Index

AAE example, 466–467, 476
aborting games, 188, 190
adaptive behavior, 81
adaptive limited-supply auction, 424–427
adoption as coordination problem, 636
adverse selection, 677
advertisements. *See* sponsored search auctions
affiliate search engines, 712
affine maximizer, 228, 317, 320
affinely independent, 57
agents. *See* players
aggregation of preferences. *See* mechanism design
aggregation problem, 651–655
algorithmic mechanism design. *See also* mechanism design; distributed algorithmic mechanism design
allocation in combinatorial auction, 268, 270–272
AMD. *See* algorithmic mechanism design
"AND" technology, 603–606
announcement strategies, 685–686
anonymous games, 40
anonymous rules, 247, 250
approximate core, 389–391
approximate equilibria, 45, 138, 143, 167
ApproximateTreeNash, 166–168, 176
approximation mechanisms, computationally efficient
  alternative solution concepts, 321–327
  dominant strategy, impossibilities of, 317–320
  history, 327
  multidimensional domains, 310–317
  overview, 301–303
  single-dimensional domains, 303–310
  submodularity, 623–624
  theorems, 305, 307, 309, 315, 318, 324
Arrow–Debreu market model, 103, 104, 121–122, 136
Arrow's theorem, 212–213, 239
artificial equilibrium, 61
ascending auctions, 289–294
ascending price auction, 126
assortative assignment, 704
asymmetries in information security, 636–639
atomic bids, 280, 282
atomic selfish routing, 461, 465–468, 470–472, 475–477, 482–483
atomic splittable model, 483
attribute auction, 344
auctions
  adaptive, limited-supply, 424–427
  ascending, 289–294
  bidding languages, 279–283
  call market, 654–655
  combinatorial. *See* combinatorial auctions
  competitive framework, 344–345
  convergence rates, 342–344
  deterministic optimal price, 340
  digital goods, 332, 338, 340, 345–346
  dynamic, with expiring items, 412, 420–424
  examples in mechanism design, 209–210, 220–221
  first price (Bayesian analysis), 20, 234–236
  frugality, 350–354
  iterative, 283–287
  known single-minded combinatorial, 418
  lower bounds, 346–347
  profit maximization, 331–332, 336

auctions (*cont.*)
  random sampling optimal price (RSOP) auction, 341–342
  random sampling profit extraction, 348–349
  single-item, 332, 337
  sponsored search auctions. *See* sponsored search auctions
  symmetric, 340
  truthful combinatorial, 316–317
  Vickrey auction. *See* Vickrey auction
automated market makers, 662–665, 670
autonomous systems (ASes), 364–365, 370–371, 373–379, 487, 507
axiomatic method, 404

backward induction, 69
balanced flow, 111–116, 119
balls into bins problem, 451–452, 530
bandwidth-sharing game, 6–7, 452–455, 587, 588
banking and security, 634, 647
barter-based system, 600–601
basis matrix, 65
battle of the sexes game, 7, 12
Bayes' rule, 667
Bayesian first price auction, 20
Bayesian-Nash implementation, 233–237, 416, 431–436
Bayesian network structured market, 662
Bayesian optimal mechanism design, 333, 335–338, 357
behavior strategy, 67
  sequence form, 71
best response
  in graphical games, 162
  and learning in games, 18
  max-weight best response policy, 524
  and Nash equilibrium, 30–31, 54, 497
  in peer-to-peer networks, 605
  polyhedron, 57–59
  for identical machines, 522–524
  in reputation systems, 686
  in strict incomplete information games, 223
best response polyhedron, 57
BGP. *See* Border Gateway Protocol (BGP)
bid format and price formation, 666–667
bid vector, 453–454
bidders
  bidding languages, 279–283
  in combinatorial auctions, 267–268
  exposure problem, 292
  iterative auctions (query model), 283–287
  single-minded, 270–275, 295, 323–324, 332
  single-value, 322
  sponsored search auctions. *See* sponsored search auctions
bidding languages, 279–283, 295, 310
bilateral network formation game, 507
bilateral trade, 220–221
bimatrix game, 30, 54–57, 62, 152
binding inequality, 57–59
BitTorrent, 570, 589, 596, 600–601
blocking coalition, 253–255
blocking pair, 255, 256, 507
blogs, 622, 627, 630
BNIC. *See* Bayes-Nash incentive-compatible
Bondareva–Shapley theorem, 388, 389, 391, 407
Boolean circuit, 41, 43
Boolean events, 658, 661
Boolean market model, 666, 668
bootstrapping problems, 636, 647, 689
Borda count, 211
Border Gateway Protocol (BGP), 372, 374, 376, 378–379, 381
bounded communication, 356
Braess's Paradox, 464–465, 475, 481
Brandes' algorithm, 645
brittle and nonbrittle comparators, 43
broadcast and secure channels, 185, 201
Brouwer's fixpoint theorem, 32, 41–43
budget balanced, 22, 392, 393, 501
budget constraints. *See* sponsored search auctions
bundle-price ascending auctions, 292–295
bundles of items. *See* combinatorial auctions
bundling, 356

call market auction, 654–655
capacity augmentation, 479–480
capacity investments, 590
Cascade Model, 620–621, 624–625
cascading behavior in networks
  contagion threshold, 615–616
  finding influential sets of nodes, 622–627
  general social contagion, 618–622
  history, 630–631
  networked coordination games, 614–618
  online data empirical studies, 627–630
  overview, 613–614
  theorems, 617, 618, 624–626
CE. *See* correlated equilibrium
cell structure, 644–645
censorship resistance, 640–643
centrality attacks, 645
CEPE auction. *See* consensus estimate profit extraction (CEPE) auction

