

Index

- acoustic streaming, *see* steady streaming
- active particle, *see* locomotion
- added mass, 110, 113, 215
- angular velocity, 3, 60–62, 68, 69, 74, 86, 88, 89, 194, 229, 233
- ballistic motion, 126, 136, 164, 165, 169, 215
- Basset force, 109, 112, 215
- bead–spring chain, 119, 175–188, 228
- bead–spring dumbbell, *see* dumbbell model
- biharmonic equation, 13, 28
- Blakelet, 93
- boundary integral equation, 85, 98–102
- Bretherton constant, 74, 195
- Brinkman model, *see* porous medium
- Brinkmanlet, 51, 54
- Brownian dynamics simulation, 129–132, 144, 149–156, 169
- Brownian force, 133–136, 175, 178, 196, 197, 224
- Brownian motion, 64, 77, 114, 139–143
 - in a complex fluid, 211–215
 - of polymer segments in flow, 224–227
 - on a circle or sphere, 158–161
- Cauchy tensor, 8, 235
- causality, causal function, 117, 203, 243
- central limit theorem, 141, 250
- characteristic function, 250
- characteristic ratio, 173
- complex fluid, xi, 1, 9, 12, 156, 170, 192, 201, 205, 211
- conformation tensor, 191, 192
- connector vector, connector force, 174, 176, 178, 189, 199, 224
- convected derivative, 9
 - corotational or Jaumann, 233
 - Gordon–Schowalter, 233
 - lower or covariant, 23, 233, 235
 - upper or contravariant, 8, 191, 192, 232
- convolution, 205, 209, 211, 250
 - Fourier, 242
 - Laplace, 243
- correlation function, 253
 - and Wiener–Khinchin theorem, 254
 - autocorrelation, 117, 253
 - time correlation function, 117, 119, 120, 124, 125, 130, 133, 162, 245, 253
 - velocity autocorrelation function, 117–121, 123, 133, 138, 163, 166, 211, 213
- covariance, 130, 249
- covariant and contravariant basis vectors, 6, 7
- creep compliance, 233
- cross-correlation theorem, *see* Wiener–Khinchin theorem
- Darcy’s law, *see* porous medium
- Dean flow, 218
- Deborah number, 207
- deformation gradient tensor, 6
- deformation rate tensor, *see* rate of strain tensor
- delta family, 244
- delta function, 244–247
- diffusion, 116, 126–129, 133–136, 139–143, 156–158, 170
 - and Wiener process, 139–143
 - anomalous, 129
 - in a complex fluid, 211–215
 - Kirkwood diffusivity, 190
 - of momentum, 13, 104–110
 - of polymers in solution, 179–182
 - of stress or conformation, 192
 - rotational, 158–168, 193–199, 204
 - short-time, 148
 - Stokes–Einstein diffusivity, 127, 135, 154, 182
 - Taylor–Green–Kubo formula, 128
- divergence theorem, 11, 19–21, 24, 34, 58, 100, 240
- double dot product, 197, 239
- drift velocity, 143, 148, 159, 195
- dumbbell model, 24, 188–193, 216–227
 - FENE-P model, 193
- dynamic pressure, 13
- elongational viscosity, *see* extensional flow
- ensemble average, 115, 247–249
- entropic force, *see* Brownian force
- entropic spring, 175
- equipartition principle, 115, 122
- ergodicity, 119, 253
- Ermak–McCammon algorithm, *see* Brownian dynamics simulation

- Euler–Maruyama scheme, *see* Brownian dynamics simulation
- Ewald sum, 47–50, 87
- expected value, *see* ensemble average
- extensional flow
- biaxial, 4, 234
 - planar, 4, 5
 - Trouton ratio, 222
 - uniaxial, 4, 76, 198, 222–223, 227
 - viscosity, 193, 222
- Faxén’s laws, 66–68, 88
- FENE spring, 176, 193
- Finger tensor, *see* Green tensor
- flow instability, 218–222
- fluctuation-dissipation theorem, 119, 150
- fluid element, 3
