

References

1. D.R. Anderson, D.J. Sweeney, T.A. Williams, *Linear Programming for Decision Making* (West Publishing, New York, 1974)
2. P.M. Anselone, L.B. Rall, The solution of characteristic value-vector problems by Newton's method. *Numer. Math.* **11**, 38–45 (1968)
3. M. Avriel, *Nonlinear Programming. Analysis and Methods* (Dover Publications, Mineola, 2003)
4. E.M.L. Beale, Numerical Methods in *Nonlinear Programming*, ed. by J. Abadie (North Holland Publishing, Amsterdam, 1967)
5. J.T. Betts, *Practical Methods for Optimal Control and Estimation Using Nonlinear Programming*, 2nd edn. SIAM's Advances in Design and Control (2010)
6. J.F. Bonnans, J.Ch. Gilbert, C. Lemaréchal, C.A. Sagastizábal, *Numerical Optimization: Theoretical and Practical Aspects* (Springer, New York, 2006)
7. F. Chatelin, *Eigenvalues of Matrices* (Wiley, Chichester, 1995)
8. K.A. Cliffe, T.J. Garratt, A. Spence, Eigenvalues of block matrices arising from problems in Fluid Mechanics. *SIAM J. Matrix Anal. Appl.* **15**(4), 1310–1318 (1994).
9. R. Cottle, E. Johnson, R. Wets, George B. Dantzig (1914–2005). *Not. AMS* **54**(3), 344–369 (2007)
10. G.B. Dantzig, *Linear Programming and Extensions* (Princeton University Press, Princeton, 1963)
11. V.N. Faddeeva, *Computational Methods of Linear Algebra* (Dover Publications, New York, 1959)
12. J. Franklin, *Methods of Mathematical Economics* (Springer, New York, 1980)
13. H. Goldstein, *Classical Mechanics* (Addison-Wesley, Readings, 1981)
14. G.H. Golub, Ch.F. Van Loan, *Matrix Computations*, 2nd edn. (Johns Hopkins, Baltimore, 1989)
15. J. Guckenheimer, P. Holmes, *Nonlinear Oscillations, Dynamical Systems, and Bifurcations of Vectors Fields* (Springer, New York, 1983)
16. E. Hairer, C. Lubich, G. Wanner, *Geometric Numerical Integration*, 2nd edn. (Springer, New York, 2006)
17. S. Jiménez, L. Vázquez, Analysis of a nonlinear Klein-Gordon equation. *Appl. Math. Comput.* **35**, 61–94 (1990)
18. S. Jiménez, P. Pascual, C. Aguirre, L. Vázquez, A panoramic view of some perturbed nonlinear wave equations. *Int. J. Bifurcat. Chaos* **14**(1), 1–40 (2004)
19. S. Jiménez, L. Vázquez, A dynamics approach to the computation of eigenvectors of matrices. *J. Comput. Math.* **23**(6), 657–672 (2005)
20. N. Karmarkar, A new Polynomial-time algorithm for linear programming. *Combinatorica* **4**(4), 373–395 (1984)

