autoregression and Moving Averages | 190 |
| 8.7.1. Introduction | 190 |
| 8.7.2. Variance and Covariance | 190 |
| 8.7.3. Stationarity and Differences | 191 |
| 8.7.4. Autocorrelation | 191 |
| 8.7.5. Correlogram | 192 |
| 8.7.6. Partial Autocorrelation | 193 |
| 8.7.7. Moving Average Process | 193 |
| 8.7.8. Autoregressive Process | 193 |
| 8.7.9. ARIMA Process | 194 |
| 8.7.10. Requirements and Tests on ARIMA Processes | 194 |
| 8.7.11. Summary | 196 |
| 8.8. Statistical Transfer Functions | 196 |
| 8.8.1. Introduction | 196 |
| 8.8.2. Cross-Correlation | 196 |
| 8.8.3. Transfer Function Models | 197 |
| 8.8.4. Summary | 198 |
| 8.9. Recursive Estimation | 198 |
| 8.9.1. Introduction | 198 |
| 8.9.2. Transfer Function Models | 198 |
| 8.9.3. State-Space Models | 201 |
| 8.9.4. Summary | 202 |
| 8.10. Conclusion | 202 |
| Problems | 202 |

| | |
|---|------------|
| CHAPTER NINE. SYSTEMS AND MODELING II: PROCESS, PURPOSES, AND APPROACHES | 205 |
| 9.1. Introduction | 205 |
| 9.2. The Modeling Process | 206 |
| 9.2.1. Introduction | 206 |
| 9.2.2. Modeling Purposes | 206 |
| 9.2.3. Summary | 209 |
| 9.3. Modeling Approaches | 209 |
| 9.3.1. Introduction | 209 |
| 9.3.2. Critical Reviews | 210 |
| 9.3.3. Declaring Assumptions | 210 |
| 9.3.4. Verbal-Sentential | 210 |
| 9.3.5. Diagrammatic | 210 |
| 9.3.6. Mathematical | 211 |
| 9.3.7. Statistical | 217 |
| 9.3.8. Logical | 223 |
| 9.3.9. A Methodology for Modeling Structured Situations | 224 |
| 9.3.10. Summary | 226 |
| 9.4. Case Studies | 226 |
| 9.4.1. Introduction | 226 |
| 9.4.2. Background and Purposes | 226 |
| 9.4.3. Fluid-Electrolyte Acid-Base Balance | 228 |
| 9.4.4. Critical Review | 233 |
| 9.4.5. ARIMA Modeling | 233 |
| 9.4.6. Transfer Function Modeling | 238 |
| 9.4.7. Compact Compartmental Modeling | 249 |
| 9.4.8. Comparison of the Compact Approaches | 251 |
| 9.4.9. A Complex Control System Model | 252 |
| 9.4.10. Consideration of the Complex Approach | 256 |
| 9.4.11. Logical Modeling | 259 |
| 9.4.12. Qualitative, Quantitative, and Logical Modeling Approaches | 261 |
| 9.4.13. Summary | 264 |
| 9.5. Conclusion | 265 |
| Problems | 265 |

**CHAPTER TEN. SYSTEMS SCIENCE:
MAKING SENSE OF THE
PHILOSOPHICAL ISSUES 267**

| | |
|--|-----|
| 10.1. Introduction | 267 |
| 10.2. The Philosophical Issues | 268 |
| 10.2.1. Introduction | 268 |
| 10.2.2. Four Main Areas of Dispute | 268 |
| 10.2.3. Summary | 270 |

| | |
|--|------------|
| 10.3. Making Sense | 270 |
| 10.3.1. Introduction | 270 |
| 10.3.2. The Scientific Approach | 270 |
| 10.3.3. Science and Matters of Society | 271 |
| 10.3.4. Summary | 272 |
| 10.4. Tying It All Together | 273 |
| 10.4.1. Introduction | 273 |
| 10.4.2. An Impressionistic View | 273 |
| 10.4.3. Summary | 275 |
| 10.5. Conclusion | 275 |
| Problems | 275 |
| | |
| REFERENCES | 277 |
| | |
| INDEX | 285 |