

Index

- $\nabla\theta(x)$, xxx
- $\nabla_x(\cdot)$, xxxiv, 554
- $\partial f(x)$, xxxi, 127-128, 137-139, 142
- $H_x(\cdot)$, xxxiv, 554
- $\delta K_1(x^0)$, 147
- $\delta \bar{K}_1(x^0)$, 151
- $\langle v_1, \dots, v_n \rangle$, xix, 143, 145-156
- $\cong, \geq, >$, 3, xvi
- \setminus , xviii
- $O(n^r)$, xxiv, 160, 174
- \emptyset , xviii
- $[\Gamma, b]$, 314 – 315, 317, 321 – 322, 324, 328

- $\|A\|$, 363
- A_i, A_j , xvi, xvii, 3
- ACBV, 292-296
- Active
 - constraints, xxvi, 437, 445, 558, 560, 564-565
 - set, set method, xxxviii, 447-448
 - subspace, 446
- Accumulation pt., 361-362, 369-372, 375-378, 380, 384-385
- Adequate matrix, 86, 228, 235
- Affine func., xxiii, 124, 540
- Algorithm, xxiii
 - to check PD, 20-22
 - to check PSD, 22-23
- Almost complementary
 - basic vec., 72, 106, 273, 275, 278, 292
 - extreme half-line, 74, 109
 - feasible basic vec., 71-72, 75, 86, 106-109, 112
 - lexico feasible basis, 75, 86
 - property, 113
 - ray, 72, 107
 - solution, 117
 - vector, xxvii, 72, 117, 182
- Alternate sols. of LCP, 465-468
- Approximate
 - Brouwer fixed pts., 134
 - types 1, 2, 134
 - Kakutani fixed pts., 136
 - types 1, 2, 136
- Approx. opt. sols.
 - need for, 398
- Arithmetic-geometric means ineq., 579

- Armijo ineq., 424
- Armijo step size proc.
 - in line min., 405
 - 1st order, 405
 - 2nd order, 405
 - in unconstrained min., 424-425
- Artificial var., 67, 77, 98, 105, 254, 296
- Assignment, 529
- Assignment prob., 55
- At most one sol., 211, 219
- Attenuation factor, 404, 423

- $b(\mathbf{S})$, 316-317, 323, 325-326, 328
- $B(\mathbf{S})$, 316-318
- $[B, b]$, 314
- $\mathbf{B}(b; \bar{x})$, 318-320, 323-324
- $\mathbf{B}(a^0, \rho)$, 479-486
- $\text{Bd}(\mathbf{E})$, 347, 351, 355
- BFGS formula, XXi, 32-33, 38, 40, 430-431
- BFGS method, 430-431
- BFS, xxi, 3, 63, 69, 71, 73-75, 87, 90, 175, 255, 271, 281, 292, 304, 474-476
- Back substitution method, 336
- Backward diff. approx., 409
- Banach contraction mapping, 364
- Bard's method, 260-261
- Barr-Gilbert algo., 331-332
- Barrier func., 469-470
 - logarithmic, 469-470
- Basic
 - cols., 63
 - feasible sol., 3, 63-64
 - sol., xxx, 63
 - degenerate, xxx, 64
 - nondegenerate, xxx, 64
 - var., 63, 67, 70, 77-80
 - vec., 63, 67, 71, 78, 82-83
- Basis, 63
 - feasible, 63-64
 - infeasible, 64
 - inverse, 80-82, 154-157, 264-269, 272, 281-284
 - lexico feas., 65
 - terminal, 87
- Battle of the sexes, 43
- Bimatrix games, 41, 45, 95, 108-114

