
Contents

Preface	xi
Chapter 1. Crystallization Dynamics	1
§1.1. Derivation of the K-A Model	3
§1.2. Emergence of the Poisson Distribution from the Binomial Distribution	6
§1.3. Testing the K-A Model	7
§1.4. A New Model	9
§1.5. The Averaging Process	11
§1.6. Choosing the Probability Density f	11
§1.7. Why Did the K-A Model Fail?	15
Exercises	16
Notes	20
Chapter 2. Will the Valve Hold?	21
§2.1. Terminology	23
§2.2. The Relevant Forces	24
§2.3. The Equation of Motion	26
§2.4. Analysis: Is the Initial Value Problem Well-Posed?	27
§2.5. Revising the Model	28

§2.6. Revision 1: Adding a Reference Distance	31
§2.7. Revision 2: Changing the Initial Conditions	32
§2.8. P_{\max} : The Maximal Pressure	34
Exercises	37
Notes	39
Chapter 3. How Much Will that Annuity Cost Me?	41
§3.1. Interest Basics	41
§3.2. Mortgages	43
§3.3. Loan Repayment	49
§3.4. Present Value	50
§3.5. Annuities	50
§3.6. Hazard Rate Functions	51
§3.7. Expected Lifetime	56
§3.8. An Annuity Problem	57
§3.9. $V(Y)$: How the Expected Value of the Annuity Varies	60
Exercises	61
Chapter 4. Dimensional Analysis	65
§4.1. A Classical Example: The Pendulum	65
§4.2. Dimensional Analysis: The General Procedure	69
§4.3. The Energy Released by a Nuclear Bomb	72
§4.4. Exploration: How to Cook a Turkey	76
Exercises	83
Chapter 5. Predator-Prey Systems	85
§5.1. The Lotka–Volterra Model	85
§5.2. The Effect of Interference on the System	89
§5.3. Linearization: The General Procedure	94
§5.4. Solving Linear Systems	97
§5.5. Classification of the Equilibria	100
§5.6. The Phase Paths	103
§5.7. Multiple Species	106

Contents	ix
§5.8. Exploration A: Structural Stability	107
§5.9. Exploration B: The Lorenz Attractor	112
Exercises	116
Chapter 6. A Control Problem in Fishery Management	121
§6.1. Variables and Parameters	122
§6.2. The Logistic Growth Model	122
§6.3. Maximizing the Sustainable Catch	124
§6.4. Maximizing the Profit	127
Exercises	131
Chapter 7. Formal Justice	133
§7.1. The Basic Functional Equation	133
§7.2. Formal Justice: A Generalized Approach	138
§7.3. Multiple Qualifications	140
§7.4. Exploration: Exotic Solutions of Cauchy's Functional Equation	144
Exercises	148
Chapter 8. Traffic Dynamics: A Microscopic Model	151
§8.1. The Braking Force	151
§8.2. Density and Flux at Equilibrium	153
§8.3. A Case Study: Propagation of a Perturbation	158
§8.4. Exploration: Peano's Existence Theorem	167
Exercises	170
Chapter 9. Traffic Dynamics: Macroscopic Modelling	171
§9.1. Scalar Conservation Laws	172
§9.2. Solving Initial Value Problems for First-Order PDEs	175
§9.3. The Green Light Problem	180
§9.4. Smooth Initial Data, and General Scalar Conservation Laws	184
§9.5. Intersecting Characteristics	187
Exercises	195

Bibliography

199