CES. *See* constant elasticity of substitution (CES)
cheap pseudonyms, 597, 679, 683
"cheap talk" preamble phase, 188
Chernoff bound, 532, 533–535
chicken game, 45–46
churn, 594
Clarke pivot rule, 219–221, 561
clearing prices. *See* market clearing prices
click through rate (CTR), 701–704, 707, 712
clique strategy, 644–646, 721–722
coalition game. *See* cooperative game theory
coalition-proof equilibrium, 192
coalitions of agents, 250, *See also* collusions
coarsest common refinement, 653
Cobb-Douglas functions, 139, 143, 146, 155
collective utility function, 405
collusion-proof ex-post Nash equilibria, 376
collusions, 189, 191, 199, 356, 597
combinatorial auctions
  alternative solution concepts, 321–327
  applications of, 269–270
  ascending auctions, 289–294
  bidding languages, 279–283
  communication complexity, 287–289
  computationally efficient mechanisms. *See* approximation mechanisms
  definitions and problem, 267–269
  history, 295–296
  iterative auctions (query model), 283–287
  linear programming relaxation, 275–277
  multidimensional domains, 310–317
  single-minded case, 270–275, 332, 418
  theorems, 273, 277, 278, 282, 285, 288, 289, 291, 294
  truthful, 316–317
  Walrasian equilibrium, 277–279
combinatorial prediction markets, 657–662, 670
combined value trading, 658, 672
combining expert advice. *See* external regret
  Internet routing, 376–379
commitment types, 682
common value model, 238
communication complexity in combinatorial auctions, 287–289, 295
communications networks
  alternative pricing and incentive approaches, 587–590
  efficiency analysis, 583–584
  future research, 589–590
  large networks (competitive models), 572–578
  monopoly pricing and equilibrium, 582
  oligopoly pricing and equilibrium, 582–583
  overview, 571–572
  pricing and efficiency with congestion externalities, 579–582
  pricing and resource allocation theoretic models, 578–579, 584–587
  theorems, 584, 585
compact prediction markets, 661–662
competitive analysis, 344–345, 351, 352–354, 413, 417, 421
competitive auctions, 345–349, 355
competitive digital goods auction, 345–346
competitive equilibrium
  definition, 292
  large communications networks, 572–578
  price takers, 546–547
  smooth market-clearing mechanism, 552
  social welfare, 293
competitive ratio, 345–348, 354, 357, 358, 422, 425
complementary slackness, 74
complementary slackness conditions, 104, 109
complements *vs*. substitutes, 268, 290, 292
complete information models, 239
completely labeled, 58, 59, 61–63, 66
complex networks and topology, 643–646
compound prediction markets, 659–661
computational aspects of prediction markets. *See* prediction markets
computational evolutionary game theory
  classical evolutionary model, 718–720
  computational complexity of evolutionarily stable strategies, 720–723
  evolutionary dynamics applied to selfish routing, 723–728
  future research, 733
  graphs, 728–733
  history, 733–734
  overview, 717–718
  theorems, 719, 723, 727, 731
computational indistinguishability, 185
computational manipulation example, 366–367
computationally efficient mechanisms. *See* approximation mechanisms
computer science and game theory, 363–364
computer science *vs*. economics, 301–303
concave games. *See* submodular games
conditional equilibrium, 164, 176
conditional securities, 659
Condorcet's paradox, 211
congestion control algorithm, 576–577
congestion games, 41, 463, 482, 497–498, 579–582
consensus, 349–350

consensus estimates, 356
consensus estimate profit extraction (CEPE) auction, 350
constant elasticity of substitution (CES), 139, 149–151, 155
constant sum games, 89–90
constraint satisfaction programming (CSP), 169
consumer demand and constant elasticity of substitution, 149–150
consumer sovereignty (CS), 392
consumer surplus, 580
contact process, 630
contagion threshold, 615–618, 620
contingent claims/contracts. *See* prediction markets
continuous double market, 654, 662, 666–667
convergence, 342–344, 373, 523–524, 669; *see also* learning
  rates, 342–344, 523–524
  times, 669
convex program, 104, 105–109, 112
convex programming for market equilibria
  approximate equilibrium, 138
  definitions, 136–137
  equilibrium *vs.* optimization, 139–140
  exchange economies and weak gross sustainability, 142–148
  Fisher model with homogeneous consumers, 141–142
  gross substitutability, 138
  limitations, 150–152
  models with production, 152–155
  overview, 135–136, 155–156
  tâtonnement process, 137–138, 144, 147
  utility function special forms, 139, 148–150
cooperative game theory
  barter-based system, 600–601
  and cost sharing, 21–22, 385–387
  graphical games, 177
  overview, 20–21
  in peer-to-peer networks, 588–589, 593, 596
  reputation as incentive, 596–600
  strong Nash equilibrium, 21
  in wireless networks, 589
coordination game, 7–8, 614–618
coordination ratio. *See* price of anarchy
core, 22, 387–391, 402
correctness and privacy properties, 184, 194–195, 197
correlated equilibrium
  approximating, 48
  definition, 46, 47, 90
  ex ante, 196
  in graphical games, 161–163, 169–175
  Markov networks, 170–174
  mediators, removing, 192–195
  vs. Nash equilibria, 47–48
  overview, 14–16, 45–47
  regret minimization, 88–92
  in succinct games, 48–49
  and swap regret minimization, 90–91
cost benchmark, 352
cost function, 462, 663–665
cost matrix, 4, 5, 8
cost-sharing
  and cooperative games, 385–387
  core, 387–391
  facility location game, 397–402
  and fair division, 21–22, 347
  games, 501
  group-strategyproof mechanisms and cross-monotonic schemes, 391–394
  history, 406–408
  limitations of cross-monotonic schemes, 400–402
  mechanism, 392
  multicast transmission mechanism, 367–370
  overview, 405–406
  primal-dual schema, 394–400
  Shapley value and Nash bargaining solution, 402–405
  submodular game, 395–397
  theorems, 388, 389, 391, 394, 396, 398, 401, 404, 405
costs. *See also* prices
  censorship, 642–643
  defense *vs.* attack, 644
  defining, 9
  function, 9–10
Credence system, 597
critical payment, 274, 419, 430–431
critical values, 229
cross-monotonic cost-sharing schemes, 391–394, 396–397, 400–402
cryptography
  game theory influences on, 197–202
  game theory notions and settings, 187–189
  history, 203–204
  influence on game theory, 191–197
  multiparty computation, 181–182, 185–187
  multiparty computation *vs.* games, 189–191
  overview, 202
  security of multiparty computation, 182–185
CS. *See* consumer sovereignty
currency-based p2p systems, 594, 601–602

DAMD. *See* distributed algorithmic mechanism design

decision making in uncertain environment, 79–81. *See also* regret analysis
decision policy, 414
decomposition-based mechanism, 312–314
deferred acceptance algorithm, 256–258
degenerate games, 56, 65–66
delegation defense, 646
demand bundle, 284, 292–294
denial of service attacks, 634
derandomization, 355
design metric and inefficiency of equilibria, 454–456
design of scalable resource allocation mechanisms. *See* scalable resource allocation mechanisms
deterministic algorithm, 308–309
deterministic optimal price auction, 340
dictatorship, 214, 247
diffusion of innovations, 613–614, 622, 627–630
digital goods auctions
  competitive model, 345–346
  consensus estimation and truthfulness with high probability, 349–350
  convergence rates, 342–344
  decision problem, 347
  definition, 332
  theorems, 340
  and virtual surplus, 338
diminishing returns, 621, 624–626, 628
direct reciprocity, 594
direct-revelation online mechanisms, 414–416
disagreement outcome, 404–405
discrete tâtonnement process, 144, 147
dispute wheel, 373–374, 378–380
distance-vector, 371
distributed algorithmic mechanism design (DAMD)
  vs. algorithmic mechanism design, 365, 380
  combining networking and mechanism design perspectives, 376–379
  history, 380–381
  interdomain routing, 374–376
  multicast transmission cost-sharing, 367–370
  networking perspective, interdomain routing, 371–374
  open problems, 380
  overview, 363–365, 379–380
  theorems, 369, 370, 378
  of Vickrey–Clarke–Groves mechanisms, 366–367
distributed computation through markets, 665–669, 670–671
distributed mechanism, 375
distributed reputation systems, 693
distributed shortest-path routing, 481
divisible matching problem, 660–661
divisible *vs.* indivisible orders, 659
dominant strategies, 10–12, 91–92, 222–225, 317–320
dominant strategy incentive-compatible (DSIC), 415, 428, 430, 436
dominated strategy, 60
DOP auction. *See* deterministic optimal price auction
double marginalization problem, 586
DSIC. *See* dominant strategy incentive-compatible
dual growth process, 109–110
duopoly pricing, 580
dynamic aspects of sponsored search auctions, 707–711
dynamic attacks in reputation systems, 694
dynamic environments and online mechanism design, 413–417
dynamic parimutuel markets, 664–665
dynamic VCG mechanism, 433–434
dynamics of regret minimization, 99

