

Contents

Preface xv

- 1 Introduction 1**
 - 1.1 Market and Market Design 1
 - 1.2 Do We Necessarily Have Prices? 2
 - 1.3 More on Markets 3
 - 1.3.1 What a Market Needs to Work 4
 - 1.3.2 Commodities 5
 - 1.4 Market Design: First Example 6
 - 1.4.1 Feeding America 6
 - 1.4.2 The First Design 7
 - 1.4.3 The Problems . . . 9
 - 1.4.4 . . . and a Solution 10
 - 1.4.5 Results 11

- 2 Simple Auctions 13**
 - 2.1 Introduction 13
 - 2.1.1 Auctions: A Definition 14
 - 2.1.2 Auctions Are Everywhere 14
 - 2.2 Valuations 16
 - 2.3 Payoffs and Objectives 17
 - 2.4 Ascending Auctions 18
 - 2.4.1 The English Auctions 18
 - 2.4.2 Bids, Strategies, and Payoffs in the English Auctions 21
 - 2.4.3 Ticking Price 22
 - 2.4.4 Truthful Bidding 23
 - 2.5 Second-Price Auction 25
 - 2.5.1 The Essence of the English Auction 25
 - 2.5.2 The Vickrey Auction 26
 - 2.5.3 English versus Second-Price Auctions 28

2.6	First-Price Auction	29
2.6.1	Definition	29
2.6.2	Optimal Bids in the First-Price Auction	30
2.6.3	Dutch Auction	34
2.7	Revenue Equivalence	36
2.8	Reserve Price	40
2.8.1	Optimal Reserve Price	42
2.8.2	Reserve Price versus Adding More Bidders	45
3	An Analysis of eBay	49
3.1	Introduction	49
3.2	eBay in Detail	50
3.2.1	Proxy Bidding	50
3.2.2	Bids and Bid Increments	51
3.2.3	Updating Rules	51
3.3	eBay as a First-Price Auction?	54
3.4	Bid Sniping	54
3.4.1	Amazon versus eBay	55
3.4.2	Data Analysis	56
3.5	Reserve Price	59
4	The Vickrey-Clarke-Groves Auction	61
4.1	Introduction	61
4.2	The Model	61
4.3	The VCG Auction	63
4.3.1	Computing the Optimal Assignment	63
4.3.2	Calculating Prices	66
4.4	Incentives under the VCG Auction	67
4.5	Relation with the Vickrey Auction	68
4.6	The Complexity of the VCG Auction	69
5	Keyword Auctions	71
5.1	Introduction	71
5.2	Running Billions and Billions of Auctions	73
5.3	The Origins	74
5.3.1	Payoff Flows	75
5.4	The Google Model: Generalized Second-Price Auction	76
5.4.1	Quality Scores	76
5.4.2	Truth-telling under the GSP Auction	78
5.4.3	Equilibrium under the GSP Auction	78

5.4.4	Assumptions about the Long-Run Equilibria	79
5.4.5	Refinement: Envy-Free Equilibrium	79
5.4.6	The Generalized English Auction	88
5.5	The Facebook Model: VCG for Internet Ads	91
5.5.1	Comparing VCG and GSP Auctions	91
5.5.2	The Rationale for VCG	94
6	Spectrum Auctions	95
6.1	How Can Spectrum Be Allocated?	95
6.1.1	Lotteries	95
6.1.2	Beauty Contests	96
6.1.3	Why Run Auctions?	97
6.2	Issues	98
6.2.1	General Issues	98
6.2.2	Collusion, Demand Reduction, and Entry	99
6.2.3	Maximum Revenue	101
6.2.4	The Exposure Problem	102
6.2.5	Winner's Curse	103
6.3	The Simultaneous Ascending Auction	104
6.4	Case Studies	106
6.4.1	The U.S. 1994 PCS Broadband Auction	106
6.4.2	Mistakes	109
7	Financial Markets	113
7.1	Introduction	113
7.2	Treasury Auctions	113
7.2.1	Outline	113
7.2.2	How Treasury Auctions Work	115
7.2.3	Analysis	118
7.3	Double Auctions	119
7.4	Initial Public Offering	123
7.4.1	Allocation and Pricing through Contracts	124
7.4.2	Auctions for IPOs	124
8	Trading	127
8.1	Stock Markets	127
8.2	Opening and Closing	132
8.3	High-Frequency Trading	135
8.3.1	Market Structure	135
8.3.2	Market Regulation	137

8.3.3	Surfing on the Latency	139
8.3.4	What Is the Matter with High Frequencies?	141
8.3.5	A Flawed Market Design?	143
8.4	Alternative Market Designs	145
8.4.1	Slowing Down Markets?	145
8.4.2	Frequent Batch Auctions	147
9	The Basic Matching Model	149
9.1	The Basic Matching Model	149
9.1.1	Preferences	150
9.1.2	Matching	152
9.1.3	Stability	153
9.2	Algorithms and Mechanisms	156
9.2.1	Algorithms?	156
9.2.2	Matching Mechanism	159
9.3	Finding Stable Matchings	159
9.3.1	The Deferred Acceptance Algorithm	160
9.3.2	Deferred Acceptance and Stable Matchings	162
9.4	Preferences Over Stable Matchings	164
9.4.1	Musician-Optimal and Singer-Optimal Matchings	164
9.4.2	Proofs	165
9.5	Incentives with the Deferred Acceptance Algorithm	167
10	The Medical Match	173
10.1	History	173
10.2	The Many-to-One Matching Model	175
10.2.1	Preferences in the Many-to-One Matching Model	176
10.2.2	Matchings and Stability in a Many-to-One Matching Model	179
10.2.3	Finding Stable Matchings	182
10.2.4	One-to-One v. Many-to-One Matchings: Similarities and Differences	184
10.3	Why Stability Matters	186
10.3.1	A Natural Experiment	186
10.3.2	Unraveling in the Lab	187
10.4	The Rural Hospital Theorem	190
10.5	The Case of Couples and the Engineering Method	192
10.5.1	A Very Complex Problem	192
10.5.2	When Theory Fails	193
10.5.3	Fixing the NRMP	194