21. L.G. Khachiyan, A polynomial Algorithm in Linear Programming. Dokl. Akad. Nauk SSSR, **244**(S), 1093–1096 (1979), translated in *Soviet Mathematics Doklady* **20**(1), 191–194 (1979)
22. V.V. Konotop, L. Vázquez, *Nonlinear Random Waves* (World Scientific, Singapore, 1994). See also references [379], [403], [326], [404] and [191], therein.
23. M.C. Navarro, H. Herrero, A.M. Mancho, A. Wathen, Efficient solution of a generalized eigenvalue problem arising in a thermoconvective instability. *Comm. Comput. Phys.* **3**(2), 308–329 (2008)
24. L. Perko, *Differential Equations and Dynamical Systems*, 3rd edn. (Springer, New York, 2001)
25. W.H. Press, S.A. Teukolsky, W.T. Vetterling, B.P. Flannery, J.G.P. Barnes, *Numerical Recipes in C. The Art of Scientific Computing*, 2nd edn. (Cambridge University Press, Cambridge, 1995)
26. M. Rossignoli, *The Complete Pinball Book: Collecting the Game & Its History* (Schiffer Publishing, Atglen, 2011)
27. F. Santos, A counterexample to the Hirsch conjecture, arXiv:1006.2814 (2010)
28. J. Stoer, R. Burslicsh, *Introduction to Numerical Analysis*, 2nd edn. (Springer, New York, 2002)
29. W.A. Strauss, L. Vázquez, Numerical solutions of a nonlinear Klein-Gordon equation. *J. Comput. Phys.* **28**, 271–278 (1978)
30. J. Todd, The condition number of the finite segment of the Hilbert matrix. *Natl. Bur. Stand. Appl. Math. Ser.* **39**, 109–116 (1954)
31. L. Vázquez, S. Jiménez, Analysis of a mechanical solver for linear systems of equations. *J. Comput. Math.* **19**(1), 9–14 (2001)
32. L. Vázquez, J.L. Vázquez-Poletti, A new approach to solve systems of linear equations. *J. Comput. Math.* **19**(4), 445–448 (2001)
33. L. Vázquez, J.L. Vázquez-Poletti, A mechanical approach for linear programming. <http://www.uni-bielefeld.de/ZiF/complexity>; *ZiF Preprint* 2001/066 (2001)

Index

A

Asymptotic behaviour(s), 17, 36, 48, 53, 57, 71, 73, 97

B

Basis, 5, 7, 38, 50, 51, 54, 62, 67, 85, 88, 93, 94

Boundary(ies), 99, 101, 103–105, 107–109, 112, 118–120, 122, 124–127, 129–131

C

Conservation, 1–4, 6, 17, 44, 45, 47, 62, 69, 71, 72, 100

Conservation law, 2–4, 44, 45, 47, 62, 72

Conservative, 1, 4, 5, 11, 13

Constraint(s), 7, 8, 99, 100, 104, 105, 107–113, 117–126, 128, 130, 132, 133

Convergence, 17, 19–22, 25, 29, 31–33, 35–38, 40, 46, 48, 49, 57, 67–70, 72–73, 75, 77, 78, 83–98