early-arrival misreports, 415, 430
early stopping, 190
economics *vs.* computer science, 301–303
effective bandwidth pricing, 587
efficiency in sponsored search auctions, 703–705
efficient market hypothesis, 657, 672
egalitarian function, 443
Eigentrust algorithm, 597
Eisenberg–Gale program
  combinatorial algorithms, 104
  convex, 105–108, 155
  Nash bargaining solution, 402
  primal-dual schema, 109
elastic traffic, 584–585
elasticity of substitution, 139
elections and mechanism design, 209, 211–212
electronic market design, 210
Ellipsoid method, 156
empirical distribution, 339–341
empirical Myerson mechanism, 339–341
empty threats, 195–196, 201
envy-freedom, 355, 712
epidemic. *See* cascading behavior in networks
equilibria
  approximate, 45
  artificial, 61
  atomic flow, 466

equilibria (*cont.*)
Bayesian-Nash, 235
complexity of finding, 16, 29–31
computational, 191
correlated, 14–16, 45–49
equilibrium price, 23, 25, 108–109, 135
finding. *See* finding equilibria
graphical games. *See* graphical games
for identical machines, 522–524, 529–533
inefficiency. *See* inefficiency of equilibria
via labeled polytopes, 57–60
of markets. *See* market equilibria
Nash. *See* Nash equilibrium
nonatomic flow, 463
noncooperatively computable, 198
vs. optimization, 139–140
price characterization, 667–669
reduced strategic form, 69–70
regret analysis. *See* regret analysis
sequence form, 73–74
in sponsored search auctions, 705–707
subgame perfect, 19–20, 68–69
for uniformly related machines, 524–529, 533–537
Wardrop. *See* Wardrop equilibria
Euler's identity, 142
evolutionarily stable strategy (ESS), 718–723, 729–731, 734
evolutionary game theory. *See* computational evolutionary game theory
ex ante correlated equilibrium, 196
ex-post incentive compatible. *See* incentive compatible mechanisms
ex-post Nash equilibrium, 375–376, 377–379
ExactTreeNash, 168, 177
exchange economy, 136, 142–148, 566
exchange model. *See* Arrow–Debreu model
exclusivity, 197
existence and uniqueness in atomic selfish routing, 470–472
existence and uniqueness in nonatomic selfish routing, 468–470
expected capacity pricing, 587
exporting routes in BGP, 372–373
exposure problem, 292
expressiveness *vs.* simplicity in language, 279
extensive game, 40, 54, 66–68, 188–189, 195–197
external regret
in constant sum games, 89–90
generic reduction to swap regret, 92–94
minimization of, 82–88
model, 81–82
overview, 80–81
and partial information model, 94–96
externality, 273, 579

facet, 57
facility location game
and cost sharing, 386–387, 389–390
and network formation games, 502–506
open problems, 510–511
primal-dual scheme and cross-monotonicity, 397–402
Shapley values and, 403
fair division, 21–22
Fair, Optimal eXchange (FOX) protocol, 601
fair sharing rule, 489
fairness, 184, 194, 355, 501, 572, 581, 584, 639
faulty parties, 182–184, 186
FCC auctions, 269
feedback in reputation systems, 683–689
file-sharing game, 594–596, 640
finding equilibria
PPAD, 36–39
complexity, 16
correlated equilibrium, 45–49
Lemke–Howson algorithm, 33–36
NP-completeness and Nash equilibrium, 31–33
overview, 29–31, 49–50
reduction to Brouwer, 41–45
succinct game representations, 39–41
first price auction (Bayesian analysis), 234–236, 335
first welfare theorem, 103, 277
Fisher's model
Arrow–Debreu model and, 121–122
concave utilities, 131
exchange model with proportional endowments, 140
with homogeneous consumers, 141–142
linear case, 104, 105–108, 121, 131
linear utilities, 121–122, 131
fitness function, 718–719, 729–732
fixed pricing, 588
fixpoint. *See* Brouwer's fixpoint theorem
flat fees, 588
flow, 462, 463, 465, 468–470, 723
forecast, 653–654. *See also* prediction markets
formation games and network design. *See* network formation games
FPTAS. *See* fully polynomial time approximation schemes
fractional allocations
algorithm, 306–307
domain, 311
load function, 307

optimum, 314–315
free-market environment, 597–598
free-riding, 595, 597, 599, 601, 608, 637, 647
frugality, 350–354
full information model, 81
fully mixed equilibria, 529–533
fully mixed Nash equilibrium conjecture, 531
fully polynomial time approximation schemes (FPTAS), 607

gadgets, 42–43
game theory
computational evolutionary. *See* computational evolutionary game theory
and computer science, 363–364
cryptography, influences on, 197–202
efficiency, 191
and information security, 635–636
vs. issues in cryptography, 189
and multiparty computation. *See* multiparty computation (MPC)
notions and settings, 187–189
and regret minimization, 88–92
game tree, 54, 68, 70, 72–74
games. *See also* specific game names and types
aborting, 188, 190
battle of the sexes, 7–12
Bayesian, 20
best response and learning in, 18, 30–31
compactly represented, 9–10
cooperative, 20–22
cooperative and cost sharing, 385–387
coordination, 7–8, 614–620
cost sharing, 501
definition, 3, 88
graphical. *See* graphical games
ISP routing, 4–5
matching pennies, 8–9
pricing, 14, 502
prisoners' dilemma, 3–6, 443–444, 446–447, 595, 680, 681
repeated and online, 356
routing. *See* routing games
routing congestion, 7–8, 96–99
simultaneous move, 9
standard form, 9–10
succinct representations of, 39–41
tragedy of the commons, 6–7, 595
transferable utility, 21, 385–386, 387–391
two-person zero-sum, 16–18, 73
ultimatum, 19–20
with turns, 18–20
Gao–Rexford conditions, 376–380
general equilibrium theory, 22–23, 103
General Threshold Model, 619–620, 626
generalized first price (GFP) auctions, 702, 704–705
generalized median voter scheme (g.m.v.s.), 250, 251
generalized second price (GSP) auctions, 702, 704–706
generalized-WMON, 318–319
Gibbard–Satterthwaite theorem, 213–215, 243, 244
Gittins' index policy, 435
global connection game, 488–489, 494–498, 500–502, 509–510
global trust values, 597
goods. *See* market equilibria
government policy and mechanism design, 210, 221
graphical exchange economies, 176–177, 178
graphical games
complexity of finding Nash equilibrium, 40
computational benefits, 160
correlated equilibrium, 161–163, 169–175
definitions, 161–163
future research and open problems, 177
interdisciplinary benefits, 160
Markov networks, 170–174
Nash equilibrium in, 160–161
Nash equilibrium in tree graphical games, 164–169
overview, 159–161, 177–178
structural benefits, 160
greedy algorithms, 83–84, 315, 522
greedy auctions, 273–274, 422, 709
Green-Laffont, 368
grim-trigger strategy, 601, 681, 683
gross substitutability, 138, 145
group-strategyproof mechanisms, 391–394
GS. *See* gross substitutability
GSP auctions. *See* generalized second price (GSP) auctions