- Binding direction, 437
- Binding ineq. const., 163
- Block pivot, 203-204, 262
- Block pivoting method, 262-263
- Block principal pivoting, 203-204, 262
- Blocking var., 273-278
- Boiler problem, 391-394
- Bottom layer, 149-155
- Boundary, 149-150
- Boundary faces, 144-145, 150
- Bounded set, xxiii
- Bounded sol. set, 233, 237
- Branch and bound, 186, 466-467
- Branching, 164
- Bracket, 400-401, 403, 406-408, 410
 - how to select, 401
- Brouwer's fixed pt., 123, 128-134, 364
 - approx. for, 134
- C_0, C_+ -matrices, 86
- CQ, 172
- $\mathcal{C}(M)$, xix, 4-7, 218-219, 224, 228, 234, 240
- Candidate problem, 164-165
- Canonical tableau, 65-66, 68-70, 79
- Cardinality, xviii, xxi
- Cauchy-Schwartz ineq., xxxix, 481, 523
- Caution for NLP use, 545
- Ceiling, xvii
- Central diff. approx., 409
- Chandrasekaran's algo., 333-335, 359
- Characteristic values, 281-282, 285
- Chicken and egg prob., 29-31
- Cholesky factor, xl, 315, 327, 473
- Chord, 532
- Circumscribing sphere, 479
- Col. adequate mat., 85-86
- Combination vec., 314-315
 - opt., 314-315, 321
- Comb. search for active const., 564-565, 575
- Combinatorial styruature of LCP, 223
- Compact convex set, 128-130, 134-136, 158-159
- Comparison matrix, 227, 381, 387
- Complement of, 7, 121, 196-197, 201, 211, 268, 281-282, 287, 290-291, 293
- Complementary
 - BFS, 199, 352
 - basic vec. xxvi, 7, 196
 - basis, xxvi, 7, 199
 - cone xix, xxvi, 2-7, 197, 217-220, 229, 287-288, 301-307
 - degenerate, xxix, 6, 229, 234
 - historical comment, 115
 - feasible basic vec., xxvii, 7
 - feasible basis, xxvi, 46, 79, 104, 110-111
 - matrix, xxvi, 7-8, 196-197, 203, 467
 - pair, xxvi, 5, 7
 - pivot algo., 63, 66-114, 180-184, 187, 226, 232-233, 304-307
 - complexity of, 160-162, 306-307, 312
 - worst case exam. 306-307, 312
 - conds. for it to work, 85-97, 99-101, 108, 111-114
 - cycling in, 74-75, 83-84
 - for fixed pts., 124, 133, 148
 - geometric interpretation, 304-305
 - historical comment, 114
 - nemerial exam., 77-83, 98, 107-108
 - variants of, 97-99, 105-114
 - pivot phase, 291-296
 - pivot rule, 66, 72, 81, 106, 110, 292
 - pivot proc., 294
 - point, 260
 - set of vec. xxvi, 5, 7
 - sol., 7, 102
 - vector of var., 7-8
- Complementarity constraint, 7, 87, 198, 352
- Compl. slackness conds., 564, 569
 - for LP, 516, 573
- Completely labeled simplex, 153
- Completely Q, Q_0 -matrices, xxviii, 227-228
- Complexity of P -matrix LCP, 463
- Computational complexity, 160, 172, 300-313
 - empirical average, 162
 - of comp. pivot algo.
 - worst case, 160, 306-307, 312
 - average case, 161-162
 - of Dantzig-Cottle PP algo., 312
 - of Graves' PP algo., 312
 - of parametric LCP, 301-304, 312
 - of PP algo. I, 307-311
 - of variable dimension algo., 312
 - average case, 161
 - worst case, 160
- Concave func., 127, 532-533, 535-541, 562, 569, 573, 592
- Concave regression problem, 49
- Conjugacy, 431-432
- Conjugate descent methods, 431-433
- Conjugate directions, 430-433
- Conjugate gradient methods, 436
- Constrained line min., 413-421
- Constrained linear regression, 29-31
- Constraint qualification, 139, 172, 552, 558-559, 565, 568-569
- Continuous deformation, xl
- Continuously diff. func., xxxi
- Contraction mapping, 364
- Convert near opt. to opt., 474-476
- Convex approx., 380