linear, 32, 83

quadratic, 83, 84, 92, 94

rate, 21, 31, 35–38, 67, 83–96

D

Damped method, 19–23, 33–35, 37, 39, 40, 95

Discrete energy, 7, 11, 19, 119, 129

Dissipation, 4–6, 16, 62, 118, 120, 123

Dissipation law, 44, 47, 62, 129

Dissipative, 4–6, 8, 11–13, 17, 24, 25, 38, 43, 119, 128

Dynamical system, 5, 24, 44, 46, 48, 49, 54, 58, 61, 67, 69–71, 79–82

Dynamical system method, 68–81

E

Eigenspace(s), 43, 47–49, 51, 53, 67, 68, 71–74, 83, 93, 94, 97

defective, 51

extremal, 43

intermediate, 43, 73, 83, 97

non-defective, 63

Eigenvector(s), 15, 43–54, 57–63, 67–77, 79–85, 88, 90–94, 97, 98, 119

generalized, 47, 48, 50–53, 58, 74, 75, 80
proper, 51–54, 58, 62

Energy

discrete, 7, 11, 19, 119, 129

potential, 1, 6, 7, 99, 100, 108, 128

Equation(s) of (the) motion, 1, 123, 128

(a priori) estimate, 22, 33, 35, 39, 40, 71, 88

Estimation(s), 5, 35, 97, 104, 107, 117

F

Feasible region, 101–103, 106–109, 111, 112, 118, 120, 122–132

G

Gauss–Seidel (method), 29–30, 32

H

Hilbert, 26

I

Ill-conditioned, 18, 31, 39

J

Jacobi (method), 15, 29–30, 32, 33, 39

Jacobian, 3, 12, 46–52, 69–71, 74, 84, 85, 90, 92, 129

- Jordan (canonical) basis, 3, 4, 12, 38, 58, 79, 85, 88, 93, 94, 119
- Jordan (canonical) form, 59, 60, 63, 64, 79, 85
- L**
- Law
- conservation, 1–4, 44, 45, 47, 62, 72
 - dissipation, 47, 62, 129
 - variation, 1, 5, 7, 11, 12, 16, 18, 119
- Linear equations, 15–41, 43
- M**
- Matrix(ces)
- complex eigenvalues, 59–61
 - complex eigenvectors, 61
 - defective eigenvalues, 61
 - generalized eigenvector, 58
 - Hilbert, 26
 - Jordan form, 59, 60
 - non-defective eigenvalues, 61
 - Rayleigh quotient, 61
 - second order expression, 58
 - singular, 24–25, 27, 38–39, 41, 47, 48, 68, 77–78, 84, 87, 97
- Mechanics, 1–13, 15–17, 20, 24–26, 31, 43, 99, 100, 102–104, 106, 108, 110, 112–114, 117, 118, 120, 121, 126, 132
- Minimization, 99, 101, 106, 108, 113–115, 118, 121, 127, 130–132
- Multiplicity(ies)
- algebraic, 47, 48, 50, 81, 82
 - geometric, 47, 48, 50, 53, 82
- N**
- Newton, 17, 43, 84
- Newtonian, 1–13, 100, 101, 106, 107, 117, 118, 128
- Newton's method, 83, 84, 87, 88, 92, 96
- O**
- Objective function, 7, 99, 100, 102–104, 108, 112, 113, 117–128, 130
- Optimal (value(s) of the) parameter(s), 22, 25, 27, 28, 33, 35
- Optimization, 1, 5, 7, 103–112, 117, 118, 124
- Overdamped method, 33, 37, 38, 41, 223–26
- Particle, 1–8, 15, 17, 100–109, 111, 112, 117, 118, 120, 123–128
- Pinball, 7, 99, 101, 113
- Potential, 1, 2, 4–8, 10, 67, 99, 100, 108, 117, 118, 120, 123, 127–130
- Power method(s)
- direct, 67, 71
 - inverse, 68, 78–82
 - inverse with seed, 68, 78, 80, 97
- Precision, 4, 8, 24, 29, 36–38, 70–72, 80, 88
- Primal problem, 99, 100
- Programming
- linear, 99–115, 117, 118, 128
 - nonlinear, 15, 117, 128–131
 - quadratic, 7, 8, 117–133
- Q**
- Quadratic method, 88–96
- R**
- Rayleigh quotient, 31, 46, 49, 57, 61, 77, 81–82
- S**
- Singular value(s), 22
- Solution
- non-unique, 113
 - numerical, 1, 19, 24, 37, 38, 48, 119, 120, 129
 - particular, 16
- Spectrum, 18, 47, 49–52, 78
- Stability, 1, 2, 16, 43, 47, 48, 53–57, 129
- Stable, 5, 6, 16, 18, 19, 43, 47, 53, 74, 76
- Steepest descent (method), 29–33, 39
- Størmer–Verlet method, 5, 13, 129, 131
- Strauss–Vázquez method, 4–6, 8, 11–13, 129
- Symmetries, 1
- System(s)
- dynamical, 5, 24, 43–49, 54, 58, 61, 67–82
 - linear, 17, 18, 26, 29, 32, 34, 37, 39–41, 43, 68, 118
 - mechanical, 15, 17, 24, 25, 43
- T**
- Trajectory(ies), 5, 53, 57, 103, 107, 109, 118, 120, 123
- U**
- Unstable, 2, 6, 43, 74, 77
- V**
- Variation law, 1, 5, 7, 11, 12, 16, 18, 119