ham sandwich problem, 38
Hawks and Doves game, 719–720, 734
hidden actions, 239, 594, 602–609, 636–638, 648
hill-climbing, 623–624, 630
hiring-a-team auctions, 351
hiring, secretary problem, 424–425, 427
honest-but-curious parties, 182, 186, 197
honest parties, 182, 183
hot potato routing, 602
house allocation problem, 253–255, 262, 263

IC. *See* incentive compatible mechanisms
idea futures. *See* prediction markets
ideal model, 183
identity,682. *See also* reputation systems
IDoWDS, 200–202
imitative dynamics of selfish routing model, 723–726, 734
importing routes in BGP, 372
improvement step, 519–520, 522–524, 528
incentive compatible differentiated pricing, 589–590
incentive compatible mechanisms
  approximation in ascending auctions, 286
  characterizations of, 225–226
  direct characterization, 226
  interdomain routing, 375
  mechanisms with money, 217–218
  price uniqueness, 230–231
  randomized mechanisms, 231–233
  scalable resource allocation mechanisms, 560
  single-minded bidders, approximation, 272–275
  single-parameter domains, 228–230
  social choice, 214, 215
  weak monotonicity, 226–227
  weighted Vickrey–Clarke–Groves mechanisms, 227–228
incentives and information security. *See* information security
incentives for honest reporting, 690
incentives in communication networks. *See* communications networks
incentives in peer-to-peer networks. *See* peer-to-peer networks (P2P)
incomplete information games, 187–188, 222–223, 647
incremental cost-sharing, 403
incremental function, 620, 621, 624–626
incumbents, 717, 718, 720, 729–732
Independent Cascade Model, 621, 625
independent private values, 222–223
indirect reciprocity, 594, 596
individual rationality (IR), 219, 252, 333,419; *see also* voluntary participation
indivisible matching problem, 659–660
indivisible order matching, 660, 661
inefficiency of equilibria
  communications networks. *See* communications networks
  as a design metric, 454–456
  examples, 446–452
  history, 456–457
  measures of, 444–445
  in network formation games. *See* network formation games
  overview, 443–444
  price of anarchy, 445
  price of stability, 446
  in resource allocation. *See* scalable resource allocation mechanisms
  in routing games. *See* routing games
  in selfish load balancing. *See* selfish load balancing
inequalities
  binding, 57–59
  characterizing equilibrium, 154
  correlated equilibrium, 46
  irredundant, 57
  Jensen's, 727
infinite time horizon and discounting, 434
influential sets of nodes, 622–627, 630
information aggregation problem, 651–655
information cascades, 684
information markets. *See* prediction markets
information-measuring software security, 638
information security
  censorship resistance economics, 640–643
  complex networks and topology, 643–646
  informational asymmetries, 636–639
  insurance-based approaches to information security, 639
  misaligned incentives, 634–636
  overview, 633–634, 646–647
  in reputation systems, 678
information set, 54, 67
initiation fee, 682
integer pivoting, 63–65
integrality gap, 314–316
interdependent values, 238–239
interdomain routing
  combining networking and mechanism design perspectives, 376–379
  introduction, 370–371
  mechanism design perspective, 374–376
  networking perspective, 371–374
internal regret. *See* swap regret
Internet Service Providers (ISPs), 4–5, 587, 602
invisible hand, 217
Iowa Electronic Market (IEM), 655, 671
irrelevant information sets, 70–72
IR. *See* individual rationality
item-price ascending auctions, 290–292, 295
iterated deletion of weakly dominated strategies (IDoWDS), 200–202
iterative auctions (query model), 283–287
iterative wrapper, 322

Jensen's inequality, 727
job scheduling problem, 302–310
joint deviation. *See* coalitions of agents
joint forecast, 653

K-rank-sybilproof, 691–692
k-resiliency, 191–194, 200
Karush-Kuhn-Tucker (KKT) conditions, 104, 106, 107, 109–110, 125, 128, 140, 141, 573, 575
Kelly's model, 104–105, 124–125, 402
keyword auctions. *See* sponsored search auctions
kidney matching model, 262, 263
KKT conditions. *See* Karush-Kuhn-Tucker (KKT) conditions
known interesting-set assumption, 429–430
known single-minded combinatorial auction, 332
known single-minded (KSM) players, 323–324, 418
KP model. *See* load balancing games
Kuhn's theorem, 71

labels, 57–60
labeled polytopes and equilibria, 57–60
Lagrangian function and multipliers, 173, 547, 556, 573–575, 578
large actions spaces and regret minimization, 98
largest processing time (LPT) algorithm, 528–529
late-departure misreports, 415, 423, 430
latency function, 96, 97, 584, 724,726; *see also* cost function
lattice formulation, 259–260, 263
LCP. *See* linear complementarity problem
leaders, 43
learning. *See also* regret analysis
  coordinated learning, 435
  response and learning, 18, 30–31, 54
Lemke–Howson algorithm, 33–36, 59, 61–63, 391
Lemke's algorithm, 74
Leontief functions, 139, 152
LH algorithm. *See* Lemke–Howson algorithm
liability, in information security, 634–636
limited misreports, 415, 419, 420, 423, 428–430
linear complementarity problem, 74
linear exchange economies, 149
linear programming relaxation, 260–261, 275–278, 284–285, 388, 395, 406
Linear Threshold Model, 619, 626
link-state, 371, 373
Lipschitz continuous, 723–725
LiveJournal, 627–630
load balancing games
  defining price of anarchy, 521–522
  example, 520–521
  history, 538–540
  introduction to, 518–520
  mixed equilibria on identical machines, 529–533
  mixed equilibria on uniformly related machines, 533–537
  overview, 517–518, 537–538
  price of anarchy, 521–522
  pure equilibria for identical machines, 522–524
  pure equilibria for uniformly related machines, 524–529
local connection game, 489–494, 506–509
local effect games, 41
local game matrices, 162
local neighborhood equivalence, 170–171
local-to-global link, 624, 626
locally envy-free, 705–707
locally optimal solutions, 378
logarithmic scoring rule, 686, 687
loser-if-silent, 325
low communication, 544, 551–552
low-dimensional strategies, 544, 551–552, 564
lower bounds, 287–289, 346–347, 421
LP formulation. *See* linear programming relaxation
Lyapunov function, 575–576, 725–726, 734

