

Index

- A-stability, 476
- adaptivity, 218
- adjacency matrix, 283, 312
- advection equation, 486, 492
- advection-diffusion, 487, 497, 536, 537
- Airy equation, 430
- algorithm, 20
- aliasing, 389
- Allen–Cahn equation, 417, 436, 482, 535
- Antilles, Wedge, 449
- Arnoldi iteration, 335, 344
- asymptotic notation, 61
- \(backslash), 45, 104, 112, 156, 167
- backward error, 24, 83, 125
- barycentric interpolation formula, 366
- barycentric weights, 365
- Bauer–Fike theorem, 289
- beam equation, 504
- Bernoulli numbers, 211
- Bessel’s equation, 415, 430
- Black–Scholes equation, 450
- boundary conditions, numerical implementation of, 426, 433, 452, 477, 518, 532
- boundary layer, 431
- boundary-value problem, 410
- Broyden update, 161
- Burgers equation inviscid, 499 viscous, 489
- C3PO, 121, 409
- cardinal functions, 180, 184, 360, 384
- Carrier equation, 415
- CFL condition, 491
- characteristic polynomial, 287
- Chebyshev equation, 416
- Chebyshev points first kind, 382 second kind, 373, 422
- Chebyshev polynomials, 382
- Clenshaw–Curtis integration, 391
- collocation, 425
- condition number, 16 of a matrix, 80, 105 of eigenvalues, 289 of elementary functions, 18 of finite differences, 205 of initial-value problems, 231 of interpolation, 179 of least squares, 105 of rootfinding, 123
- conjugate gradients, 345
- conservation law, 486
- consistency, 239
- contraction map, 134
- convergence rate, *see also* order of accuracy linear, 132, 323, 340, 344 quadratic, 139, 329 spectral, 375, 390 superlinear, 146
- Crank–Nicolson, 462
- D’Alembert’s solution, 504
- Dahlquist theorems equivalence, 276 first stability barrier, 277 second stability barrier, 476
- deflation, 127
- differentiation matrix, 456, 512
- diffusion equation, 451
- digits (significant digits), 11
- dimension, 242
- dimension reduction, 304, 333
- Dirichlet condition, 433, 451
- discretization, 175
- domain of dependence, 490
- double precision, 12
- doubly exponential transformation, 400
- eigenvalue, 286, 338 conditioning of, 289 decomposition, 287, 316, 463 dominant, 320, 326
- elliptic PDE, 524
- eps, 12
- error function, 224
- Euler’s method, 235, 246
- Euler–Maclaurin formula, 211
- evolutionary PDE, 450
- explicit method Adams–Bashforth, 262 Euler’s (for a system), 246 Euler’s (for IVPs), 235 Heun’s, 252 improved Euler, 250 modified Euler, 252 one-step, 238 Runge–Kutta, 249
- extrapolation, 212
- FFT, 388
- field of values, 303
- fill-in, 313
- finite difference parabolic PDE, 456
- finite differences, 160, 196 boundary value problems, 425 elliptic PDE, 512 matrix, 418 parabolic PDE, 452