- Convex func., 23, 125-128, 138-139, 329, 531-542, 562, 569, 573, 576-577, 585, 589, 591, 594
- Convex hull, 330, 332, 520-521, 531, 541
- Convex program, xxxviii, 102, 390, 533, 562, 569
- Convex QP, xxxiv, 25, 28, 88-89, 103-104, 247, 289-297, 336-354
- Convex
- Combination, 520
 - polyhedron, 521, 577
 - polytope, 521, 531
 - set, 128-130, 134-136, 519-539, 546, 577-579
 - sum of, 521
- Convex vec., 596
- Copositive, xxvii, 85, 99-101, 140, 174, 178, 186, 236, 238, 370-371, 398
- complexity of testing, 165-166, 174, 178
- Copositiveplus matrix, xxviii, 85, 92, 99, 105, 108, 186-187, 231, 233, 235-237, 289, 300, 310, 370-372, 384
- Critical index, 321-327
- Crucial row, 264-269
- Curvature estimates, 420
- Curve in R^n , 548-549
- diff., 542, 549-550, 553, 560
 - parametric representation, 548
 - tangent line to, 549
- Curve fitting, 391-392
- Cubic interpolation method, 407-408
- Cycling, 68, 75, 83-84, 111, 256-258, 261, 263, 272, 286-287
- DFP method, 430-431
- Dantzig-Cottle PP method, 273-278
- Defining index, 85
- Degeneracy, 74, 110, 219
- Degenerate, xxix, xxx, 64
- basic sol., xxx, 64, 70-71
 - compl. cone, xxix, 6, 198, 225-226, 234
 - matrix, xxix, 85, 196-197, 204, 215-216
 - pivot step, 68, 70, 285
 - principally, xxix, 85
 - strongly, xxx, 229-230
 - vector, xxx, 64, 198
 - weakly, xxx, 229-230
- derivatives, 408-409
- analytical, 409
 - finite diff. approx., 409
- Descent direction, xxxvi, 33-34, 141, 414, 422, 429-430, 433
- steepest, xli, 426-427, 429, 433
- Descent methods, xliii, 140-141, 179, 389-452
- converge to local min.?, xliii, xliv, 141, 179, 398
 - for linear constraints, 434-448
 - for unconstrained min., 421-433
- Descent property in SQP, 34
- Descent seq., 179-180, 440, 447
- Determinant, 15-20
- Diag $\{a_1, \dots, a_n\}$, 477
- Diagonal
- element 367-383, 487-489
 - matrix, 367-368, 372, 376, 381, 386, 477, 486-488
- Differentiable, xxxi
- concave, convex func., 537-538, 589-590
 - curve, 542, 549-550, 553, 560
 - func., xxxi, 356, 536-537, 541, 543, 587-588
- Direction, xxxvi, 3
- descent, xxxvi
 - feasible, xxxvi
 - of neg. curvature, 422
- Discrete opt. prob., 389, 393
- Distinguished var., 274-278
- Dominant principal diag., 227, 238
- Double PP step, 201-202, 206-207, 254, 264-265, 269-271
- Driving var., 274-278
- Drop in Gravitational algo., 498-505
- Dropping
- col., 154
 - var., 67-68, 70-71, 73, 75, 81, 111, 154, 156-157, 290
 - vertex, 148
- e, e, e_n , xviii, 67
- E, E_0 , 227
- \mathbf{E}, E_r , 347-348, 350-359
- $E(d), E^*(d), E^*(0)$ -matrices, 229, 232
- $\mathbf{E}(p, D), \mathbf{E}(x^r, A^r)$, 338, 343-344
- Edge directions, 468
- Eigen values, 363, 381
- Eligible to drop, 68
- Elimination form, 81
- Ellipsoid, 338, 343, 345, 347, 350-351, 356, 472-474, 489
- min. a linear function on, 473-474
- Ellipsoid algo., 336-354
- for LCP, 347-354
 - for LP, 476, 495-498
 - for NLP, 356-358
 - for nearest pt., 338-346
 - importance of, 337
- Empty set, xviii
- Entering
- col., 156
 - var., 67, 69, 72-73, 78, 81, 106, 293-295, 306
 - vertex, 148, 150-151
 - choice rule, 150
- Enumeration method
- for general QP, 163-165, 174, 186
 - for LCP, 8-9, 62-63, 465-468
 - for copositeness, 165, 174