MAB. *See* partial information model
makespan minimization, 305–310, 450, 452, 517, 518, 525–530
malicious parties, 182
manipulation-resistant reputation systems. *See* reputation systems (manipulation-resistant)
marginal cost (MC), 368–370, 468
marginal cost pricing, 478–480, 588
marginal traders, 655
marginal utility, 562
market-based approaches to information security, 638–639
market clearing prices
  bid format and price formation, 666
  definition, 23–24, 105
  equilibrium price characterization, 668–669
  proportional allocation mechanism, 545–546
  rational expectations equilibrium, 656
  in resource allocation, 555–557
  smooth market-clearing mechanism, 552–553
  and Walrasian equilibrium, 277

market equilibria
Arrow–Debreu model, 121–122
auction-based algorithm, 122–124
balanced flows, 111–115
combinatorial algorithms for, 103–105
convex programming limitations, 150–152
convex programming models with production, 152–155
convex programming techniques for, 135–141, 155–156
exchange economies and weak gross sustainability, 142–148
finding tight sets, 117–118
Fisher model with homogeneous consumers, 141–142
Fisher's linear case and Eisenberg–Gale convex program, 105–108
graphical exchange economies, 176–177
and mechanism design, 209
open problems, 109
overview, 22–23, 131
prices as equilibrium prices, 108–109
in resource allocation markets, 124–125
simple algorithm, 23–26
single-source multiple-sink markets algorithm, 126–131
utility functions for, 148–150
market maker, 652, 654–655, 662–665, 670
market power, 454
market predictions. *See* prediction markets
market scoring rules, 663–664
marketing. *See* cascading behavior in networks; sponsored search auctions
Markov decision process, 432, 435
Markov networks, 170–174
Markov process, 93
matching. *See* stable matching problem
matching pennies game, 8–9
matching problem, 659–661
matrix form, 9–10
matroid, 353
maximal Nash subset, 66
maximum aggregate utility, 550–551
maximum flow, 112–114, 690, 692
MC. *See* marginal cost (MC)
McDiarmid's inequality, 343
MDP. *See* Markov decision process model
measures of inefficiency, 444–445
mechanism design
Bayesian-Nash implementation, 233–237
Clarke pivot rule, 219–220
combinatorial auctions. *See* combinatorial auctions
complete information models, 239
computationally efficient mechanisms. *See* approximation mechanisms
definition, 209
direct characterization of incentive compatible mechanisms, 226
distributed algorithmic. *See* distributed algorithmic mechanism design
examples and applications, 209–211
hidden actions, 239
history, 239–240
implementation in dominant strategies, 222–225
incentive compatible, 217–218, 225–226
interdependent values, 238–239
online. *See* online mechanism design
price uniqueness, 230–231
randomized mechanisms, 231–233
risk aversion model, 238
single-parameter domains, 228–230
social choice, 211–215
theorems, 213, 214, 219, 227–230, 232, 236
Vickrey auction, 216–217
Vickrey–Clarke–Groves mechanisms, 218–219
weak monotonicity, 226–227
weighted Vickrey–Clarke–Groves mechanisms, 227–228
mechanism design and profit maximization
Bayesian optimal mechanism design, 335–338
examples and applications, 331–332
frugality, 350–354
history, 357–358
overview, 331–334
prior-free approximations to the optimal mechanism, 339–344
prior-free optimal mechanism design, 344–350
open problems, 354–357
theorems, 334, 336, 338, 340, 341, 343, 345, 346, 348, 353
truthful mechanisms, 333–334
mechanism design without money
future research and open problems, 262
history, 263
house allocation problem, 253–255
lattice formulation, 259–260
overview, 243–244
single-peaked preferences over policies, 244–252
stable matchings, 255–262
theorems, 247, 251, 254, 256–258, 260, 261
median voter rule, 246
mediated games, 188

mediators, removing in correlated equilibrium, 192–195
minimax theorem, 89–90
misreports, 415, 419, 420, 423, 428–430
mixed strategy
  bimatrix games and best response, 54
  graphical games, 162, 167
  introduction to, 8–9
  in load balancing games, 518, 529–537
  vs. pure strategies, 520–522
mixed strategy Nash equilibria, 13, 450–452
mobile ad hoc networks (MANETs), 602
model-free *vs.* model-based frameworks, 413
monopoly pricing and equilibrium, 580, 582
monotone algorithm for job scheduling, 305–310
monotone hazard rate, 337
monotonicity
  cross-, 392–393
  deterministic policy, 418
  in facility location problems, 505
  in peer-to-peer networks, 606, 619, 623–624
  progressive cascading behavior, 616–617
  single-minded bidders, 274
  weak, 226–227, 304–305, 307–309, 318–319, 428
Moulin's theorem, 392–394, 402, 403, 407, 408
MPC. *See* multiparty computation
multi-armed bandits problem (MAB). *See* partial information model
multicast cost-sharing, 332, 367–370
multicommodity flow network, 462
multidimensional domains, 302, 310–317
multiparty computation (MPC)
  cryptographic influences on game theory, 191–197
  existing results, 185–187
  game theory influences on cryptography, 197–202
  game theory notions and settings, 187–189
  vs. games, 189–191
  generalizations, 182
  history, 203–204
  overview, 181–182, 202
  rational, 199–202
  security of, 182–185
  theorems, 185, 193, 199
multipath routing, 603
multiplayer games. *See also* graphical games; specific multiplayer games
  definitions, 161–163
  graphical, 159–161
multiplication game, 42
mutants, 717, 718, 722, 729–732
Myerson's mechanism, 337–339, 341–342, 357, 435, 703
myopic behavior, 667

Nash bargaining solution, 404–405
Nash equilibrium
  aggregate utility, 550–551
  Bayesian-Nash implementation, 233–237
  and bimatrix games, 54–57, 152
  is a combinatorial problem, 31
  computational, 191
  and correlated equilibrium, 14–15, 163
  in degenerate games, 66
  and evolutionarily stable strategy, 719–720
  finding. *See* finding equilibria
  and frugality, 352
  in games with turns, 18–20
  games without, 13–14
  in graphical games, 160–162
  inefficiency of equilibria, 446
  k-resiliency, 194
  and Lemke–Howson algorithm, 33–36, 61–63
  mixed strategy, 13, 529–533
  in network formation games, 488
  and NP-completeness, 31–33
  in potential games, 497, 499–500
  in resource allocation games, 547–549
  pure strategy, 12–13, 55, 519, 520, 528–529, 724
  and regret minimization, 96–99
  selfish routing, evolutionary dynamics of, 725–726
  in Shapley network design games, 449–450
  smooth market-clearing mechanism, 552–553
  strong, 21
  subgame perfect, 19–20, 68–69, 681–683
  with succinct game representations, 39–41
  symmetric, 30–31, 34
  theorems, 13, 17, 34, 47
  in tree graphical games, 164–169
  in two-person zero-sum games, 16–18
  without full information (Bayesian games), 20
Nashification, 529
NashProp, 161, 164, 168–169, 177–178
NCC. *See* noncooperatively computable (NCC)
NE. *See* Nash equilibrium
network complexity, 365, 367–370, 380, 381
network congestion games, 41
network formation games
  and facility location, 502–506
  global connection games, 500–501
  local connection games, 489–494, 506–509

