

Contents

Preface	vii
Part 1. Averaging Methods	1
Introduction	3
Time Scales	3
Oscillating Systems	5
Examples: Oscillatory Linear Systems	6
Overview	7
Chapter 1. Averaging Differential Equations	9
1.1. Averaging Nonlinear Systems	10
1.2. Highly Oscillatory Linear Systems	16
1.3. Perturbed Harmonic Systems	19
1.4. Rotation Numbers and Vectors	26
1.5. Pendulum Array in an Oscillatory Environment	35
1.6. Canonical Models in Weakly Connected Networks	41
Exercises	43
Chapter 2. Difference Equations	49
2.1. Averaging Nonlinear Discrete-Time Systems	50
2.2. Linear Difference Equations	52
2.3. Examples	54
2.4. Analyzing Discrete-Time Signals	57
2.5. Examples	58
2.6. Averaging and Computer Simulations	61
Exercises	65
Chapter 3. Averaging over Random Noise	67
3.1. Diffusion Processes	68
3.2. Random Processes	70
3.3. Random Perturbations of Nonlinear Differential Equations	76
3.4. Difference Equations Perturbed by Random Noise	79
3.5. Volterra Integral Equations Perturbed by Random Noise	80
Exercises	82

Part 2. Boundary Layer Methods	83
Introduction	85
Chapter 4. Asymptotic Stability and Singular Perturbations	89
4.1. Linear Stability Theory for Nonlinear Systems	89
4.2. Stability and Perturbation	91
4.3. Gradientlike Systems: Lyapunov Functions	99
Exercises	102
Chapter 5. QSSA for Boundary Layer Problems	105
5.1. Quasi-Static Linear Problems	105
5.2. Nonlinear Initial Value Problems	111
Exercises	125
Chapter 6. Other Singular Perturbation Problems	129
6.1. Quasi-Static Oscillations	129
6.2. Relaxation Oscillations	133
6.3. Boundary Value Problems	140
6.4. Nonlinear Stability Analysis	142
6.5. Explosion Mode Analysis of Rapid Chemical Reactions	147
Exercises	150
Appendix. Circuit Theory	155
Bibliography	159
Index	161