

Contents

1	Introduction	1
1.1	Building	2
2	Ideal gas	6
2.1	Fluctuations of the ideal gas	8
3	Rubber bands	11
3.1	The game	11
3.2	Analysis	11
3.3	Simulation	13
3.4	Independent folk	15
3.5	How often does the prediction go wrong?	17
4	Percolitis	19
4.1	An epidemic model	19
4.2	Discussion	22
4.3	Behavior of the order parameter near the critical point	24
4.4	Approach to equilibrium	25
4.5	Discreteness and fluctuations*	30
4.6	Self-organized criticality (SOC): Applications to galaxies and mean field theory	34
4.7	The truth about percolitis	38
4.8	Abstract percolation	42
4.9	Percolation applications	44
4.10	True epidemiology	45
5	Ferromagnetism	50
5.1	Curie–Weiss ferromagnets	55
5.2	Magnetization	57
5.3	Fluctuations greater than \sqrt{N}	60
6	Maximum entropy methods	63
6.1	Information	63
6.2	Maximum entropy	66
6.3	Using maximum entropy to study Supreme Court voting	71

7	Power laws	76
7.1	Power laws are scale free	78
7.2	Diffusion	79
7.3	Preferential attachment (the rich get richer)	81
7.4	Exponential functions of exponential distributions	84
7.5	Superposition of exponentials	85
7.6	Critical phenomena and self-organized criticality (SOC)	85
8	Universality, renormalization and critical phenomena	89
8.1	The nearest neighbor one-dimensional Ising model	90
9	Social sciences	104
9.1	Econophysics	105
9.2	Stock market bubbles and crashes	110
9.3	Linguistics	115
9.4	Power laws for cities	119
9.5	Urban discrimination	121
9.6	Voter models and elections	128
9.7	Crowd control	131
9.8	Traffic	133
10	Biological sciences	140
10.1	Firefly synchronization	140
10.2	Biorobotics and glass	147
10.3	Gene distributions	151
10.4	Flocking	156
10.5	Kuramoto model	162
10.6	Ecology	171
10.7	Neurology	176
11	Physical sciences	180
11.1	Power laws for luminescence	180
11.2	Large scale structure	184
11.3	Galactic morphology	187
12	Putting it all together	191
	Appendix A Notation	196
	Appendix B Background in statistical physics	198
	Appendix C Fractals	204
	Appendix D Review of probability	206
D.1	Basics	206
D.2	Counting	210
D.3	The central limit theorem	211
D.4	Markov processes	213
D.5	Stochastic dynamics	214

D.6	The notion of probability	216
D.7	Stirling's approximation	216
D.8	Exercises in probability	218
Appendix E	The van der Waals gas	221
Appendix F	The logistic map	223
Appendix G	Lagrange multipliers	226
G.1	Two variables, one constraint	226
G.2	Generalization, more than one constraint	227
G.3	Example	228
Appendix H	Complexity in the observable representation	229
H.1	The observable representation	229
Appendix I	A Quotation	239
Appendix J	Solutions to exercises	240
	References	261
	Index	278