

---

# Index

- Adams–Bashforth method, 25, 32, 86, 298, 299  
 Adams–Moulton method, 301  
 added mass, 118, 258, 260, 261, 263, 264, 288–290  
 added-mass, 393, 400, 423  
 advection upwind splitting method, AUSM, 418, 432–437  
 ALE, see arbitrary Lagrangian–Eulerian, 115, 121, 141  
 aliasing, 306  
 AMR, see adaptive mesh refinement, 74  
 angular momentum, 13  
 approximate state Riemann solver, 416  
 area coordinates, 133  
 artificial currents, see parasitic currents, 67, 68  
 artificial diffusion, see diffusion, numerical, 32, 45, 275, 276  
 ASTAR, 419  
 Atwood number, 176, 178  
 AUSM, see advection upwind splitting method, 418, 432–437  
 averaging, 239  
 averaging, ensemble, 240, 241  
 averaging, time, 240  
 averaging, volume, 240–243  
  
 backward Euler, 118  
 barycentric coordinates, 227  
 BBBC, see boundary conditions, bounce-back, 184  
 BBGKY theory, 169, 170  
 Bingham fluid, 117  
 Bird–Carreau fluid, 117  
 block structured grid, 95  
 body fitted grids, 22, 26, 31, 79, 94  
 Boltzmann equation, 160  
 boundary conditions, 32, 101, 184, 277, 303, 358, 359, 383  
 boundary conditions, bounce-back, BBBC, 184, 185, 187, 188  
 boundary conditions, diffusive, 184  
 boundary conditions, inflow, 34, 35, 108, 117  
 boundary conditions, outflow, 34–36, 100, 102, 103  
 boundary conditions, periodic, 221  
 boundary integral method, 21, 196, 197, 206  
 Boussinesq limit, 64  
 breaking dam problem, 69  
 breakup, 63  
 bubble columns, 5, 20  
 bubble, collapse, 74  
 bubbles, 20, 70–73, 245, 252, 364, 436  
 bubbles in fluidized beds, 361  
 buoyancy force, 290  
  
 Cahn–Hilliard equation, 64  
 capillary number, 17  
 CATHARE, 400, 402, 403, 426  
 Cauchy data, 266  
 Cauchy problem, 278–280  
 CAVEAT, 368  
 cell-surface quantities, 330, 376  
 CFL, see Courant–Friedrichs–Lewy condition, 25, 336, 381, 387, 394, 398, 409, 412  
 CFX, 325, 344, 393, 403  
 chaining, 153, 154  
 Chapman–Enskog expansion, 163, 168  
 characteristic form, 282  
 characteristic lines, 268, 271, 273, 277  
 CIP, see constrained interpolated propagation, 21, 38, 63  
 CLAWPACK, 84  
 closure, 249, 251, 354, 356, 358, 360  
 co-located grid, 31, 34, 36, 81  
 coalescence, 63  
 COBRA, 391, 402  
 collision models, 146, 147, 149, 161, 185  
 collision probability, 171  
 collisional stress, 246  
 collocated grid, 354, 372  
 color-fluid model, 164  
 compatibility relations, 282, 377, 378  
 conjugate gradient algorithm, 84, 129, 146, 233  
 conservation form, 43, 404  
 conservation of energy, 249