- Fokker–Planck equation, 147, 148, 150, 154, 160, 161
- force dipole, 31–35, 38, 63, 87, 94, 95, 99, 186, 188, 190, 217, 225, 227
- rotlet, 32, 33, 35, 61, 88, 102
 - stresslet, 32, 33, 35, 36, 53, 63, 66, 69, 86, 87, 96, 102, 111, 121, 124, 125
 - stresslet for sphere in linear flow, 68
- Fourier transform, 45–46, 241–243
- and linear viscoelasticity, 204–210
- freely jointed chain, 173, 188
- friction coefficient, 39, 60, 71
- anisotropic, 71, 137, 166
 - polymer, 182
 - rotational, 61, 74, 195
 - spherical bubble, 87
- Frobenius norm, 5, 239
- Gaussian chain, *see* ideal chain
- Gaussian distribution, *see* normal distribution
- generalized Langevin equation, 132–133, 211
- relation to a Markov process, 133, 137, 212
- generalized Stokes–Einstein relation, 211
- Gordon–Schowalter derivative, *see* convected derivative
- grand resistance tensor, 70
- Green tensor, 8, 192, 235
- Green’s first identity, *see* Green’s identities
- Green’s formula, *see* Green’s identities
- Green’s function, 26, 154
- arbitrary domain, 90
 - for Laplacian operator, 56
 - free space, 26–29, 34
 - point source or potential, 29
 - reciprocity, 90–91
 - regularized, 43, 48
 - semi-infinite domain, 91–94
- Green’s identities, 102, 241
- Green’s second identity, *see* Green’s identities
- Green–Kubo formula, 128
- harmonic function, 55
- associated Legendre polynomials, 57
 - spherical harmonics, 56–58
- Hooke’s law, 175, 188
- Hookean or neo-Hookean solid, 8, 192, 203
- hoop stress, 218
- hydrodynamic interactions, 38–42, 86, 178
- and diffusion of polymers, 179–182
 - between a particle and a wall, 95, 111
 - in confined systems, 94, 97–98
 - screening, 52, 97
 - when inertia is nonnegligible, 106
- hydrodynamic mass, *see* added mass
- ideal chain, 173–175, 177, 181, 182, 188, 193
- ill-posed problem, 78
- incompressible flow, 10, 12
- eigenvalues of velocity gradient, 3
 - equipartition of energy, 122
 - mechanical energy balance, 21
 - pressure, 12, 22
- interfacial tension, 15
- Jeffery orbits, *see* rigid rod model *or* nonspherical particles in flow
- Kelvin–Voigt model, 203
- Kramers chain, 173–175
- Kramers–Kronig relations, 208–210
- Kronecker delta, 237
- Kuhn length, Kuhn segment, 173
- Lamb’s general solution, 57
- Langevin dynamics simulation, *see* Brownian dynamics simulation
- Langevin equation, 114–120, 123, 129, 137, 139, 149–156, 194, 253
- and material frame indifference, 228
 - inertialess, 130, 143, 151–156, 180
 - reformulation of generalized Langevin equation, 212
 - relation to stochastic differential equation, 143, 150
- Laplace transform, 243
- and generalized Stokes–Einstein relation, 211–215
 - and Langevin equation, 116
- left Cauchy–Green tensor, *see* Green tensor
- Leibniz’s rule, 11, 241
- light scattering, 138
- linear flow, 2, 7, 23, 86
- nonspherical particle in, 74–77
 - sphere in, 59, 62–64
- linear response theory, 201
- locomotion, 25, 36
- flagellar, 72–73
 - linked rigid bodies, 18
 - near a surface, 102
 - pushers and pullers, 66

- squirmer model, 64–66, 88
with rotational diffusion, 162–166
- Lorentz reciprocal relations, 19–20, 60, 70, 110, 125
and boundary integral equations, 98
and Faxén's laws, 66, 88
and fluctuating hydrodynamics, 125
and reciprocity of Green's functions, 91
