Contents

	Preface			xv
1	Probabi	lity Theory		1
	1.1	Basic Set Theory and Mathematical No	tation	1
	1.2	Probability Spaces		2
	1.3	De Morgan's Laws		3
	1.4	Interocitors		3
	1.5	The Direct Evaluation of Probabilities		3
	1.6	Probability as Frequency		4
	1.7	Craps		5
	1.8	A Marksman Contest		5
	1.9	Sampling		5
	1.10	Aces Up		6
	1.11	Permutations		6
	1.12	Combinations and Sampling		7
	1.13	Mechanical Defects		7
	1.14	Mass Defection		7
	1.15	House Rules		7
	1.16	The Addition Rule for Probabilities		8
	1.17	A Guessing Game		8
	1.18	North Island, South Island		8
	1.19	Conditional Probability		9
	1.20	Bayes' Rule		9
	1.21	Extrasensory Perception		10
	1.22	Les Cinq Tiroirs		10
	1.23	Drug Testing		10
	1.24	Color Blindness		11
	1.25	Urns		11
	1.26	The Monty Hall Game		11
	1.27	The Logic of Murder and Abuse		11
	1.28	The Principle of Insufficient Reason		12
	1.29	The Greens and the Blacks		12
	1.30	The Brain and Kidney Problem		12
	1.31	The Value of Eyewitness Testimony		13

	1.32	When Weakness Is Strength	13
	1.33	The Uniform Distribution	16
	1.34	Laplace's Law of Succession	17
	1.35	From Uniform to Exponential	17
2	Bayesia	n Decision Theory	18
	2.1	The Rational Actor Model	18
	2.2	Time Consistency and Exponential Discounting	20
	2.3	The Expected Utility Principle	22
	2.4	Risk and the Shape of the Utility Function	26
	2.5	The Scientific Status of the Rational Actor Model	30
3	Game T	Theory: Basic Concepts	32
	3.1	Big John and Little John	32
	3.2	The Extensive Form	38
	3.3	The Normal Form	41
	3.4	Mixed Strategies	42
	3.5	Nash Equilibrium	43
	3.6	The Fundamental Theorem of Game Theory	44
	3.7	Solving for Mixed-Strategy Nash Equilibria	45
	3.8	Throwing Fingers	46
	3.9	Battle of the Sexes	46
	3.10	The Hawk-Dove Game	48
	3.11	The Prisoner's Dilemma	50
4	Elimina	nting Dominated Strategies	52
	4.1	Dominated Strategies	52
	4.2	Backward Induction	54
	4.3	Exercises in Eliminating Dominated Strategies	55
	4.4	Subgame Perfection	57
	4.5	Stackelberg Leadership	59
	4.6	The Second-Price Auction	59
	4.7	The Mystery of Kidnapping	60
	4.8	The Eviction Notice	62
	4.9	Hagar's Battles	62
	4.10	Military Strategy	63
	4.11	The Dr. Strangelove Game	64

	4.12	Strategic Voting	64
	4.13	Nuisance Suits	65
	4.14	An Armaments Game	67
	4.15	Football Strategy	67
	4.16	Poker with Bluffing	68
	4.17	The Little Miss Muffet Game	69
	4.18	Cooperation with Overlapping Generations	70
	4.19	Dominance-Solvable Games	71
	4.20	Agent-based Modeling	72
	4.21	Why Play a Nash Equilibrium?	75
	4.22	Modeling the Finitely-Repeated Prisoner's Dilemma	77
	4.23	Review of Basic Concepts	79
5	Pure-St	rategy Nash Equilibria	80
	5.1	Price Matching as Tacit Collusion	80
	5.2	Competition on Main Street	81
	5.3	Markets as Disciplining Devices: Allied Widgets	81
	5.4	The Tobacco Market	87
	5.5	The Klingons and the Snarks	87
	5.6	Chess: The Trivial Pastime	88
	5.7	No-Draw, High-Low Poker	89
	5.8	An Agent-based Model of No-Draw, High-Low Poker	91
	5.9	The Truth Game	92
	5.10	The Rubinstein Bargaining Model	94
	5.11	Bargaining with Heterogeneous Impatience	96
	5.12	Bargaining with One Outside Option	97
	5.13	Bargaining with Dual Outside Options	98
	5.14	Huey, Dewey, and Louie Split a Dollar	102
	5.15	Twin Sisters	104
	5.16	The Samaritan's Dilemma	104
	5.17	The Rotten Kid Theorem	106
	5.18	The Shopper and the Fish Merchant	107
	5.19	Pure Coordination Games	109
	5.20	Pick Any Number	109
	5.21	Pure Coordination Games: Experimental Evidence	110
	5.22	Introductory Offers	111
	5.23	Web Sites (for Spiders)	112