- 11 Assignment Problems** 197
 - 11.1 The Basic Model 197
 - 11.1.1 Public versus Private Endowments 198
 - 11.1.2 Evaluating Assignments 198
 - 11.2 Finding Efficient Assignments 199
 - 11.2.1 Serial Dictators 199
 - 11.2.2 Trading Cycles 200
 - 11.2.3 Implementing Allocation Rules 205
 - 11.2.4 Individual Rationality and the Core 210
 - 11.3 Mixed Public-Private Endowments 212
 - 11.3.1 Inefficient Mechanisms 213
 - 11.3.2 Two Efficient Solutions 217

- 12 Probabilistic Assignments** 223
 - 12.1 Random Assignments 223
 - 12.1.1 Preliminaries 223
 - 12.1.2 The Birkhoff–von Neumann Theorem 225
 - 12.1.3 Evaluating Random Assignments 227
 - 12.2 Random Serial Dictatorship 229
 - 12.3 The Probabilistic Serial Mechanism 231

- 13 School Choice** 239
 - 13.1 The Many-to-One Assignment Model 239
 - 13.1.1 Preferences versus Priorities 239
 - 13.1.2 The Model 241
 - 13.1.3 Assignments 241
 - 13.1.4 Stability and Efficiency 242
 - 13.2 Competing Algorithms 245
 - 13.2.1 The Role of Each Side of the Market 245
 - 13.2.2 The Deferred Acceptance Algorithm 246
 - 13.2.3 The Immediate Acceptance Algorithm 248
 - 13.2.4 Top Trading Cycles 250
 - 13.3 The Problem with the Immediate Acceptance Algorithm 256
 - 13.4 Applications 257
 - 13.4.1 The Boston School Match 257
 - 13.4.2 The New York City School Match 259

- 14 School Choice: Further Developments** 263
 - 14.1 Weak Priorities 263
 - 14.1.1 The Problem 263
 - 14.1.2 Efficiency Loss 264

14.1.3	The Student-Optimal Assignment with Weak Priorities	265
14.1.4	Restoring Efficiency	266
14.1.5	How to Break Ties If You Must	272
14.2	Constrained Choice	276
14.2.1	Issues	277
14.2.2	From Very Manipulable to Less Manipulable	279
15	Course Allocation	283
15.1	Preliminaries	283
15.2	Bidding for Courses	284
15.2.1	The Bidding and Allocation Process	285
15.2.2	Issues: Nonmarket Prices and Inefficiency	286
15.2.3	Deferred Acceptance with Bids	288
15.3	The Harvard Business School Method	290
15.3.1	The Harvard Draft Mechanism	290
15.3.2	Strategic Behavior	291
15.3.3	Welfare	293
15.4	The Wharton Method	295
15.4.1	Approximate Competitive Equilibrium from Equal Incomes	296
15.4.2	The Wharton Experiment	298
16	Kidney Exchange	303
16.1	Background	303
16.2	Trading Kidneys	305
16.2.1	Trades versus Waiting List	306
16.2.2	The Kidney Exchange Algorithm	306
16.2.3	Chain Selection Rules	309
16.2.4	Efficiency and Incentives	311
16.3	On the Number of Exchanges	313
	Appendix A: Game Theory	317
A.1	Strategic Form Games	317
A.1.1	Definition	317
A.1.2	Pure and Mixed Strategies	318
A.2	Extensive Form Games	319
A.2.1	Definition	320
A.2.2	Strategies	321
A.2.3	Imperfect Information	322

A.3	Solving Games	324
A.3.1	Dominated and Dominant Strategies	324
A.3.2	Elimination of Dominated Strategies	326
A.3.3	Nash Equilibrium	328
A.4	Bayesian Games: Games with Incomplete Information	330
A.4.1	Introductory Example	330
A.4.2	Definition	331
Appendix B: Mechanism Design		335
B.1	Preliminaries	335
B.2	The Model	337
B.2.1	Mechanism	337
B.2.2	Implementing Social Choice Functions	339
B.2.3	Direct versus Indirect Mechanism	340
B.3	Dominant Strategy Implementation	341
B.3.1	The Revelation Principle	341
B.3.2	The Gibbard-Satterthwaite Theorem	342
B.3.3	The Vickrey-Clarke-Groves Mechanism	343
B.4	Bayesian Mechanism Design	344
B.4.1	Bayesian Incentive Compatibility	344
B.4.2	Trading: The Myerson-Satterthwaite Theorem	345
Appendix C: Order Statistics		349
C.1	Expected Highest Valuation	349
C.1.1	Obtaining the Cumulative Density Function	350
C.1.2	Obtaining the Probability Density Function	350
C.1.3	Calculate the Expectation	350
C.2	Expected Second-Highest Valuation	351
C.3	Conditional Expectation of the Highest Valuation	352
C.4	Changing the Upper and Lower Bounds	353
Notes		355
References		365
Index		369