network formation games (*cont.*)
Nash equilibrium in potential games, 499–500
open problems, 508–511
overview, 448–450, 487–489
potential function method and price of stability, 498–499
potential games and congestion games, 497–498
potential games and global connection games, 494–497, 509–510
theorems, 491–493, 497, 498, 500, 501, 503, 505, 506
neutrality, 318, 320
no dispute wheel, 373–374, 378–380
no positive transfer (NPT), 392
no-trade theorems, 657, 663, 672
nonatomic selfish routing, 461–465, 468–470, 472–475, 478, 480–482, 499
noncooperatively computable (NCC), 197–199
nondegenerate, 56, 60
nondirect revelation, 223–224
nonlinear Pigou's example, 464, 479
nonoblivious cost-sharing scheme, 501
nonprogressive *vs*. progressive processes, 616–617, 621–622
nontransferable utilities (NTU) in cooperative games, 385–386, 391,405. *See also* house allocation problem
nonutilitarian, 518
normal form games, 161; *see also* standard form
Northwest corner rule, 704, 712
NP-completeness and Nash equilibrium, 31–33, 271, 623, 661, 720, 723
NTU. *See* nontransferable utilities

oblivious cost-sharing schemes, 501
oligopoly pricing and equilibrium, 582–583, 586
one-dimensional strategies, 564
one-shot simultaneous move games, 9
online allocation problem, 707–711
online mechanism
adaptive, limited supply auction, 424–427
challenge of, 412–413
dynamic auction with expiring items, 420–424
dynamic environments, 413–417
dynamic Vickrey–Clarke–Groves mechanism, 433–434
ex-post incentive compatible, 428
future research, 435–436
history, 436–437
known interesting-set assumption, 429–430
Markov decision process model, 432
overview, 411–413
planning in model-based environments, 434–435
simple-price-based online auctions, 428
stochastic policies, 430–431
theorems, 419, 420, 422, 423, 426, 427, 430, 433
truthfulness for single-value preference domains, 417–420
onto condition, 245, 247, 249–252, 263
operationally complete market, 662
opportunistic unchoking mechanism, 600
opportunity cost, 708–709
optimal contract, 605–607
optimal sale price, 338, 341, 342
optimal single price profit, 345, 348
optimal stopping theory, 424–425
optimization program in sponsored search engines, 710
optimization *vs*. equilibrium, 139–140
option set for strategy-proofness, 248
OR bids, 280–283
"OR" technology, 603–604, 606, 607, 669
organisms, in evolutionary game theory, 717–718

P2P. *See* peer-to-peer networks (P2P)
PageRank, 404, 406, 408, 597, 689–690, 692
pairwise stable equilibrium, 507, 615, 729
parallel information sets, 70
parallel-serial topologies, 585–586
Pareto-optimality, 103, 245, 249, 662
parimutuel games, 664–665
partial information model, 81, 94–96
parties in multiparty computation, 182–184, 193–194
partition model of knowledge, 653
path auctions, 351, 353, 354
path-vector, 371–373
Pathrank algorithm, 690
pay per click, 699, 701, 703, 707, 711
pay-your-dues (PYD) strategy, 682–683, 695
payment policy, 414–415, 422
payoffs
in bimatrix games, 54, 55
defining, 9
evolutionarily stable strategy, 720–721
and inefficiency, 444, 453
in parimutuel games, 665
with risk-neutral players, 13
in scalable resource allocation mechanisms, 555
sequence form, 72–73

payoff matrix, 8, 12, 15
peer-prediction scoring, 686–689
peer-to-peer networks (P2P)
  barter-based system, 600–601
  and censorship resistance, 640
  currency as incentive, 601–602
  pricing and incentive models, 588–589
  file-sharing game, 594–596
  hidden actions, 602–608, 637
  history, 608–609
  open problems, 608
  overview, 593–594, 608
  reputation as incentive, 596–600, 678
  theorems, 607
peering, 377
perfect information, 67
perfect recall, 54, 71
perfect security, 184
phantom feedback, 679
Pigou's example, 447–448, 456, 462–464, 469, 472–474, 479
Pigouvian taxes, 480, 580; *see also* marginal cost pricing
pivoting, 63–65
players. *See also* bidders; specific games
  leaders, 43
  limited information, 20
  loser-if-silent, 325
  in multiplayer games. *See* graphical games
  payoffs. *See* payoffs
  in peer-to-peer networks, 596
  price anticipating, 547–549
  price takers, 546–547, 573, 574
  risk-neutral, 13
  and transferable utility, 21–22
  in two-person zero-sum games, 16–18
policy-consistency, 377–379
pollution game, 5–6
polyhedra, 53, 57
polynomial local search (PLS) problems, 499–500
polynomial parity argument (directed case). *See* PPAD
polynomial weights (PW) algorithm, 86–88
polytopes, 57–60, 65
population and strategy, 595–596, 613–614, 618–622. *See also* computational evolutionary game theory
positive association of differences (PAD), 318, 319
potential function method, 448, 468, 469, 471, 472, 482, 489, 494, 496
potential games
  congestion games, 497–498
  facility location games, 503–504
  global connection games, 494–497, 509–510
  Nash equilibrium, 499–500
  price of stability, 498–499
PPAD, 36–39, 151–152, 156
PPAD-complete, 16, 41–42, 44, 45
prediction markets
  automated market makers, 662–665
  combinatorial, 657–662
  definition, 651–652
  distributed computation, 665–669
  history, 671–672
  open problems, 670–671
  setup and notation, 652–654
  survey of field, 654–657
  theorems, 660, 661, 668, 669
preference ordering, 9
prices
  equilibrium, 123
price anticipating users (in resource allocation games), 547–549
price characterization, 667–669
price competition game, 583
price correspondences, 657
price discriminate, 545
price formation, 666–667
price of anarchy
  of atomic selfish routing, 459, 463–466, 468–470, 473–479, 480–481
  coordination ratio, 456
  definition, 445, 517, 520–522
  facility location games, 504–505, 511
  fully mixed Nash equilibrium, 531–533
  in global connection games, 495
  in local connection games, 491–494
  mixed equilibria on uniformly related machines, 533
  of nonatomic selfish routing, 463–464, 472–477, 481, 447–448
  of the proportional sharing mechanism, 455–456
  pure equilibria for identical machines, 522–523
  pure equilibria for uniformly related machines, 524–528
  pure *vs*. mixed equilibria, 537–538
  reducing in routing games, 478–480
  of scalable resource allocation mechanisms, 549–551, 558–559
  in scheduling games, 451
  utility games, 505, 507
price of stability, 446–449, 490–491, 495, 498–499, 520
price of unaccountability (POU), 605–607