6	Mixed-	Strategy Nash Equilibria	116
	6.1	The Algebra of Mixed Strategies	116
	6.2	Lions and Antelope	117
	6.3	A Patent Race	118
	6.4	Tennis Strategy	119
	6.5	Preservation of Ecology Game	119
	6.6	Hard Love	120
	6.7	Advertising Game	120
	6.8	Robin Hood and Little John	122
	6.9	The Motorist's Dilemma	122
	6.10	Family Politics	123
	6.11	Frankie and Johnny	123
	6.12	A Card Game	124
	6.13	Cheater-Inspector	126
	6.14	The Vindication of the Hawk	126
	6.15	Characterizing 2 × 2 Normal Form Games I	127
	6.16	Big John and Little John Revisited	128
	6.17	Dominance Revisited	128
	6.18	Competition on Main Street Revisited	128
	6.19	Twin Sisters Revisited	129
	6.20	Twin Sisters: An Agent-Based Model	129
	6.21	One-Card, Two-Round Poker with Bluffing	131
	6.22	An Agent-Based Model of Poker with Bluffing	132
	6.23	Trust in Networks	133
	6.24	El Farol	134
	6.25	Decorated Lizards	135
	6.26	Sex Ratios as Nash Equilibria	137
	6.27	A Mating Game	140
	6.28	Coordination Failure	141
	6.29	Colonel Blotto Game	141
	6.30	Number Guessing Game	142
	6.31	Target Selection	142
	6.32	A Reconnaissance Game	142
	6.33	Attack on Hidden Object	143
	6.34	Two-Person, Zero-Sum Games	143
	6.35	Mutual Monitoring in a Partnership	145
	6.36	Mutual Monitoring in Teams	145

				Cor	ntents
	6.37	Altruism(?) in Bird Flocks			146
	6.38	The Groucho Marx Game			147
	6.39	Games of Perfect Information			151
	6.40	Correlated Equilibria			151
	6.41	Territoriality as a Correlated Equilibrium			153
	6.42	Haggling at the Bazaar			154
	6.43				156
	6.44	Algorithms for Finding Nash Equilibria			157
	6.45	Why Play Mixed Strategies?			160
	6.46	Reviewing of Basic Concepts			161
7	Princip	al-Agent Models			162
	7.1	Gift Exchange			162
	7.2	Contract Monitoring			163
	7.3	Profit Signaling			164
	7.4	Properties of the Employment Relationship			168
	7.5	Peasant and Landlord			169
	7.6	Bob's Car Insurance			173
	7.7	A Generic Principal-Agent Model			174
8	Signalia	ng Games			179
	8.1	Signaling as a Coevolutionary Process			179
	8.2	A Generic Signaling Game			180
	8.3	Sex and Piety: The Darwin-Fisher Model			182
	8.4	Biological Signals as Handicaps			187
	8.5	The Shepherds Who Never Cry Wolf			189
	8.6	My Brother's Keeper			190
	8.7	Honest Signaling among Partial Altruists			193
	8.8	Educational Signaling			195
	8.9	Education as a Screening Device			197
	8.10	Capital as a Signaling Device			199
9	Repeate	ed Games			201
	9.1	Death and Discount Rates in Repeated Gam	es		202
	9.2	Big Fish and Little Fish			202
	9.3	Alice and Bob Cooperate			204
	9.4	The Strategy of an Oil Cartel			205