- conservation of mass, 9, 11, 15, 21, 27, 29, 31, 40, 89, 116, 139, 244, 272, 286, 287, 321, 369, 379, 380, 390, 395
- conservation of momentum, 15, 18, 21, 24, 43, 139, 142, 197, 198, 246, 250, 252, 253, 257, 272, 324–326, 334–336, 338, 423, 427, 428, 430
- consistency, 406
- constrained interpolated propagation, CIP, 21, 38, 63
- contact discontinuity, 405, 434
- contact stress, 356
- continuity equation, 9, 15
- continuous dependence on data, 264, 267
- continuous surface force, CSF, 50, 67
- Courant condition, see Courant–Friedrichs–Lewy condition, 377
- Courant–Friedrichs–Lewy condition, 25, 329, 336, 377, 381, 387, 394, 398, 409, 412
- Crank–Nicholson scheme, 25, 124, 298
- CSF, see continuous surface force, 50, 67
- curvature, 13, 50, 56, 62, 228, 229, 232
- curved boundary, 187, 189
- curvilinear grids, 22
- cut-cell methods, 31
- cylinder, 92, 185, 193
- cylindrical grid, 92
- Darcy’s law, 176, 191
- Delaunay–Voronoi tessellation, 130
- diffusion, numerical, 32, 45, 275, 276
- dimensional splitting, 419
- dipoles, 196
- direct forcing, 87, 88
- direct numerical simulations, DNS, 19
- Dirichlet data, 280
- disperse flows, 253
- distance function, 59, 61
- distributed Lagrange multiplier, DLM, 115, 141, 142
- DLM, see distributed Lagrange multiplier, 115
- donor-cell scheme, 330, 401, 402
- double-layers, 197, 205, 229, 230
- drafting, kissing and tumbling, 151
- drag coefficient, 17, 108, 109, 151, 260, 290
- drag on a sphere, 151
- drag reduction, 73
- drag, Oseen, 259
- drag, Richardson–Zaki, 262
- drag, Stokes, 151, 258, 259
- drift-flux model, 253, 280, 416, 423, 428, 430, 434
- drops, 67, 75
- dynamic remeshing, 226
- Eötvös number, 16
- eddy turnover time, 315
- emulsions, 197, 199, 201, 221
- enhanced oil recovery, 175
- ENO, see essentially non-oscillatory scheme, 32
- ENO, see essentially nonoscillatory scheme, 409
- Enskog’s theory for dense fluids, 169, 170, 172
- entropy condition, 405
- entropy fix, 415
- essentially non-oscillatory scheme, ENO, 32
- essentially nonoscillatory scheme, ENO, 409
- Euler equations, 432
- Eulerian–Eulerian description, 254, 390
- Eulerian–Lagrangian scheme, 368, 373
- Eulerian–Lagrangian description, 253
- Ewald summation, 222–224, 236
- expansion fan, 405, 409, 410
- expansion shocks, 404
- fast Fourier transform, 237, 305
- fast multipole methods, 236
- Favre average, 245
- Faxén’s law, 258
- FDS, see flux-difference splitting, 413, 414
- feedback forcing, 88
- fictitious domain, 115, 141, 142
- filament, 56, 75
- film, 41, 56, 57
- finite element method, space-time, 137
- finite volume method, 326
- finite-volume method, 26, 94
- FLUENT, 388
- fluidized beds, 3, 20, 361
- flux-difference splitting, FDS, 413, 414
- flux-vector splitting, FVS, 413, 431
- fractional-step method, 26, 85, 99, 144, 145, 299, 300, 307, 417
- Fredholm integral equation, first kind, 209, 217
- Fredholm integral equation, second kind, 217
- free-energy model, 167
- front tracking, 38, 50, 57
- Froude number, 15
- fluidized bed, 354
- FVS, see flux-vector splitting, 413, 431
- Galerkin method, 126, 139
- Galilean invariance, 168, 169, 193
- Galilei number, 16
- gas–solid flows, 308
- Gauss quadrature, 103, 230, 231
- generalized buoyancy force, 255
- ghost cells, 33, 383
- ghost fluid method, 65, 84
- ghost point method, 23
- GLBM, see lattice Boltzmann method, generalized, 184–186
- GMRES, 84, 129, 140, 233
- Godunov method, 409, 412, 413, 421
- granular temperature, 357, 360
- gravity currents, 69
- Green’s function, 197, 204, 206, 207, 219, 232
- Green’s function, periodic, 224
- grid independence, 42, 269, 364
- grid refinement, 42, 57
- grid stretching, 104, 106