- lubrication interactions and flow in thin films, 81–87
pressure, 85
- Lyapunov exponent, 23
- material frame indifference, 227–233, 235
- material line, 2, 23, 189, 191
- material point, 2
- Maxwell model, 202–203, 206, 214
upper convected, 192, 217
- memory kernel, *see* generalized Langevin equation
- migration of particles in flow, 18, 95–97, 102
inertial, 110–111
polymers in solution, 178, 190, 217
- mobility, 39, 131, 167
and polymer diffusion, 180
for N point particles, 38–42
for N spheres, 68–69, 91
grand mobility for N spheres, 87
grand mobility for nonspherical particle, 70
in confined systems, 94–95, 102
regularized point particles, 44, 53
- modulus
complex, 205
loss, 206
relaxation, 201–210, 234
shear, 191
storage, 206
- multipole expansion, 34–36, 55, 58, 85, 87
Laplace equation, 56
- Navier–Stokes equation, 12–13, 104, 111
boundary conditions for, 14
including thermal fluctuations, 120–126
linearized, 14
- nonspherical particles in flow, 69–81
Jeffery orbits, 74–77, 226
- normal distribution, 131, 139–143, 175, 250–253
- normal stress differences and coefficients, 216–218
and viscoelastic flow instability, 221
- Oseen–Burgers tensor, *see* Stokeslet
- Péclet number, 136, 204
- persistence length, 171–172, 193
- Piola tensor, 23
- point force, *see* Stokeslet
- point source, 29–30, 53, 54, 91
- polymer solution, 8, 156, 170–200, 224–227
concentrated, 171
semidilute, 171
- porous medium, 50–53, 182
Brinkman model, 51
- Darcy's law, 51, 97
- potential dipole, 30, 36, 52, 53, 60, 64, 66, 71, 77, 87, 94, 113
swimmer, 64–66
- potential flow, 29, 51
- power spectrum, 254
- probability density function, *see* probability distribution function
- probability distribution function, 29, 247–253
Boltzmann, 134, 175, 187
contracted, 249
evolution equation for, 133, 147–149
for polymer conformation, 173–179, 224
joint, 248
marginal, 249
Maxwell, 114, 134
Maxwell–Boltzmann, 149, 169
moment of, 248
orientational, 158–161
stationary, 253
- pseudovectors and pseudotensors, 33, 60, 74, 240
- random variables, 29, 116, 247–253
independent, 249
- random walk, 141, 156
self-avoiding, 177, 181
wormlike, 161–166, 171
- rate of strain tensor, 3, 25, 68, 69, 86, 232
- Rayleigh criterion, *see* flow instability
- relaxation spectrum, 183–186, 207
- relaxation time, 24, 182, 191, 197, 204
inertial-viscous, 35, 116, 127, 136, 150, 151
Rouse and Zimm scaling, 185
- resistance, *see* mobility
- resistive force theory, *see* slender body theory
- Reynolds number, 13
moving sphere at finite value of, 104–106
particle migration at finite value of, 110–111
- rheology, 201–218
extensional, 222–227
- Riemann–Lebesgue lemma, 78
- right Cauchy–Green tensor, *see* Cauchy tensor
- rigid rod model, 71, 74–77, 193–200, 233, 235
semidilute and concentrated solutions, 194
- rod-climbing, *see* Weissenberg effect
- rotlet, *see* force dipole
- rotlet doublet, 102
- Rouse chain, Rouse mode, 183, 184
- screening, 52
and diffusion of polymers, 182
in confined systems, 97, 98, 178
in Ewald sum method, 48
in porous media, 52–53
- SDE, *see* stochastic differential equation
- self-propelled particle, *see* locomotion
- slender body theory, 72, 77–81, 88, 89, 106, 227
- slip velocity, *see* migration of particles in flow

