

Index

- acoustic, admittance, 412, 413
 - compactness, 399
 - energy flux, intensity, power, 399
 - filter, 418
 - Green's function, 398
 - particle velocity, 390
 - plane waves, 392
 - power in terms of admittance, 416
 - Reynolds number, 446
 - wave action, 372
 - wave equation, 391
- action, wave, 364
 - propagates at group velocity, 366
- added mass, 44
 - tensor, 71
- admittance, applied to Helmholtz resonator, 417
 - bulbous termination, 421
 - cavity, 416
 - circular aperture, 432
 - definition 412, 413
 - flanged open end, 426
 - narrow constriction, 419
 - open end, 424
- Abramowitz, M., 202
- aileron, 192
- airfoil, cambered, 178
 - flat plate, 88, 170
 - Joukowski, 175
 - oscillating, 197
 - symmetric, 178
 - with flap, 190
 - unsteady theory, 195
- Airy function, 326, 351
- alternating tensor, 4
- angle of attack, 179
- aperture, 95, 140, 147, 280
 - admittance, 432
- average Lagrangian, 366
 - simple pendulum, 371
- axisymmetric flow,
 - equation satisfied by Stokes stream function, 237
 - Hill's spherical vortex, 237
 - Laplace equation, 46
- backspin, 114
- Batchelor, G. K., 224, 262
- Bernoulli equation, 16
 - at free surface, 286
 - steady flow, 20
- Bessel's equation, 308
- Biot-Savart formula, 221
 - applied to creeping flow, 229
 - equivalence to Green's formula, 230
 - influence of internal boundaries, 228
 - irrotational flow, 229
 - vortex filament, 222
 - rectilinear vortex, 226
- binormal, 19
- Blasius, boundary layer calculation, 253
 - force, 116
 - formulae, 115
 - lift calculation, 173
 - moment, 117, 169
- bluff body drag, 261
- body force, 3, 10
 - conservative, 10, 15
- Borda's mouthpiece, 65
- boundary conditions, 12
 - free surface, 286
 - redundant, 36
- boundary layer, 61
 - approximation, 249
 - Blasius, 253
 - damping of surface waves, 298
 - displacement thickness, 252
 - drag, 252
 - flat plate, 249
 - thermal, 445
 - velocity profile, 251

- boundary layer thickness, 249
 - von Kàrmàn's momentum integral formula, 251
 - displacement, 252
- branch-cut, 108, 375
 - integral, 335
- breakwater, 373
- Cauchy-Riemann equations, 104
- Cauchy's integral theorem, 182, 184, 185
- causality condition, 301, 396
- centre of volume, 35
- Chaplygin's method, 159
- characteristics, 318
 - of Hamilton-Jacobi equation, 355
- circle theorem, 106
- circulation, 14
 - conservation, 14, 171
 - per unit length, 195
- Coanda, effect, 142
- edge flow, 142
- compact Green's function, 405
 - applied to vibrating body, 406
 - applied to Rayleigh scattering, 407
- cylindrical duct, 438
- complex potential, 104
 - circular cylinder, 106, 110
 - elliptic cylinder, 169
 - uniform flow, 104
 - line vortex, 109
 - linear theory for thin airfoil, 195
 - source, 119
 - infinite duct, 130
 - half-plane, 131
- complex velocity, 104
- compression wave, produced by train, 439
- conductivity, thermal, 8
 - thermometric, 446
- conformal transformation, 128
 - applied to Laplace's equation, 129
 - of sources and vortices, 130
 - rigid strip, 87
- conical horn, 434
- connected, multiply, 40
 - simply, 40
- contraction ratio, 67, 147, 149, 151
- conservative body force, 10
- continuity equation, 2, 11, 14
- creeping flow, definition, 242
 - past sphere, 229, 242
 - rotating sphere, 246
- Crocco's equation, 214
 - steady ideal flow, 236
- cylinder, with circulation, 110, 117
 - equation of motion, 112
 - added mass tensor, 113
 - motion under gravity, 114
 - elliptic, 168
- cyclic, constant, 40
 - irrotational flow, 39
- d'Alembert's paradox, 37
- damping, surface waves, 297
 - sound in a duct, 445
- Darboux vector, 19
- Debye, P., 379
- deep water waves, 288
 - dispersion relation, 288
- delta function, definition, 23
- descent, method of, 400
- diffraction by a breakwater, 373
- diffusion, from line vortex, 240
 - molecular, 8
 - of vorticity, 36, 239
- dipole, 24
- displacement thickness, 252
- dissipation, by vorticity production, 201
 - frictional, 9
- divergence, definition, 2
 - theorem, 3
- downwash, 275
- drag, blade in jet, 152
 - Blasius boundary layer, 253
 - boundary layer, 252
 - coefficient, 152, 263
 - downwash formula, 275
 - ideal flow, 58
 - plane wall, 240
 - predicted by free-streamline theory, 151
 - sphere, 264, 267
 - Stokes, 244
 - wake structure, 264
- dual integral equations, 376
- efficiency of oscillating airfoil, 202
- end correction, calculated by Rayleigh, 429
 - circular aperture, 432
 - circular cylinder, 99, 422
 - flanged open end, 426
 - physical significance, 428
- energy, conservation for surface waves, 315
 - dissipation by vorticity production, 201
 - equation, 8, 11, 318, 324, 356, 366
 - incompressible flow, 10
 - internal, 6, 8
 - kinetic, 8, 293, 316
 - potential, 293, 315
 - propagates at group velocity, 317, 366
 - simple pendulum of variable length, 369
 - surface waves, 291
 - thermodynamic, 8
 - wave, defined relative to moving medium, 367
- enthalpy, definition, 9
 - total, 215
- entropy, specific, 9
- error function, 239
- exponential horn, 433
- far field, 22
 - acoustic, 398