- Helmholtz equation, 26, 88  
Herschel-Bulkley fluid, 117  
hindrance function, 262  
history force, 260, 263, 264, 289, 290  
homogeneous flow model, 252, 423, 426, 428, 430, 434  
hyperbolic system, 265, 268, 410
- immersed boundary method, 21, 80, 85, 97  
immersed interface method, 65  
implicit continuous Eulerian, ICE, 390  
index function, 174  
inertial bias, 109, 317  
inter-phase slip algorithm, IPSA, 346, 350  
intermolecular potential, 165, 167, 170, 174  
interparticle potential, 165  
interpolation, 54, 227, 292–296, 314  
IPSA, see inter-phase slip algorithm, 346, 350
- Kelvin–Helmholtz instability, 177, 180  
kinematic boundary condition, 11  
kinetic theory closures, 356, 357  
Knudsen number, 162  
Kolmogorov scales, 108, 291, 308, 309, 316
- Lagrangian integral time scale, 315  
large eddy simulation, 322, 368  
lattice Boltzmann method, generalized, GLBM, 184–186  
lattice Boltzmann method, LBM, 160  
lattice gas automaton, LGA, 160  
Lax–Wendroff scheme, 45, 408, 421  
LBM, see lattice Boltzmann method, 160  
Lennard-Jones potential, 165, 167, 170, 174  
level set method, 21  
level-set method, 37, 57, 61, 63  
LGA, see lattice gas automaton, 160  
lift force, 261, 263, 290  
limiter, 332, 377, 378, 420  
limiter, Chakravarthy–Osher, 421  
limiter, flux, 361, 420  
limiter, Minmod, 332, 421, 422, 427  
limiter, slope, 332, 421, 422  
limiter, Superbee, 332, 361, 364, 367, 427  
linear momentum, 13  
linear multistep methods, 298  
Lorentz integral identity, 237  
Lorentz reciprocal theorem, 203, 216
- MAC, see marker-and-cell method, 21, 51  
macromolecules, 196  
Marangoni stresses, 230  
marker function, 20, 21, 43, 48, 52, 55, 57, 62, 76  
marker points, 20, 21, 51, 54, 81  
marker-and-cell method, MAC, 21, 51  
marker-function, 56  
mass loading, 319  
mass-conservation algorithms, 343  
mean-field approximation, 169, 171, 172, 174, 195
- mechanical energy, 250  
memory force, 259  
mesh locking, 128  
mesh velocity, 122, 123, 128  
MFX, 360  
microscale jetting, 75  
MILES, 394  
mobilities, 197  
mobility formulation, 202  
mobility tensor, 208, 209  
momentum equation, 10, 13, 15  
momentum forcing, 88, 89  
monotone schemes, 46, 408  
monotone upstream-centered scheme for conservation laws, MUSCL, 331, 332, 422, 429, 435  
Morton number, 16  
moving boundaries, 185, 190  
MRT, see multiple relaxation times, 184, 193, 195  
MRT-GLBM, 187, 189  
multi-fluid models, 323  
multiple relaxation times, MRT, 184, 193, 195  
MUSCL, see monotone upstream-centered scheme for conservation laws, 332, 429, 435
- Navier–Stokes equations, 9, 40  
Newton linearization, 328  
Newton–Krylov method, 401  
Newton–Raphson algorithm, 128, 140, 371  
non-conservative form, 10, 43  
number density, 256
- Ohnesorge number, 17  
Oldroyd-B fluid, 116, 150, 153  
OLGA, 323, 379, 391  
one-fluid formulation, 22, 37, 38, 41, 42, 57, 76  
one-way coupling, 313  
Oseen tensor, 205
- parasitic currents, 67, 68  
PARCS, 390  
partial elimination algorithm, PEA, 339, 341, 374  
particle phase stress, 356  
particle-mesh methods, 236, 237  
PEA, see partial elimination algorithm, 339, 341, 374  
permeability, 175, 176, 191, 193  
PeTra, 323  
phase change, 244, 245  
phase function model, 174, 176  
phase-field method, 21, 37, 63, 64, 68  
Picard iteration, 217, 233, 371  
Picard linearization, 328, 381  
piecewise linear interface calculation, PLIC, 48, 50  
piecewise parabolic method, PPM, 67  
pipelines, 6  
PISO, 344, 349