price takers (in resource allocation games), 546–547, 573, 574, 576
prices
  automated market makers, 662–665
  in communications networks. *See* communications networks
  for differentiated services, 587–588
  equilibrium, 23, 25, 108–109, 135; *see also* market equilibria
  and information security, 638
  market clearing, 23, 24, 105, 106, 122; *see also* market clearing prices
  in sponsored search auctions, 699–701
  uniqueness of, 230–231
pricing game, 14, 502
primal-dual schema, 104, 109–110, 126, 291, 394–400, 407
Prim's algorithm, 501
principal-agent model in peer-to-peer networks, 602–606
prior distribution, 333, 337, 339
prior-free mechanism design, 344–350
  convergence rates, 342–344
  empirical distributions, 339–341
  random sampling, 341–342
prior probability distribution,653; *see also* Bayesian-Nash implementation
Prisoners' dilemma, 3–6, 443–444, 446–447, 595, 680, 681
privacy and correctness properties, 184, 194–195, 197
probabilistic functions, 182, 186, 201, 620, 679
procurement auction, 220, 269
profit benchmark, 333, 344–345, 349, 350, 354
profit extraction problem, 347
profit extractor, 347–350, 358
profit maximization and mechanism design
  Bayesian optimal mechanism design, 335–338
  in communications networks, 579–582
  examples and applications, 331–332
  frugality, 350–354
  history, 357–358
  overview, 331–334
  prior-free approximations to the optimal mechanism, 339–344
  prior-free optimal mechanism design, 344–350
  future research, 354–357
  theorems, 334, 336, 338, 340, 341, 343, 345, 346, 348, 350, 353
progressive *vs*. nonprogressive processes, 616–617, 621–622
proportional allocation mechanism, 544–551, 558, 564
proportional fairness, 125
proportional sharing, 452, 455–456
pseudonyms, 597, 679, 683
public good cost sharing, 251–252
pure strategy Nash equilibrium, 12–13, 55, 466, 519, 520, 528–529, 724
PW algorithm. *See* polynomial weights (PW) algorithm

quadratic scoring rule market maker, 664
quality of service (QoS), 587
query model (iterative auctions), 283–287, 310

random ordering, 403, 424, 427
random replenishment, 644
random sampling empirical Myerson, 341–342
random sampling optimal price (RSOP) auction, 341–346, 355, 357
random sampling profit extraction auction, 348–349
randomized-greedy (RG) algorithm, 83, 84
randomized incentive compatible mechanisms, 231–233
randomized rounding, 307–308
randomized scheduling algorithm, 307–308
randomized strategies, 8–9; *see also* mixed strategies
randomized weighted majority (RWM) algorithm, 85–86
rank-strategyproof, 690
rater reputations, 679–680, 684–688, 695
rational expectations equilibrium, 652, 656–657, 672
rational multiparty computation, 199–202
realization plan, 71–74
reciprocity, 594, 600
recommendation incentive programs, 626–627, 630
Red-Blue utility model, 640–641
reduced strategy, 69–70
reductions, 41–45
regret analysis
  external regret minimization, 82–88
  generic reduction from external to swap regret, 92–94
  lower bounds, 87–88
  model, 81–82
  overview, 80–81, 99
  partial information model, 94–96
  regret minimization and game theory, 88–92
  regret minimization strategies in routing games, 96–99

theorems, 82–85, 87, 88
relative optimality, 333; *see also* competitive analysis
replicator dynamics, 727
reputation as incentive, 594, 596–600, 678
reputation systems (manipulation-resistant)
dynamics, 678
effect of, 680–683
eliciting effort and honest feedback, 683–689
history, 694–695
importance of, 677–680
meta-evaluation, 684
metrics and benchmarks in reputation systems, 694
open problems and extensions, 693–694
sybilproofness, 690–693
theorems, 691, 692
and transitive trust, 689–693
whitewashing, 682–683
residency matching, 255
resilient equilibrium, 191–192
resource allocation markets, 124–125, 452–454,573. *See also* communications networks; scalable resource allocation mechanisms
revelation principle, 12, 224–225, 231, 234, 356, 416–417, 589
revenue equivalence, 236–237, 356, 705
revenue maximization. *See* profit maximization and mechanism design
reverse auction, 220
ring structure, 644–645, 647
risk aversion model, 238
risk-neutral, 13
Roberts theorem, 228
rock-paper-scissors game, 44, 45
routing congestion game, 7–8, 96–99; *see also* routing games
routing games
atomic selfish routing, 465–468, 482–483
Braess's Paradox, 464–465, 475, 481
existence and uniqueness, 468–470
vs. global connection games, 495
history, 480–483
network formation games. *See* network formation games
nonatomic selfish routing, 462–465, 480–482
nonexistence in weighted atomic instances, 467
overview, 461–462
Pigou's example, 447–448, 456, 462–464, 469, 472–474, 479
potential function, 470–472
price of anarchy in atomic selfish routing, 475–477
price of anarchy in nonatomic selfish routing, 472–475
reducing the price of anarchy, 478–480
theorems, 468, 471, 472, 476, 478, 479
routing matrix, 572, 575
routing protocol, 371–379
routing security, 636
RSEM. *See* random sampling empirical Myerson
RSOP auction. *See* random sampling optimal price (RSOP) auction
RSPE auction. *See* random sampling profit extraction auction
RWM algorithm. *See* randomized weighted majority (RWM) algorithm

satisfiability, 31–33, 500, 524, 529
scalable resource allocation mechanisms
characterization theorem, 551–559
history, 565–566
overview, 543–544, 564
proportional allocation, 544–551
theorems, 546, 547, 549, 554
Vickrey–Clarke–Groves approach to, 559–563
scalar strategy VCG mechanisms, 559–563
scale-free networks, 643, 648
scheduling games. *See* load balancing games
scheduling related machines, 303–304, 450–452, 577
scoring peer-prediction, 686–689
second-price auction. *See* Vickrey auction
second welfare theorem, 278
secret-sharing, 186–187, 200, 201
secretary problem, 424–425, 427
secure and broadcast channels, 185
securities markets. *See* prediction markets
security. *See* information security
security of multiparty computation, 182–185, 190
security parameters, 185
seeder, 600
selfish load balancing. *See* load balancing games
selfish routing, 447–448, 723–728; *see also* routing games
semihonest parties, 182
sequence form, 70–74
sequential decision problem, 431, 437
serial connection, 585–586
service differentiation, 598–600
Shamir secret-sharing scheme, 186, 187, 201
Shapley cost-sharing mechanism, 495

