

Contents

Contents

v

Foreword

vii

Before we begin

ix

0.1 To the Student	ix
0.2 To the Instructor	xviii
0.3 Acknowledgments	xix

I Fundamental Concepts

1

1 Measuring

3

1.1 Units and Measurement	4
1.2 Scientific Notation	23
1.3 Estimates, Precision, and Orders of Magnitude	33
1.4 Communicating Quantitative Information	44
1.5 Exercises for Chapter 1	59

2 Flowing

67

2.1 Stocks, Flows, and Equilibrium	69
2.2 Energy Stocks and Flows	81
2.3 Calculating Equilibrium States	95
2.4 Energy Flows in the Climate System	106
2.5 Exercises for Chapter 2	118

3 Connecting

127

3.1 Networks and Connections	129
3.2 Networks and Behavior	140
3.3 Feedback and Dynamic Networks	151
3.4 The Exponential Model	164
3.5 Exercises for Chapter 3	176

4 Changing

183

4.1 Logarithms and Change	185
4.2 Logistic Models and the Limits to Growth	206

v

4.3 Measuring Feedback Strength	221
4.4 Tipping Points	239
4.5 Exercises for Chapter 4	252
5 Risking	259
5.1 Understanding Data	261
5.2 Probabilities and Predictions	278
5.3 Expectations and Payoffs	300
5.4 Assimilating New Information	317
5.5 Exercises for Chapter 5	337
6 Deciding	345
6.1 Market Perspectives and Large-Scale Change	348
6.2 The Strange Behavior of Rational People	360
6.3 The Tragedy of the Commons	373
6.4 After Math: Decision-Making and Ethics	388
6.5 Exercises for Chapter 6	402
II Case Studies	409
7 Case Studies	411
7.1 Mathematics and Persuasive Writing	413
7.2 The Changing Risks of Wildfires	419
7.3 Is Recycling Worth It, Really?	426
7.4 World Population Growth and the Demographic Transition	433
7.5 Genetic Engineering and the Future of Food	443
7.6 Nuclear Power Is a Commitment to the Future	450
7.7 Using Electricity Efficiently at Home	458
7.8 Growth and Payback Time for Solar Energy	466
7.9 Energy Return on Energy Invested	470
7.10 Exercises for Chapter 7	475
III Resources	481
8 Resources for Student and Instructor	483
8.1 Resources for Further Reading and Writing	483
8.2 Useful Numbers for Sustainability Calculations	483
List of Figures	491
List of Tables	498
Bibliography	501
Index	519