- Epigraph, 533-534, 593
 Eq. constrained NLP, 55, 390, 548-558
 Equilibrium strategy, 41-44, 108, 111, 114, 184
 Euclidean distance, norm, xvii, xli, 314, 316, 328, 330, 338, 386
 Exact line search, 423-433
 Existence theorems, 526
 Exponential growth, 160, 310-312
 Extreme half-line, 68-69, 72-74, 101, 104
 initial, 73, 86-87 secondary, 74
 terminal, 87, 100, 113
 Extreme pt., 347-348, 352, 439-440, 531

f-vector, 264-268, 271
 Face, xxix, 143, 148, 154
 boundary, interior, 144-145
 Facet, xxix, 288, 305, 318
 Factorial, xix
 Far side, 318
 Farkas' lemma, 91, 502, 513-515, 566
 application to LP, 514-516
 Feasible
 basis, 63, 67
 direction, xxxvi, 546
 direction descent method, 469
 half-line, 69, 103-104, 167-168, 170, 475, 500
 search direction, 435
 sol., xxiii, 64, 508
 system, 507-508
 Feasibility range, 282-287
 Fermat's last theorem, 171, 396
 as an NLP, 396
 Fermat's prob., 448-450
 Finite diff. approx., 409, 428, 435
 Finite no. of sols., 197-198
 Finite precision arithmetic, 345, 398
 effect on precision, 398
 Finite procedure
 to check Q, Q_0 , 244-246
 to solve general QP, 163-166
 for LCP, 8-9, 465-468
 Finite term. prop., 399
 First order nec. opt. conds., xxxv, 142, 543-545, 554, 557-558, 561, 564-569, 574, 575, 584
 Fixed pt., 114, 137-142
 computing methods, 123-124, 131-133, 143-159, 160, 162
 theorems, 128-130, 134-136
 Fletcher and Reeves method, 432
 Floor, xvii
 Forward diff. approx., 409
 Forward move, 119
 Fractional objective func., 55
 Frank-Wolfe method, 439-443
 Fully semi-monotone, 227, 234, 248

 Fundamental inconsistent eq., ineq., 507-508, 510-511, 519

 Gac's & Lovasz lemma, proc., 349, 353
 Gale's theorem of alt., 518
 Gauss-Jordan pivot step, 67, 509
 Gaussian pivot step, 13-14, 20, 174, 461
 General QP, 97, 163-170, 185, 186
 Generalized diag. dominant, 227, 238
 Generalized gradients, 541-542
 Generalized LCP, 221-222
 Ghost story, 75-76
 Global max., min., xxi, xxxviii, 137, 139-140, 168-172, 234, 394-397, 400-401, 533-536, 544, 563, 565, 569, 575, 589-591
 complexity of comp., 171, 396-397
 definition, 394-395
 Global opt., 562, 574, 587
 Golden ratio, 403
 Golden section search, 402-403
 Gordan's alternative, 517
 Gradient, xxx, 124, 421, 540, 568
 finite diff. approx., 409
 generalized, 390, 541-542
 projected, 434, 445-446
 Gradient based methods, 389
 for line min., 403, 405, 407-408
 for linear constraints, 434-450
 for unconstrained min., 426, 428-433
 Gradient proj. method, 445-447, 460, 498
 Gradient support ineq., 536-537, 543
 Graves' PP method, 263-273, 289, 312
 Gravitational method, 498-505

 $H(\theta(x)), H_x(\cdot)$, xxxi, xxxiv, 554-558, 561-562, 568-569
 $\mathbf{H}(\mathbf{S})$, 316-317, 324
 H -matrix, 227, 387
 Half-line, xxxvi, 3-4, 69, 102, 305
 extreme, 69, 101
 feasible, 69, 103-104, 167-168, 170
 Haunted house, 75-76
 Hereditary PD, symmetry, xxxvii-xxxviii, 33, 430-431
 Hessian matrix, xxxi, 124, 137, 421, 433, 536, 543-545, 554, 557-558, 566
 approx. 32-33
 approx. for inverse, 429
 projected, 434
 Higher order separation thms., 219
 Hilbert matrix, 30-31, 56
 Homogeneous func., 297
 Homogeneous sol., 69, 113
 Homogeneous system, 472
 Holder's ineq., 580
 Homotopy methods, xl, 159
 Hyperplane, xxix