- Smoluchowski equation, 133–136, 139, 148, 154
 for bead–spring dumbbell in solution, 188
 for polymer chain in solution, 178
 for rigid rod in solution, 195, 197, 235
 solvent quality, 177
 θ solvent, 177
 good solvent, 177
 poor solvent, 177
 source dipole, *see* potential dipole
 spin tensor, *see* vorticity
 steady streaming, 111
 stochastic calculus, 143–147
 Itô stochastic chain rule, 146
 Itô stochastic integral, 144
 Itô's formula, 146, 169
 Stratonovich stochastic integral, 144
 systems with constraints, 158–161
 stochastic differential equation, 143, 144, 146
 coordination transformations and constraints, 156–161
 evolution equation for probability distribution, 147–149
 for bead–spring chain in solution, 180, 183
 for rigid rod in solution, 195, 198
 multidimensional, 148
 numerical solution, *see* Brownian dynamics simulation
 relation to Langevin equation, 143, 150
 stochastic process, 248
 ergodic, 253
 stationary, 253
 Stokes equation, Stokes flow, 13, 15–23
 dissipation principle, 20
 fluctuating Stokes equation, 125
 general solution, 55–57
 integral form of Stokes equation, *see* boundary integral equation
 reversibility, 16
 solutions, *see* Stokeslet, potential dipole, force dipole, multipole expansion
 stress equilibrium, 18
 transient Stokes equation, 14, 107, 112
 Stokes layer, 109
 Stokes's law, 39, 60, 71
 inertial modification, 106
 rotational, 61, 88
 Stokesian dynamics, 85, 156
 Stokeslet, 26–29, 35, 57–58, 60, 71, 77, 78, 80
 above a plane wall, 91–94
 and point particle approximation, 39
 in a bounded domain, 94, 97
 in bead–spring chain models, 178
 periodic array, 44–50
 regularized, 42, 43, 53, 200
 Stokeslet doublet, *see* force dipole
 strain rate tensor, *see* rate of strain tensor
 stress tensor, 11, 12
 and stresslet, 33, 38
 extra, 11
 fluctuating, 121, 123–125
 for bead–spring dumbbell model, 190
 for rigid rod model, 195–199
 in a polymer solution, 186–188
 in a suspension, 36–38, 62–64
 Newtonian fluid, 12
 osmotic, 128
 polymers in extension, 222–227
 polymers in shear, 216–218
 Stokeslet, 28
 symmetry of, 24
 viscous, 12
 stresslet, *see* force dipole
 Strouhal number, 13, 111
 substantial derivative, 8
 surface tension, *see* interfacial tension
 suspension, 85, 133, 156
 Smoluchowski equation, 136
 stress tensor, 36–38
 viscosity, 62–64
 swimming, *see* locomotion
 thermal velocity, 115, 152
 Trouton ratio, *see* extensional flow
 velocity gradient, 2
 virtual mass, *see* added mass
 viscoelastic flow instability, *see* flow instability
 viscoelasticity, 8, 12, 192, 203
 linear, 201–210
 nonlinear, 216–227
 viscosity, 12
 bead–spring chain, 193
 bead–spring dumbbell in solution, 192
 complex, 205, 210, 212
 Einstein expression for dilute suspension, 63
 extensional, 222, 223, 227
 intrinsic, 63
 Krieger–Dougherty equation, 64
 rigid rod in solution, 197
 shear-thinning, 226
 suspension, 62–64
 zero-shear, 197, 204
 vorticity, 3, 232
 Weissenberg effect, 219
 Weissenberg number, 204, 216, 219
 as ratio of stresses, 217
 extensional flow, 223, 234
 rheology at high values of, 224–227
 well-posed problem, 78
 Wiener process, 139–143
 differential of, 141, 145
 increment of, 141
 Wiener–Khinchin theorem, 119, 253–254
 wormlike chain, 171–172
 Zimm model, 181, 185