

## Index

- Abel–Plana formulas, 138
- absolute stability, 38
- Adams–Bashforth (AB), 7, 27, 37, 40, 41
- Adams–Moulton (AM), 27, 37, 41
- aliasing, 19, 66, 116, 171, 173
- analytic
  - continuation, 35, 190
  - function, 74, 95, 113–115, 122, 135, 138, 149, 150, 157
- automatic differentiation, 31
- backward differentiation (BD), 27, 37, 41
- Benjamin–Feir instability, 66
- Bürgi, Jost, 1
- Butcher diagram, 28
- cardinal functions, 23, 100, 163
- Cauchy problem, 151, 152
- Cauchy’s integral formula, 115
- Cauchy–Riemann (CR) equations, 113
- characteristic equation, 37, 40
- characteristic function, 120
- characteristics, 56, 70
- Chebfun, 17, 26, 144
- Chebyshev
  - expansion, 195
  - polynomial, 17, 96
- circle-chain theorem, 35
- closest point method, 111
- compact stencils, 5
  - FD, 7, 45, 46, 71, 72
- complex plane
  - FD, 112, 133
  - PS, 119
- complex step method, 114
- complex variables, 112
- condition number, 104
- conjugate gradient method, 82
- conservation laws, 68–71
- consistency, 36, 51
- constrained linear system, 183
- continuation problem, 152
- contour integral, 115, 135, 149, 158
- convergence, 14, 36, 51, 139
  - rates, 11, 31, 33, 47, 68, 76, 80, 133, 134, 140, 144, 149, 198, 199, 207
- convolution, 152, 162
- convolution theorem, 168, 170
- corner singularity, 65
- correction stencil, 134, 147
- Courant–Friedrichs–Lewy (CFL), 51, 56
- curse of dimensionality, 21, 204, 207
- Dahlquist stability barrier, 41
- deferred correction, 45, 46, 185
- Delaunay triangulation, 109
- differentiation matrix (DM), 54, 64, 81, 96, 105
- Dirichlet-to-Neumann problem, 152
- discontinuous function, 22, 69, 70
- dispersion, 64
- dissipation, 64
- errors, 10, 20, 115, 119, 136
- Euler, Leonhard, 125
- Euler equations, 70
- Euler–Boole formula, 137
- Euler–Maclaurin (EML), 125, 133, 134, 140
- Euler–Mascheroni constant, 132
- Euler’s
  - formula, 167
  - transformation, 138
- extrapolation
  - Aitken, 138, 187

- methods, 185–193
  - ODE solution method, 36, 200
  - Richardson, 45, 46, 185
- FD variations
  - mimetic (MFD), 194
  - nonstandard (NSFD), 194
- FD weights
  - algorithms, 2–8
  - complex plane, 116
  - tables, 9, 58, 77, 116
- finite volume method, 58, 109
- forward Euler (FE), 27, 28, 32, 36, 38, 55
- Fourier
  - discrete transform (DFT), 169, 172, 175
  - fast transform (FFT), 19, 115, 152, 170, 173, 175, 177
  - Parseval's relation, 168
  - series, 23, 116, 167, 168
  - transform, 152, 167
- Fourier, Joseph, 167
- fractional derivative, 141–154
  - algorithm
    - complex plane, 149–150
    - Grünwald–Letnikov, 144
    - real axis, 144
  - Caputo, 142, 147
  - Riemann–Liouville, 142
- Gaussian elimination, 81
- Gershgorin's theorem, 43, 55
- Gibbs phenomenon, 21, 163
- Godunov's method, 71
- Gragg–Bulirsch–Stoer (GBS), 36, 200
- Gregory, James, 1
- Gregory's method. *See* quadrature, Gregory
- Hammer–Hollingsworth, 29, 40
- harmonic functions, 74, 116
- Helmholtz equation, 78, 151
- Hilbert transform, 152
- hypergeometric function, 33, 154
- hyperviscosity, 57, 105, 109
- imaginary stability boundary (ISB), 201
- IMEX methods, 67
- interpolation
  - barycentric, 156
  - equispaced, 23
  - Hermite, 4, 14, 132, 156
  - Lagrange, 5, 12, 28, 155
  - Newton, 156, 164
  - polynomial, 12, 86, 94, 155–158
  - spline, 159
  - trigonometric, 23, 173
- iterative improvement, 45, 82
- Jacobian, 44
- kd-tree, 102, 103, 208
- Korteweg–de Vries (KdV) equation. *See* PDE, Korteweg–de Vries (KdV) equation
- Lagrange
  - interpolation. *See* interpolation, Lagrange
  - multipliers, 102, 181–184
  - polynomial, 12, 18
- Laguerre polynomial, 154
- Laplace transform, 116
- Laplace's equation. *See* PDE Laplace's equation
- Laplacian, 150
  - FD, 73
  - hyperviscosity, 106
  - MLS, 87
- Lax equivalence theorem, 51
- Lax–Wendroff method, 50, 52, 71
- leapfrog, 53, 55, 64, 107
- Leibniz, Gottfried, 1
- level-set method, 84
- linear multistep (LM), 27
- linearly implicit time stepping, 67
- Maclaurin, Colin, 125
- Mehrstellenverfahren, 72
- method of exponential test functions, 4, 5, 127, 134, 140, 145, 146
- method of lines (MOL), 50, 54, 107
- method of monomial test functions, 3
- midpoint rule, 125
- Monte Carlo, 207
- moving least squares (MLS), 87
- multigrid method (MG), 45, 82, 111, 209
- Navier–Stokes (NS) equations, 67, 70, 71, 108
- Newton, Isaac, 1
- Newton–Cotes, 124, 129, 139, 140, 196
- Newton's method, 41, 43, 80, 188
- node set, 204
  - Cartesian grid, 204
  - Chebyshev, 16
  - Halton, 206
  - hexagonal grid, 205
  - quasi-uniform, 102, 109, 207
  - random, 206
- Nyquist frequency. *See* reflection frequency
- ODE
  - boundary value problems (BVP), 42–45
  - initial value problems (IVP), 26–41