- Hypograph, 533, 535
- I, I_r , xviii
- INS, INS_k -matrix, 230
- Implicit func. theorem, 551-552
- Inactive constraints, 437-438, 559, 565
- Inconsistent system, 508, 511
- Inexact line search, 423, 431
- Infeasible basis, 64, 254
- Infeasible system, xxvi, 86, 507-509, 511, 513, 516-519
- Infeasibility cond., 276, 278, 334
- Infimum, xx
- Infinite no. sols., 197-198
- Inscribed sphere, 479-480, 489, 494
- Integer linear system, 530
- Integer prog., 185-186
- Interior, 340, 348, 352
- Interior face, 145
- Interior pt., 163-164, 352
- Interior pt. barrier method, 470
- Intermediate value theorem, 15
- Interval reduction, 403
- Interval of uncertainty, 403
- Inverse tableau, 66, 68, 80, 265-267, 282-284
- Isotonic vector, 595
- Iterative methods, 361-387
- Jacobian matrix, xxxii, 132, 551-553
- Jensen's ineq., 532
- K_1, \tilde{K}_1 , 145-152, 154, 158
- $\mathbf{K}(M)$, xix, 7-8, 228, 230, 234, 237
- K -matrix, 227
- k -problem, 116, 118-119
- KKT (Karush-Kuhn-Tucker)
- conds., xxxv, 37, 373-376, 397, 561, 569
 - pt., xxxv, 26, 35-36, 38, 97, 166-170,, 179-180, 368, 374, 378, 397, 437-439, 448
 - for general QP, 166-170
 - reduced, 167, 169
 - Lagrangian, xxxv
- Kakutani fixed pt., 123, 134-159, 184
- Kantorovitch ineq., 588
- Karmarkar's algo., xlv, 468-494
- Knapsack feasibility prob., 355
- $L_1(a), L_2(a), L_\infty(a)$, 392
- $L(d), L^*(d)$ -matrices, 229, 233
- L, L_1, L_2, L_* -matrices, 85, 89-96, 99, 170, 183, 229, 235
- L_1 -penalty func., xxix, 33
- LCP, xxi, 1, 3, 6-7
- LP, xxi, 3, 9, 272, 366, 377
- LRC rule, 262
- Label matrix, 153
- Labels of vertices, 153-157
- Large scale models, 392
- Lagrange multipliers, 32-34, 39, 55, 374, 376-377, 380, 434, 436-438, 447, 554-556, 560-562, 568-569, 572
- Lagrangian, xxxv, 25, 32, 554-558, 560, 564, 568-569, 571, 575
- Least squares, 30, 138, 380, 391-392, 583
- Left derivative, 410
- Left out C. pair, 71, 106, 112, 195, 215-216, 218, 224, 304
- Lemke's algo., 66
- Lexico min. ratio rule, 65, 75, 81, 84, 110-112, 273-274, 292
- Lexicographic Lemke algo., 99, 123, 161-162
- Line min., 400-421
- Linear approx. fixed pt., 152, 157-158
- Linear dependence relation, 474-476
- Linear func., xxiii
- Linearly constrained NLP, 390-393, 434-448
- Lipschitz constant, continuity, func., xxx, 541, 581-583
- Local max., min., xxi, xxxviii, 394-395
- complexity of checking, 170-179
 - do existing algos. compute it?, 397-398
 - opt. conds. for, 543-569
- Locally convex func., 179, 539
- Logarithmic barrier func., 470
- Loss matrices, 41, 45
- Lower triangular matrix, 300, 310, 335, 355, 473
- M -matrices, 227, 234, 239-240, 247
- Major cycle, 273-275, 277-278
- Matrix splittings, 383
- Max. area hexagon problem, 450
- Merit func., xxxix, 32-33, 37, 179
- Merrill's algo., 143-160, 162, 184
- Method of bisection, 403
- Method of false position, 405
- Metric matrix, 338, 427, 429
- Min. linear func. on ellipsoid, 472-474
- Min., local, global, xx, xxi, 394-395
- Min. distance prob., 26-27
- Min ratio, 67-71, 81, 111, 157
- Minkowski's ineq., 580
- Modified Newton's method, 404-405, 428
- Monk's story, 130-131
- Motzkin's alternative, 516
- $\mathbf{N}(\bar{x})$, 318-320, 323-328
- n -dimensional simplex, 143-155
- N -matrix, 230, 234
- ND, xxii, 208, 545
- NLCP, xxi, 44, 142, 260, 584
- NLP, xxii, 3, 142, 356-357
- nonconvex, 171-173, 179-180, 357
 - nonsmooth, 142

