

Index

- accuracy, 43, 176
- adaptation, 60, 178
- algebraic slip model, 150
- angular momentum, 74
- anisotropic, 70, 71
- application uncertainty, 175
- aspect ratio, 59
- average concentrations, 133
- average reaction rate, 116, 140

- Batchelor length scale, 119
- BBO equation, 147
- beta-PDF, 122
- boundary conditions, 18–21
 - axis, 20
 - best-practice guidelines, 177
 - inlet, 19, 111
 - outlet, 19
 - periodic, 6
 - symmetry, 20
 - wall functions, 106
 - walls, 19
- boundary layers, *see* turbulent boundary layers
- boundedness, 40
- Boussinesq approximation, 85
- bouyancy force, 149
- Brownian force, 149

- calibration, 180
- capillary number, 160
- cell-centred, 26
- central differencing, 40
- chemical energy, 16
- chemical reactions, 130–40
 - best-practice guidelines, 178
- collision viscosity, 167
- combustion, 137
- conditionally bounded, 40
- conservativeness, 38
- conserved scalar, 119
- consistent, 46
- continuity equation, 12
- control volume, 26

- convergence, 37
 - best-practice guidelines, 175
- Courant number (CFL), 57, 176
- Crank–Nicolson, 56

- Dahmköhler number, 118
- dense regime, 144
- dilatational viscosity, 12
- dilute regime, 144
- direct numerical simulation (DNS), 79
- discrete random walk (DRW), 154
- discretization schemes, 38–46, 176
 - comparison, 46
- dispersed flow, 144
- dissipation, 91
- dissipative subrange, 73, 76
- drag coefficient, 162
- drag force, 148
- drag models, 161
- drift velocity, 157
- dynamic LES, 81

- eddy dissipation (ED), 141
- eddy viscosity, 86
- effective viscosity, 86
- energy cascade, 72
- energy-containing subrange, 73, 76
- energy spectrum, 75
- energy transport, 16
- engulfment, 117
- Eötvös number, 162
- equation of state, 22
- equilibrium reaction, 135
- Euler–Euler, 150, 155
- Euler–Lagrange, 150, 152
- explicit method, 54

- face value, 28
- film model, 168
- filtered residual, 80
- filtered velocity, 80
- finite differences, 25
- finite elements, 25

- finite volumes, 25
- first-order accurate, 44
- first-order upwind, 41, 176
- forces on dispersed particles, 147–9
 - bouyancy force, 149
 - Brownian force, 149
 - drag force, 148
 - history force, 148
 - Magnus lift force, 148
 - pressure force, 148
 - Saffman lift force, 149
 - shear force, 148
 - thermophoretic force, 149
 - turbulence force, 149
 - virtual mass force, 148
- four-way coupling, 147
- friction velocity, 103
- frictional viscosity, 167
- Gauss theorem, 27
- Gauss–Seidel, 34
- granular flow models, 165
- granular temperature, 166
- granular viscosity, 167
 - collision, 167
 - friction, 167
 - kinetic, 167
- heat transfer, 168
- hexahedral, 58
- history force, 148
- HRIC scheme, 46
- implicit method, 55, 177
- incompressible flow, 13
- inertial subrange, 73, 76
- initial conditions, 20, 34
 - best-practice guidelines, 176
- intensity of segregation, 125
- inter-particle distance, 145
- isotropic, 68, 71, 75
- kinetic energy, 16
- kinetic energy balance, 16
- kinetic theory of granular flow (KTGF), 166
- kinetic viscosity, 167
- Knudsen number, 15, 163
- Kolmogorov hypotheses, 70
- Kolmogorov spectrum law, 76
- Kronecker delta, 12
- k – ϵ model, 89
- k – ω model, 95
- large-eddy simulation (LES), 79
- law of the wall, 105
- look-up table, 134
- low-Reynolds-number models, 108
- Mach number, 14
- macromixing, 113
- Magnus lift force, 148
- mass transfer, 168
- mean concentrations, 133
- mean free path, 9
- mesh generation, 58
 - best practice guidelines, 175
- micromixing, 113
- mixing segregation, 128
- mixing timescales, 119
 - inertial–convective mixing, 119
 - viscous–convective mixing, 120
 - viscous–diffusive mixing, 120
- mixture fraction, 119–30, 132
 - closures, 126
 - instantaneous, 124
 - mean, 124
 - variance, 122, 125
- mixture model, 150, 156
- momentum balance, 14
- multigrid, 50
- multiphase flows
 - characterization, 144
 - coupling, 146
 - loading, 145
 - particle forces, 147
 - particle spacing, 145
 - response time, 146
 - Stokes number, 145
 - volume fraction, 144
- multiphase modelling, 149–69
 - best-practice guidelines, 178
 - boundary conditions, 169
 - Euler–Euler, 150, 155
 - Euler–Lagrange, 150, 152
 - guideline, 172
 - mixture model, 150, 156
 - porous-bed model, 150, 160
 - turbulence, 153, 156, 160
 - volume-of-fluid (VOF) model, 150, 158
- MUSCL scheme, 46
- Navier–Stokes equations, 15
- near-wall modelling, 99–110
- Newtonian fluid, 10
- node-centred, 26
- non-PDF models, 141
- normal stress, 11, 84
- numerical diffusion, 60, 176
- numerical errors, 176
- Nusselt number, 169