xi

	9.5	Reputational Equilibrium	205
	9.6	Tacit Collusion	206
	9.7	The One-Stage Deviation Principle	208
	9.8	Tit for Tat	209
	9.9	I'd Rather Switch Than Fight	210
	9.10	The Folk Theorem	213
	9.11	The Folk Theorem and the Nature of Signaling	216
	9.12	The Folk Theorem Fails in Large Groups	217
	9.13	Contingent Renewal Markets Do Not Clear	219
	9.14	Short-Side Power in Contingent Renewal Markets	222
	9.15	Money Confers Power in Contingent Renewal Markets	223
	9.16	The Economy Is Controlled by the Wealthy	223
	9.17	Contingent Renewal Labor Markets	224
10	Evolutio	onarily Stable Strategies	229
	10.1	Evolutionarily Stable Strategies: Definition	230
	10.2	Properties of Evolutionarily Stable Strategies	232
	10.3	Characterizing Evolutionarily Stable Strategies	233
	10.4	A Symmetric Coordination Game	236
	10.5	A Dynamic Battle of the Sexes	236
	10.6	Symmetrical Throwing Fingers	237
	10.7	Hawks, Doves, and Bourgeois	238
	10.8	Trust in Networks II	238
	10.9	Cooperative Fishing	238
	10.10	Evolutionarily Stable Strategies Are Not Unbeatable	240
	10.11	A Nash Equilibrium That Is Not an EES	240
	10.12	Rock, Paper, and Scissors Has No ESS	241
	10.13	Invasion of the Pure-Strategy Mutants	241
	10.14	Multiple Evolutionarily Stable Strategies	242
	10.15	Evolutionarily Stable Strategies in Finite Populations	242
	10.16	Evolutionarily Stable Strategies in Asymmetric Games	244
11	Dynami	cal Systems	247
	11.1	Dynamical Systems: Definition	247
	11.2	Population Growth	248
	11.3	Population Growth with Limited Carrying Capacity	249
	11.4	The Lotka-Volterra Predator-Prey Model	251

		C	onienis
	11.5	Dynamical Systems Theory	255
	11.6	Existence and Uniqueness	256
	11.7	The Linearization Theorem	257
	11.8	Dynamical Systems in One Dimension	258
	11.9	Dynamical Systems in Two Dimensions	260
	11.10	Exercises in Two-Dimensional Linear Systems	264
	11.11	Lotka-Volterra with Limited Carrying Capacity	266
	11.12	Take No Prisoners	266
	11.13		267
	11.14	Features of Two-Dimensional Dynamical Systems	268
12	Evolutio	onary Dynamics	270
	12.1	The Origins of Evolutionary Dynamics	271
	12.2	Strategies as Replicators	272
	12.3	A Dynamic Hawk-Dove Game	274
	12.4	Sexual Reproduction and the Replicator Dynamic	276
	12.5	Properties of the Replicator System	278
	12.6	The Replicator Dynamic in Two Dimensions	279
	12.7	Dominated Strategies and the Replicator Dynamic	280
	12.8	Equilibrium and Stability with a Replicator Dynamic	282
	12.9	Evolutionary Stability and Asymptotically Stability	284
	12.10	Trust in Networks III	284
	12.11	Characterizing 2 × 2 Normal Form Games II	285
	12.12	Invasion of the Pure-Strategy Nash Mutants II	286
	12.13	A Generalization of Rock, Paper, and Scissors	287
	12.14	Uta stansburiana in Motion	287
	12.15	The Dynamics of Rock, Paper, and Scissors	288
	12.16	The Lotka-Volterra Model and Biodiversity	288
	12.17	Asymmetric Evolutionary Games	290
	12.18	Asymmetric Evolutionary Games II	295
	12.19	The Evolution of Trust and Honesty	295
13	Markov	Economies and Stochastic Dynamical Systems	297
	13.1	Markov Chains	297
	13.2	The Ergodic Theorem for Markov Chains	305
	13.3	The Infinite Random Walk	307
	13.4	The Sisyphean Markov Chain	308

xiii

xiv Contents

	13.5	Andrei Andreyevich's Two-Urn Problem		309
	13.6	Solving Linear Recursion Equations		310
	13.7	Good Vibrations		311
	13.8	Adaptive Learning		312
	13.9	The Steady State of a Markov Chain		314
	13.10	Adaptive Learning II		315
	13.11	Adaptive Learning with Errors		316
	13.12	Stochastic Stability		317
14	Table of	Symbols		319
15	Answer	s		321
Sou	arces for I	Problems		373
Rei	References			375
Ind	ex			385