- \mathcal{NP} , 174-175, 177, 461
- \mathcal{NP} -complete, xxv, 171-174, 177-178, 354-355, 453, 462
 - LCPs, 354-355
- \mathcal{NP} -hard, 166, 171, 177, 179, 355-356, 453
- NSD, xxii, 208, 539
- Near side, 318
- Nearest pt., 49-50, 182, 184, 314-332, 339, 386, 463-465
 - problem, 314-332, 338-339, 462
- Nec. and suff. conds., xxv, xxxviii
 - for convexity of PL funcs., 577-578
 - for global opt., 25, 562, 569
 - for local min. in QP, 570
 - for QP, 25
- Nec. opt. conds., xxxv, 24, 32, 47, 379, 386, 394, 397-399, 416, 426, 435, 437-438, 444-445, 542-570
- Negative curvature correction, 418
- Negative definite, semidefinite, xxii, 85, 355-356
- Newton direction, 427, 444
- Newton's method
 - for eqs., 131
 - for line min., 403-404
 - as quad. approx., 407
 - modified, 404-405
 - for unconstrained min., 132, 426-427
 - discrete or finite diff., 428
 - modified, 428
- Newton-Raphson method, 131-133, 260, 404
- Nonascent direction, 422
- Nonbasic cols., vars., 63, 67, 202
- Non-binding direction, 437
- Nonconvex
 - NLP, 171-172, 174, 179-180
 - simplest, 174, 398
 - goals for algos. of, 179-180
 - program, xxxviii, 390, 395
 - complexity of global min., 170-172, 395-397
 - complexity of checking local min., 173-179, 397-398
 - line min. algo., 416-421
 - sets, 520
- Nondegeneracy of q , 74, 262-263
- Nondegenerate, xxix, xxx, 64-65
 - basic sol., BFS, b -vec., 64, 231, 236
 - complementary BFS, 231
 - complementary cone, xxix, 6
 - matrix, xxix, 85, 105, 196-197, 204, 208, 211, 215-216, 236-237, 241-242, 461-462
 - P -func., 260
 - pivot step, 68-69, 307
 - Q -matrix, 236, 242
 - system, xxx, 64-65
- Non-diff. opt., 389
- Nonempty principal submatrix, 12
- Nonlinear compl. prob., 44, 142, 259, 584
- Nonlinear eqs., 131-133, 138
- Nonlinear program, xxxii, 139-142
 - algos. for, 400-448
 - capabilities of algos., 395-398
 - formulation ex., 391-393
 - nice prob., 395
 - smooth, xxxii, 171
 - smooth nonconvex, 171-172, 179-180
 - goals for algos., 179-180
 - types, 390
 - types of sols., 394-395
- Nonzero sum games, 41
- Norm of matrix, 363
- No. of c. sols., 197, 210-212, 219, 232-236, 241-243
- $O(n^r)$, xxiv
- One-to-one correspondence, 223, 263
- Open problems, 461-468
- Optimal line search, 423, 430
- Opt. step descent, 423
- Opt. conds., 542-571, 573-575, 580, 584
 - Principles behind them, 542
- Opt. range, 283
- Optimum
 - feasible sol., xxiii, 24
 - global, 168
- Order of LCP, 2, 322
- Original tableau, 67
- Orthants, 3, 5, 50, 218
- Overdetermined system, 138, 436
- Overestimate, 538
- \mathcal{P} , xxiv
- P -function, 259-260
- P -matrix, xxviii, 18-19, 85, 92
 - properties of, 204-205, 208-223
 - triangular, 333, 335-336
- P_0 -matrix, xxviii, 85, 93, 226, 231, 233, 235, 237, 240, 462
- p -norm, 453
- PD, xxii, 11-28, 46, 206-207
- PPT, xxii, 199-208, 217-219, 226-227, 231, 246, 257, 269, 272, 275-276, 296
- PSD, xxii, 11-28, 46-47, 103-105, 206-208, 263-277, 289-296
- Parabola, 102, 406
- Parameter estimation, 53, 391-392
- Parametric convex QP, 289-296
- Parametric LCP, 48, 280-298, 301-304, 311-312
- Partial derivatives, xxx, xxxi, 124, 409, 435, 536
- Partial enumeration methods, 186, 466, 468
- Partial line search, 423
- Partition of R^n , 218-219
- Partition prob., 453
- Path