- one-way coupling, 146
- particle collisions, 164
- particle interactions, 163
- particle pressure, 167
- particle response time, 146
- particle Reynolds number, 162
- particle spacing, 145
- particle–particle collisions, 169
- Péclet number, 39
- phase coupling, 146
- PISO, 48
- Poisson equation, 13
- porous-bed model, 150, 160
- potential energy, 16
- power-law scheme, 45
- Prandtl number, 10
- Prandtl’s mixing length, 105
- pressure force, 148
- pressure-strain, 98
- PRESTO!, 49
- presumed PDF, 122
- probability density function (PDF), 120
- QUICK scheme, 45
- radial distribution function, 167
- RANS equations, 82
- rapid granular flow, 166
- rarefaction effect, 163
- rate of strain, 10
- raw moment, 126
- reaction-progress variable, 138
- realizable k – ε model, 94
- residuals, 38
- restitution coefficient, 164
- Reynolds decomposition, 81
- Reynolds number, 69
- Reynolds stress models (RSM), 96
- Reynolds stress tensor, 84
- Reynolds stresses, 84
- RNG k – ε model, 93
- rotational velocity, 148
- Saffman lift force, 149
- sample-space variable, 122
- scalar dissipation rate, 127
- scales of segregation, 128
- Schmidt number, 9
- second-order accurate, 44
- second-order upwind, 42
- sensitivity analysis, 180
- separated flow, 144
- shear force, 148
- shear stress, 11, 84, 101
- Sherwood number, 168
- SIMPLE, 48
- SIMPLEC, 48
- SIMPLER, 48
- size distribution, 179
- skewness, 59, 175
- slip velocity, 157
- slow granular flow, 166
- Smagorinsky–Lilly model, 81
- species balance, 18
- specific dissipation, 95
- squish index, 175
- statistical methods, 66
- stoichiometric mixture fraction, 132
- Stokes number, 145
- strain rate, 10
- stratified flow, 144
- structured grid, 26, 58
- subgrid stress model, 80
- subgrid stress tensor, 80
- subgrid viscosity, 81
- substantial operator, 13
- surface-tension model, 159
- Taylor expansion, 42
- tensor notation, 8
- tetrahedral, 58
- thermal energy, 16
- thermal energy balance, 18
- thermophoretic force, 149
- third-order accurate, 46
- time step, 177
- transportiveness, 40
- truncation error, 43
- turbulence
 - characteristics, 63
 - energy cascade, 72
 - energy spectrum, 75
 - kinetic energy, 68, 90
 - statistics, 66
 - timescales and length scales, 73
 - transition, 69
- turbulence modelling, 76–99
 - best-practice guidelines, 177
 - comparison, 99
 - direct numerical simulation (DNS), 79
 - energy dissipation, 91
 - k – ω model, 95
 - large-eddy simulation (LES), 79
 - low-Reynolds-number models, 95, 108
 - near-wall region, 107
 - realizable k – ε model, 94
 - Reynolds stress models (RSM), 96
 - RNG k – ε model, 93
 - standard k – ε model, 89
 - turbulent viscosity, 85, 86
 - zonal modelling, 107

- turbulent boundary conditions, 99–112
 - inlet, 111
 - unsteady, 20
 - walls, *see* wall functions
- turbulent boundary layers, 101
 - buffer sub-layer, 102
 - fully turbulent sub-layer, 102
 - viscous sub-layer, 101
- turbulent diffusivity, 126
- turbulent energy dissipation, 91
- turbulent intensity, 112
- turbulent kinetic energy, 68, 90
- turbulent mixer model (TMM), 128
- turbulent mixing, 117
- turbulent viscosity, 85, 86
- two-way coupling, 146
- u , 103
- unbounded, 46
- under-relaxation, 49, 176
- universal equilibrium range, 73, 76
- unsteady flows, 51, 177
- unstructured grid, 58
- validation, 180
- van Leer scheme, 42
- velocity decomposition, 67
- verification, 180
- virtual mass force, 148
- viscosity models, 22
- viscous dissipation, 17
- viscous stress, 10
- volume fraction, 144
- volume-of-fluid (VOF) model, 150, 158
- von Kármán constant, 81
- vortex stretching, 74
- vorticity, 74
- wall friction velocity, 103
- wall functions, 104–7
 - best-practice guidelines, 177
 - non-equilibrium, 106
 - standard, 104
- wave number, 75
- Weber number, 160
- y^+ , 103