stiff, 38  
 orthogonal gradient method, 111  
 Padé  
   rational form, 30, 189  
   weights algorithm, 5, 8  
 parallel computing, 29, 101, 200  
 PDE, 49  
   1-D acoustic, 59  
   2-D elastic, 59, 63  
   3-D Maxwell, 59, 60  
   advection, 20, 50, 62  
   convection–diffusion, 64  
   heat equation, 52, 56, 64  
   Korteweg–de Vries (KdV) equation, 65  
   Laplace’s equation, 74–76, 122, 150–152, 200  
   Poisson’s equation, 72–74, 109  
 Poisson’s equation. *See* PDE, Poisson’s equation  
 predictor–corrector, 28, 40  
 principal value integral, 152  
 pseudospectral (PS), 17, 66  
   Chebyshev, 65, 85, 97  
   complex plane, 119  
   weights, 18  
 quadrature, 124  
   contour integration, 135  
   Gregory, 127, 140, 145, 147, 195, 200  
   Monte Carlo, 206  
 radial basis function (RBF), 91, 153, 165  
   direct, 94  
   Gaussian (GA), 91, 93, 102, 153  
   global, 89–100  
   multiquadric (MQ), 91  
   nonsingularity, 92  
   polyharmonic spline (PHS), 91, 102  
   shape parameter, 93  
   stable algorithms, 94  
   supplementary polynomials, 97  
 rational approximation, 156  
 RBF–FD, 100, 207  
   PHS+poly, 102, 104, 199  
 reflection frequency, 175  
 Richardson, Lewis F., 1  
 Richardson extrapolation. *See* extrapolation  
   Richardson  
 Riemann solver, 70  
 Romberg’s method, 186  
 root condition, 36, 37

Runge phenomenon, 12–14, 17, 65, 70, 94, 99, 100, 110, 139, 159, 199, 200  
 Runge–Kutta (RK), 27, 28, 41, 202  
   implicit (IRK), 29, 40, 67  
 seismic exploration, 20, 63, 195  
 shock, 69  
 Simpson’s rule, 129, 139, 186, 196  
 soliton, 65  
 spherical harmonics, 76  
 spline, 23, 159–166  
   B-spline, 162  
   cardinal, 163  
   end conditions, 160  
 split step, 68  
 stability analysis (PDE), 51, 107, 201  
   stability domain, 54  
   von Neumann, 51  
 stability domain (ODE), 28, 30, 38, 50, 54, 64, 201, 203  
 staggered  
   grid, 57  
   in time, 58  
   RBF–FD, 108  
 Steffensen’s method, 187  
 subsampling, 209  
 sum  
   alternating, 137, 188, 192  
   positive, 130  
   summation by parts (SBP), 57  
 Taylor, Brook, 1  
 Taylor expansion, 2, 113, 114, 116, 139, 147, 191  
   conversion to Padé, 189  
 Taylor series method, 30, 31, 41  
 trapezoidal rule (TR), 115, 124, 134, 139, 148, 186, 195  
 Trefftz method, 76  
 upwinding, 84  
 Van der Pol oscillator, 31  
 Vandermonde, 3, 147, 157, 187  
   nonsingularity, 3, 157  
 wave equation  
   1-D acoustic, 60  
   2-D elastic, 60, 63  
   3-D elastic, 63  
   nonlinear, 65–68  
 WENO, 71  
 zero-stability, 36, 51