- of C. pivot method, 73, 75-76
 - of simplicial method, 148-149
 - monk's, 130-131
- Penalty func., xxxix, 33, 141
- Penalty parameter, terms, 35, 141, 185, 396-397
- Permanent, 397
- Permutation, 146, 149-152, 208, 235, 258
- Permutation matrix, xli, 208, 384
- Perturbations, 65, 242
- Piecewise linear
 - approx., 410-411
 - approx. fixed pt., 152
 - approx. of map, 136, 152-158
 - concave min., 359
 - equations, 50
 - func., 50
 - methods, 124
- Pivot
 - col., 13, 67-69, 77, 80-81, 509
 - element, 13-14, 77, 107
 - matrix, 80
 - row, 13, 68-71, 107, 509
 - row choice rule, 258-259, 262
 - step, 13, 67-71, 76, 304-305, 509
- Point-to-set maps, 134-136, 139, 143
- Pointwise inf., sup., 124-125, 128, 138-139, 410, 533
- Polak, Ribiere, Polyak method, 432
- Polyhedral approx., 410-412, 415, 420
- Polynomial approx. methods, 406-408
- Poly. bounded algos., xxiv, 160, 468, 481, 486
 - for convex QP, 336-354
 - for LCP, 333-354
- Polynomial interpolation method, 406-408
- Portfolio prob., 29, 55
- Pos(\cdot), cone, xix, 3
- Positive (semi)definite, xxii, 11-28
- Principal
 - pivot methods, 254-278
 - pivot step (block, single, double), 201-208, 254-255, 264-272, 281-285
 - pivot transform, xxii, 199-200
 - rearrangement, xli, 208, 248, 384
 - subdeterminant, submatrix, xxi, 11-13, 15-19, 85, 203
 - subproblem, xxx, 115-119, 256-258, 302-303, 308, 310, 318, 322-323
- Principally degenerate, nondegenerate, xxix, 85, 204, 208, 461
- Prisoner's dilemma, 42
- Processing of LCP, xxvii, 89
- Product form, 81
- Projected gradient, hessian, 434, 447
- Projection, 316-317, 324-326, 328
- Projection face, 317, 327
- Projection matrix, 445-447
- Proper principal submatrix, 12
- $Q, Q_0, \bar{Q}, \bar{Q}_0$ -matrices, xxviii, 85, 89, 122, 210, 227-228, 231-233, 235-239, 241-248, 334, 462
- (q, M) , xvi, 2, 6-7
- QP, v, xxxiv
 - nonconvex, 171, 570
 - checking local min. in, 171-178
 - state tax model, 53-54
- Quadrants, 3, 218
- Quad. approx., 411, 419
 - step, 412, 414-415, 418
- Quad. rate conv., 399, 404-405, 427
- Quad. interpolation, 406-407
- Quad. term. prop., 399
- Quasi-convex func., 594
- Quasi-Newton methods, 428-431
- R^n , xvi
- R, R_0 -matrices, 229-230, 233, 235-236
- Rank 1, 2, methods, 338, 430
- Rates of convergence, 399, 404-405, 408, 413, 416-417, 426-427, 430, 433
- Radix, xvii
- Ray, initial, secondary, xxxvi, 3-4, 74, 90, 318, 320
 - termination, 73-74, 80-81, 86, 88-89, 104, 107-108, 113-114, 226, 293, 295
- Rectilinear distance, xli, 328
- Reduced gradient, hessian, method, 434, 444-445
- Reduced KKT pt., 167, 169
- Regular
 - matrix, 229, 233
 - pt., 552-555, 558-562, 568-569, 574
- Regularity cond., 552, 558-559, 565
- Relative boundary, interior, 317, 323
- Resolving degeneracy, 68
- Right derivative, 410
- Row adequate matrix, 85, 92-93
- S -matrix, 228, 235-236
- Sanctuary, 76
- Search direction, 422, 426-430, 433, 435, 444-445
- Secant method, 405
- Second order conv., 399, 404-405
- Second order opt. conds., 543, 545, 547, 555-558, 561, 565-569
- Secondary ray, xxvii, 74, 90
- Sectioning, 403, 408
- Semimonotone matrix, 85, 227
- Semipositive, xvi, 3
- Separating hyperplane, 522-531
- Separation properties, strict, weak, 213-219, 224-226, 231
- Sequential QP method, 31-40
- Sherman-Morrison formula, 486