Shapley network design game, 448–450; *see also* network formation games
Shapley value, 22, 368–369, 402–405, 407–408, 489, 501
signal, 685, 687, 688
simple polytope, 60
simple pricing rules, 590
simultaneous move game, 9
simultaneous reporting game, 685
single-dimensional domains, 303–310; *see* single-parameter domains
single-item auction, 332, 335, 337, 338, 351
single-minded bidders, 270–275, 295, 323–324, 332
  greedy mechanism for single-minded bidders, 273–274
single-parameter domains, 228–230, 303–310, 350, 354, 356, 417–420
single-peaked preferences, 244–252
single-source multiple-sink markets algorithm, 126–131
single-value players, 322, 324–325
single-valued preference domains. *See* Single parameter domains
slots, 699
smart market, 587
Smith, Adam, 217
smooth market-clearing mechanism, 552–554
social choice
  Arrow's theorem, 212–213
  Condorcet's paradox, 211
  Gibbard–Satterthwaite theorem, 213–215
  and mechanism design, 209, 210
  and mechanisms with money, 216–222
  voting methods, 211–212
social choice function, 212–215, 225–226, 237, 405
social cost, 488, 490–491, 518, 520–522, 528
social network, 614–618, 622–625, 627, 637, 643, 630
social welfare function, 212–213, 215, 218
socially efficient networks, 488, 490, 682–683
sock puppet identities. *See* phantom feedback; Sybil attacks
software security, 638
solution concepts
  correlated equilibrium, 14–15
  dominant strategy, 10–12
  mixed strategy Nash equilibrium, 13
  pure strategy Nash equilibrium, 12–13
source routing, 481, 603
spanning tree auctions, 351
sparse games, 40
specification faithfulness, 601
spectrum auctions, 269, 295
SPNE. *See* subgame perfect equilibrium
sponsored search auctions
  discussion of practice, 712
  dynamic aspects of, 707–711
  equilibrium properties, 705–707
  history, 712–713
  models and mechanisms, 701–702
  open problems, 711–712
  overview, 699–701
  static model, 702–707
  theorems, 706, 709
stable matching problem
  college student matching, 255, 261
  deferred acceptance algorithm, 256–258
  extensions, 261–262
  lattice formulation, 259–260
  LP formulation, 260–261
  overview, 255
stalling, 433
standard form, 9–10
statistical security, 184
Steiner forest problem, 406, 407, 495
Stirling's formula, 288
stochastic policies, 430–431
strategic and privacy equivalence, 196
strategic form. *See* standard form
strategic network formation, 594, 609; *see also* network formation games
strategic voting, 211–212
strategy proof mechanism. *See* truthfulness
strategy-proof rules, 243–251, 258, 262, 263, 690
strategy, 9, 10, 12, 18, 556, 561
strict equilibrium, 586
strict incomplete information, 222–223
strict quasi-concavity, 137
strong Nash equilibrium, 21
strong truthfulness, 415, 430
subgame perfect equilibrium, 19–20, 68–69, 681–683
subgames, 54
submodular function, 624–626, 630
submodular games, 395–397, 403, 504
submodularity, 623–626
substitutes *vs.* complements, 139, 268, 290, 292
succinct game representations, 39–41, 48–49
supply and demand, 135; *see also* market equilibria
support, 31, 34–36, 54
surplus sharing problem,386; *see also* cost sharing

surplus vector, 112, 121, 659–660
surplus, 119–121, 335–337,583. *See also* market equilibria
swap regret
  definition, 80–82
  and dominated strategies, 91–92
  generic reduction from external to, 92–94
  minimization and correlated equilibrium, 90–91
swarming download, 600, 601
Sybil attacks, 597, 601, 602, 608, 679, 680, 690–693
symmetric game, 30, 40, 45–46, 340

Tarski's fixed point theorem, 259–260
tâtonnement process, 137–138, 144, 147
TCP congestion control, 104–105
thin market problem, 662
tit-for-tat strategy, 595, 596
top trading cycle mechanism, 254
traffic light example, 14–15
tragedy of the commons, 6–7, 595
transferable utilities (TU) in cooperative games, 21–22, 385–391
transitivity of trust, 679, 680, 689–693
tree graphical games, 164–169
TreeNash, 164–167, 176
trembling hand perfect equilibrium, 503
trusted parties, 182, 190
truthful with high probability
truthfulness
  adaptive limited-supply auction, 425–426
  automated market makers, 662–665
  in canonical expiring items environment, 412
  combinatorial auctions, 312–314
  and dominant strategy incentive-compatible, 415
  with high probability, 349–350
  and profit maximization, 356–357
  single-valued preference domains, 417–420
TU. *See* transferable utilities
two-person zero-sum games, 16–18, 73
two-player game equilibrium computation
  bimatrix games and best response, 54–57
  degenerate games, 65–66
  extensive games, 66–68
  further reading for, 75
  integer pivoting, 63–65
  via labeled polytopes, 57–60
  Lemke–Howson algorithm, 61–63
  overview, 53–54, 75–76
  reduced strategic form, 69–70
  sequence form, 70–73
ultimatum game, 19
uniqueness of prices, 230–231
unit demand, 280
upper envelope, 57, 59
users. *See* players
utilitarian function, 443
utility, 331, 334, 357
utility function
  Cobb-Douglas, 139, 143, 146, 155
  definition, 9–10
  gross substitutability, 138, 145
  in information security, 640–641
  Leontief, 139, 152
  market equilibria, 131, 148–150
  maximizing with convex programs, 106
  for scalable resource allocation mechanisms, 544–545, 556
  special forms of, 139

valuation, 12, 20, 216–222, 238–240, 268, 331–334, 335–339, 355, 356, 374
value queries, 284
variational inequalities, 473–474
VCG mechanism. *See* Vickrey–Clarke–Groves mechanisms
vertex-order attacks, 644–646
Vickrey auction, 11–12, 216–217, 220, 335, 422, 703–704
  reserve price, 338
Vickrey–Clarke–Groves mechanisms
  and Clarke pivot rule, 219, 221
  competitive communications network problems, 573
  definition, 218–219
  distributed implementation of, 366–367
  in dynamic environments, 434–435
  and frugality, 352–353
  incentive compatible approximation, 273
  marginal cost, 368–370
  multidimensional domains and combinatorial auctions, 311
  scalable resource allocation mechanisms, 559–564
  and Walrasian equilibrium, 292
  with scaler strategies, 559–563
  weighted, 227–228
viral marketing, 622–623, 626–627, 630
virtual surplus, 336, 337, 338
virtual valuation, 335–336, 338
voluntary participation (VT), 392, 608; *see also* individual rationality
voting and mechanism design, 209, 211–215, 246

voyeurism, 197

Walras' Law, 137, 147
Walrasian equilibrium, 277–279, 290–292, 121–122
Walrasian model. *See* Arrow–Debreu model
Wardrop equilibria, 480, 579–581, 724; *see also* equilibria nonatomic flow
Wardrop model of traffic flow, 96–98,585; *see also* selfish routing
weak gross substitutability, 131
weak gross sustainability (WGS), 138, 142–148
weak monotonicity, 226–227, 304–305, 307–309, 318–319, 428
weighted-packing problem, 271
threshold function, 669
weighted Vickrey–Clarke–Groves mechanisms, 227–228
WGS. *See* weak gross sustainability (WGS)
whitewashing attacks, 597, 601, 602, 608, 679, 682–683, 695
winner's curse, 238
wireless networks, 577, 588, 589
"The Wisdom of Crowds", 652
WMON. *See* weak monotonicity
worst-case analysis, 333, 357, 558; *see also* competitive analysis

XOR bids, 280–283, 668

Zermelo's algorithm, 69
zero-sum games, 16–18, 73, 662