- finite element method, 443
 assembling equations, 443
 Fisher equation, 483
 Fitzhugh–Nagumo equations, 249
 fixed point, 127
 floating point numbers, 9, 12
 Francis QR iteration, 291
- Galerkin conditions, 441
 Gauss–Newton method, 167
 Gaussian
 distribution, 14
 integration, 393
 generating polynomials, 262
 Gibbs phenomenon, 390
 Givens rotation, 118
 GMRES, 339
 and MINRES, 344
 preconditioning, 353
 restarting, 340
 Gram–Schmidt, 110
 graph nodes and edges, 282
 Gregory quadrature formula, 216
- hat functions, 183
 heat equation, 451, 458, 460, 467, 516
 Hermite
 equation, 416
 interpolant, 36
 hermitian positive definite, 302
 Horner’s rule, 21
 Householder reflection, 113
 hyperbolic PDE, 486
- IEEE 754, 12, 14
 implicit method, 268
 Adams–Moulton, 262
 backward differentiation, 262
 backward Euler, 263
 inflow condition, 493
 initial-value problem, 227
 inner product
 of functions, 378
 of vectors, 542
 interpolation, 31, 148, 175
 by cubic splines, 189
 by piecewise linear
 polynomials, 182, 441
 by piecewise polynomials, 209
 by polynomials, 176, 198, 359
 by trigonometric functions, 384
 condition number of, 179, 186
 inverse interpolation, 148
 inverse iteration, 326
 Jacobian matrix, 153, 160, 472, 532
 Kenobi, Obi-Wan, 1, 485, 507
 Kronecker product, 525
 Krylov subspace, 332
 Kuramoto–Sivashinsky equation, 490
 Lagrange interpolation
 formula, 361
 Laguerre equation, 416
 Lanczos iteration, 344
 Laplace equation, 524
 least squares
 linear, 95
 Legendre equation, 416
 Legendre polynomials, 381
 Levenberg method, 162
 linear combination, 541
 linear system
 ODEs, 243
 overdetermined, 95
 square, 31
 linearization
 of a PDE, 532
 of an ODE, 472
 Lipschitz condition, 134
 local extrapolation, 224
 logistic equation, 228
- machine epsilon, 10
 in double precision, 12
 mantissa, 10
 mass matrix, 441
 matrix
 adjacency, *see* adjacency matrix
 as image, 283, 305, 349
 banded, 85, 314, 419
 condition number, 80, 345
 coordinate, 508
 degree, 318
 diagonal, 540
 diagonalizable, 287
 differentiation, 419, 423
 elementary, 55
 exponential, 243
 factorization, *see also*
 eigenvalue
 decomposition, *and*
 singular value
 decomposition
 Cholesky, 90, 105
 eigenvalue, 296
 LU, 51, 314, 354
 PLU, 70
 QR, 109, 113
 thin QR, 110
 for a function of two
 variables, 508
 graph Laplacian, 318
 hermitian, 296, 540
 Hilbert, 81, 83
 inverse, 44, 45, 104, 543
 Krylov, 332
 nonsingular, 543
 normal, 290
 ONC, 108
 orthogonal, *see* orthogonal matrix
 positive definite, 89, 104, 302, 345
 projection, 113
 similar, 288
 skew-symmetric, 92
 sparse, *see* sparse matrix
 symmetric, 37, 87, 104, 299, 344, 540
 Toeplitz, 292
 triangular, 46, 51, 109, 540
 unitary, *see* unitary matrix
 upper Hessenberg, 336
 Vandermonde, 32, 84, 97
 method of lines, 457, 467, 477, 495
 MINRES, 344
 misfit function, 167
 multistage methods, 250
 multistep method, 261, 266, 273
- NaN (not a number), 12
 Neumann condition, 433, 451
 Newton’s method, 3, 138, 154, 433, 532
 Newton–Cotes formula, 209
 norm
 matrix, 75, 295
 vector, 74
 normal equations, 103, 111
 numerical computing, 4
 ONC, 297

- order of accuracy, 187, 192, 203, 211, 240, 263, 363, 445
 Oregonator, 472
 orthogonal
 matrix, 109, *see also* unitary matrix
 polynomials, 380
 vectors, 107
 orthogonal matrix, 109, 113
 orthogonal projection, 382
 outer product, 543
 overflow, 12

 parabolic PDE, 451
 parameter continuation, 436
 partition of unity, 189
 pendulum, 245, 417
 periodic boundary conditions, 456
 Poisson equation, 524
 power iteration, 321
 preconditioning, 353
 predator–prey model, 242

 quasi-Newton methods
 Broyden update, 161
 finite difference Jacobian, 160
 Levenberg, 162
 Levenberg–Marquardt, 165
 quasimatrix, 379

 racquetball, 543
 random walk, 14
 Rayleigh quotient, 301
 residual, 125
Return of the Jedi, 1, 311
 Robin condition, 433
 root multiplicity, 125, 141
 rootfinding problem, 121, 268

 roots, 24
 Runge phenomenon, 373
 Runge–Kutta method, 249, 257

 Schrödinger equation, 489
 secant method, 145
 Self-Organized Networks Database, 318
 semidiscretization, *see* method of lines
 Sherman–Morrison formula, 165
 shift operator, 263
 shooting method, 411
 Simpson’s rule, 213, 219
 sine integral function, 224
 sine–Gordon equation, 504
 singular value, 293
 principal, 294
 singular value decomposition, 293, 304
 thin form, 297
 Skywalker, Luke, 311
 soap film, 538
 Solo, Han, 31, 95, 227, 359
 sparse matrix, 312, 319, 354
 spline
 cubic, 190
 natural, 192
 not-a-knot, 192
 stability, 22, 72
 of collocation, 429
 of IVP solvers, 275, 463
 of polynomial interpolation, 369
 region, 464
Star Wars: A New Hope, 31, 121, 227, 409, 449, 485, 507

 steepest descent, 162
 stencil, 263
 step size, 235
 stiff problem, 271, 471
 stiffness matrix, 441
 subdiagonal, 540
 subtractive cancellation, 15, 16, 23, 72, 108
 superdiagonal, 539
 Sylvester equation, 524
 symbolic computing, 4

 tensor-product
 domain, 507
 grid, 508
The Empire Strikes Back, 9, 95, 175, 281, 359
 trapezoid formula, 210, 390
 truncation error, 202, 238, 263

 U.S. census, 101
 unconditionally stable, 469
 underflow, 12
 unit roundoff, *see* machine epsilon
 unitary matrix, 286, 293, 299
 upwind direction, 490, 493

 van der Pol equation, 477
 vec, 515
 von Neumann, John, xi

 wave equation, 499, 521
 weak solution, 440

 Yoda, 9, 175, 281

 zero-stability, 275