- Sign nonreversal, 210, 220
- Simplest nonconvex NLP, 174, 398
- Simplex, xix, 143-158, 331, 348, 478, 480, 494
 - completely labeled, 153
- Simplicial cone, xxix, 521
- Simplicial methods, 124, 162
- Single PP step, 201-202
- Size, xxiv
- Smooth func., surface, NLP, xxxii, 390, 548
- Sparsity, 162
- Sparsity preserving SOR, 378-381
- Special triangulation, 149-155
- Spectral radius, 381
- Standard simplex, 472
- Stationary pt., xxxvi
- Steepest descent direction, xli, 426-427, 429, 432, 444, 473, 493-494
- Step length, 3-4, 422-425, 432-433
- Strict separation property, 213-219, 224, 288
- Strictly copositive, xxvii
- Strictly semi-monotone, 122, 227, 231-232, 238
- Strongly degenerate, xxx, 229
- Subcomplementary vector, set, xxvii, 195-196
- Subdifferential set, 125, 127, 137-138, 142, 410, 540-541
- Subgradients, 125-128, 415, 540-542
- Successive substitution method, 131
- Suff. opt. conds., xxv, 140, 543-544, 555-558, 561-562, 565, 567-569, 570-571, 580
- Sum of convex sets, 521
- Super diagonalization algo., 21, 23
- Superlinear conv. rate, 399
- Supporting hyperplane, xxix, 524
- Symmetric PD approx., 33, 38

- $\mathbf{T}(b, \bar{x})$, 318-320, 323-324, 326
- Tangent hyperplane, 320, 345
- Tangent line to curve, 549-550
- Tangent plane, 549-550, 553
- Tax problem, 53-54
- Terminal extreme $\frac{1}{2}$ -line, xxvii, 87, 100
- Terminal tableau, 103
- Termination conds.
 - in C. P. method, 74
 - in line search, 410
 - in fixed pt. computation, 155, 157
 - in SQP method, 34, 40
 - in unconstrained min., 433
- Theorems of alternatives, 507-519
- Tight constraints, xxvi, 437
- Top layer, 149-157
- Total enumeration, 8-9, 466
- Traffic assignment, 441-443
- Transform LP
 - to have int. feas. sol., 471
 - into Karmarkar's form, 471-472, 477, 492-493
- Triangular matrix, 335-337, 355
- Triangulations, 124, 144-159
- Tschebycheff approx., 392
- Tucker's lemma, 511-513
- Tucker's alternative, 517
- Twice differentiable func., xxxi
- Two person games, 40

- U -matrices, 230, 234
- USC maps, 135-136, 139, 158-159
- Unbounded edge, 68
- Unboundedness of obj., 101-103, 186, 499-500
- Unconstrained min., 137, 390
 - complexity of checking local min., 178-179
 - descent methods for, 421-433
 - opt. conds. for, 543-545
- Unimodal func., 402-403
- Unique compl. sol., 210-213, 219, 221-223, 230, 248
- Updated col., 66
- Upper triangular, 335, 355
- Upper semi-continuous, 135

- Van der Waerden conjecture, 397
- Variable dimension algo., 115-123
- Variable metric methods, 338, 427, 429
- Variational ineq. prob., 547-548
- Vector labeling method, 153
- Von Neumann's minimax theorem, 41

- W -matrices, 230
- weak separation matrix, 231, 236
- Weakly degenerate c. cone, xxx, 229-230
- Working active set, 447-448
- Worst case complexity, 160-161, 300, 310-311
 - of C. P. method, 160, 306-307
 - of Dantzig-Cottle PP Method, 312
 - of Grave's PP method, 312
 - of parametric LCP, 301-304
 - of PP method I, 307-311
 - of variable dimension algo., 312

- y^+ , xviii, 50
- Young's ineq., 579

- Z -matrix, xxviii, 85, 226-227, 234, 238, 240, 333-335, 359, 383
- Zero sum game, 41, 45