- PLIC, see piecewise linear interface  
   calculation, 48, 50  
 point-particle methods, 285, 286  
 Poisson equation, 26, 55  
 pole filter, 107  
 porous media, 175, 185, 191  
 power-law fluid, 117  
 PPM, see piecewise parabolic method, 67  
 pressure equation, 29, 42, 68  
 pressure waves, 281  
 pressure-weighted interpolation, 31, 353  
 projection method, 23, 24, 29, 37, 38, 42, 132,  
   213, 214, 217, 299  
 PROST-VOF method, 68
- quadratic upstream interpolation for  
   convective kinematics, QUICK, 32
- radial distribution function, 171  
 Rankine–Hugoniot condition, 404, 415, 430  
 Rayleigh–Taylor instability, 64, 69, 175–179,  
   181  
 reciprocal lattice, 224  
 reconnection, 56  
 reconstruction, 48, 50  
 reinitialization, 57, 59, 60  
 RELAP, 389, 391, 393, 402, 423–427  
 representative elementary volume, REV, 176,  
   241  
 reshaping procedure, 81  
 resistance formulation, 202  
 resistance tensor, 208, 209  
 REV, see representative elementary volume,  
   176, 241  
 Reynolds number, 15  
 Rhie–Chow interpolation, 31  
 Rhie–Chow interpolation, 351, 353  
 Richtmyer–Meshkov instability, 182  
 Riemann problem, 409, 412, 420, 423  
 Roe’s method, 414, 428–430  
 Runge–Kutta method, 32, 234, 298  
 Runge–Kutta/ENO, 58, 61
- scalar conservation laws, 404  
 segregated solvers, 324  
 semi-implicit method, 394  
 separation of scales, 240  
 SETS, see stability enhancing two-step  
   method, 398  
 sharp interface methods, 22, 23, 65, 80, 81  
 shock, 404, 409, 410, 434  
 shock-tube problem, 434  
 SIMMER, 389, 418  
 SIMPLE, 324, 339, 342, 344, 349, 360, 388  
 simple line interface calculation, SLIC, 48, 50  
 SIMPLEC, 344, 347, 349, 350  
 SINCE, 339, 374  
 SLIC, see simple line interface calculation, 48,  
   50  
 slip velocity, 253, 319  
 smoothness parameter, 332, 421
- sonic point, 410  
 source terms, 426  
 specific surface area, 176  
 spectral method, 36, 96, 102, 103, 304  
 specular coefficient, 359  
 spherical particle, 88, 92–94, 96, 109  
 spinodal decomposition, 175  
 split scheme, 25, 50, 63, 417  
 spurious currents, 165, 173  
 stability enhancing two-step method, SETS,  
   398  
 stability–hyperbolicity theorem, 272  
 stabilized space-time finite element, 115  
 staggered grid, 28, 32, 33, 37, 327, 372  
 Stokes equations, 16, 199  
 Stokes flow, 196  
 Stokes number, 17  
 Stokes response time, 291  
 Stokesian dynamics, 237  
 Stokeslet, 309  
 Strang’s splitting, 418, 419  
 streaming stress, 248, 356  
 stress tensor, 10, 116, 120, 127  
 Strouhal number, 15  
 structured grid, 23, 31, 37, 79  
 subgrid stress, 322  
 superficial velocity, 246  
 surface average pressure, 248  
 surface average stress, 248  
 surface dipole, 206  
 surface interpolation, 229  
 surface markers, 21  
 surface tension, 40, 42, 50, 52, 55, 64, 65  
 surface traction, 13, 201  
 surfactant, 197, 201, 210, 230, 234  
 suspensions, 196, 197, 221, 224
- Taylor microscale, 108  
 threads, 41, 42  
 threads, breaking, 41  
 time step limitation, 24, 88  
 time-marching methods, 297, 298  
 time-splitting scheme, see fractional-step  
   method, 26  
 topology change, 41, 42, 56  
 total variation, 408  
 total variation diminishing schemes, TVD,  
   331, 408, 421, 422  
 TRAC, 389–393, 398, 399  
 TRACE, 389  
 trapezoidal rule, 230  
 triangular surface grid, 52  
 turbulence, 96  
 turbulence dissipation, 291  
 turbulence modulation, 110, 317  
 turbulence, homogeneous, 307  
 turbulence, isotropic, 303, 307, 312  
 TVD, see total variation diminishing schemes,  
   331, 408, 421, 422  
 two-fluid models, 323  
 two-level methods, 406

470

*Index*

- two-way coupling, 319
- unstructured grid, 22
- unstructured grids, 31
- upwind method, 32, 45, 161, 330, 361, 364, 401
- van der Waals theory, 171
- velocity distribution function, 161
- virtual mass, see added mass, 118
- viscoelastic fluids, 115, 116, 141, 143, 150, 153, 154
- viscoelastic response, 197
- VOF, see volume-of-fluid method, 21, 37, 48, 50, 54, 57, 63
- volume fraction, 243
- volume-of-fluid method, VOF, 21, 37, 48, 50, 54, 57, 63
- volumetric flux, 246
- Voronoi-type grid, 374
- water packing, 403
- weak formulation, 119, 121, 123, 125, 126, 128, 143, 144, 429
- Weber number, 16
- wettability, 175
- Wielandt's deflation, 215, 217, 220