

Contents

- 1 *System Concepts and Descriptions* 1
 - Intuitive Notions 1
 - Mathematical Descriptions 6
 - Notes and References 21

- 2 *Basic Questions and Perspectives on System Theory* 23
 - Controlled versus Free Dynamics 23
 - Identification 25
 - Constraints 27
 - Stochastic Effects 30
 - Optimization 31
 - Global Perspectives 32
 - Connectivity and Graphs 35
 - Connectivity and Simplicial Complexes 37
 - Complexity 40
 - Stability 45
 - Catastrophes and Resilience 49
 - Notes and References 53

- 3 *Connectivity* 57
 - Complexes and Connections 58
 - Eccentricity 60
 - Holes and Obstructions 61
 - Betti Numbers and Torsion 66
 - p -Holes 66
 - Cochains and Coboundaries 68

Predator–Prey Relations: A Homological Example	70
Hierarchical Systems and Covers	74
Applications of q -Connectivity to Chess and Shakespearean Drama	76
Algebraic Connectivity	81
Linear Systems	82
Nonlinear Problems	88
Semigroups and Wreath Products	88
Krohn–Rhodes Decomposition Theorem	90
Decomposition of Analytic Systems	92
Notes and References	93

4 *Complexity* 97

Static Complexity	98
Dynamic Complexity	102
Computational Complexity	105
Axioms of System Complexity	106
Complexity of Finite-State Machines	108
Evolution Complexity and Evolving Structures	110
Choice Processes and Complexity	113
Design versus Control Complexity	115
A Program for Practical Applications of Complexity	116
Polyhedral Dynamics and Complexity	116
Algebraic System Theory and Complexity	117
Nonlinear, Finite-Dimensional Processes	119
Complexity and Information Theory	120
Notes and References	122

5 *Stability, Catastrophes, and Resilience* 126

External Descriptions	127
Internal Descriptions	127
Structural Stability	129
Connective Stability and Resilience	130
Graphs and Pulse Processes	131
Input–Output Stability	133
Internal Models and Stability	135
Connective Stability	141
Hopf Bifurcations	144
Structurally Stable Dynamics	147
Catastrophe Theory	151
Some Catastrophe-Theoretic Examples	156
The Cusp Catastrophe and the Logistic Equation	162
Pulse and Value Stability	163

Resilience of Dynamical Processes	166
Resilience and Catastrophes	169
Morse–Smale Systems and Resilience	173
Stability, Control, and Feedback Decisions	181
Lyapunov Stability and Pole-Shifting	183
Bifurcation Control	187
Controlled Resilience	189
Observations	193
Notes and References	193
Index	201