- fully dispersed, 336
- in terms of total impulse, 69, 224
- incompressible, 67
- of arbitrary moving body, 90
- pressure, 70
- solution of total enthalpy equation, 280
- far field Green's function, 76
- airfoil of variable chord, 92
- circular aperture, 95
- circular cylinder, 85
- circular disk, 96
- cylindrical bodies, 84
- projection or cavity, 93
- Rankine ovoid, 94
- rigid strip, 86
- special cases, 91
- sphere, 80
- symmetric form, 89
- vortex-surface interactions, 279
- flap, slotted, 191
- plain, 192
- fluid, ideal, 12, 14
- particle, 19
- force, components on rigid body, 253
- fluid of non-uniform density, 270
- in terms of the potential, 71, 255
- in terms of circulation, 111
- in terms of impulse, 254
- Kirchhoff vector formula, 256
- Fourier transform, 301
- evaluated by stationary phase approximation, 311, 323
- initial value problems, 310, 321
- free streamlines, 142
- blade in jet, 152
- Coanda edge flow, 142
- curved boundaries, 152, 157
- flow through aperture, 147
- jet from funnel, 149
- jet from source, 160
- jet deflection by vortex, 165
- source in edge flow, 161
- source in jet flow, 163
- wake of flat plate, 151
- free surface conditions, 286
- linearised, 288
- Fresnel integral, 381
- rational fraction approximation, 382
- frictional, dissipation, 9
- heating, 10
- Froude number, 143, 344
- Glauert, H., 197
- Green's formula, 30, 33
- applied to far field, 68
- equivalence to Biot-Savart formula, 230
- in terms of monopoles or dipoles, 37
- Green's function, see also far field and compact Green's function
- acoustic, 398
- cylindrical duct, 438
- in free space, 24
- shallow water wave equation, 301
- group velocity, 295
- geometrical interpretation, 296
- Rayleigh's proof that energy propagates at group velocity, 317
- shallow water waves, 295
- Stokes's illustration, 295
- propagation of wave action, 366
- Hadamard, J., 400
- Hagen-Poiseuille flow, 247
- Hamilton, principle of least action, 365
- Hamilton-Jacobi equation, 355, 359
- solution by method of characteristics, 356
- harbour, resonant oscillations, 305
- heat flux, 10
- Heaviside unit function, 31
- Helmholtz, equation for time-harmonic sound, 404
- equation for water waves, 287
- resonator, 306, 417
- vortex theorem, 213
- high-lift devices, 190
- high-speed train, 439
- elliptic nose profile, 444
- modelled by line source, 440
- snub-nosed, 443
- hodograph, transformation, 158
- variable, 144
- homotropic flow, 11, 14, 214, 391
- horn, conical, 434
- exponential, 433
- horseshoe vortex, 274
- Howe, M. S., 63, 257, 435, 442
- hydrodynamic wavenumber, 197
- ideal, fluid, 12, 14
- flow from nozzle, 60
- initial value wave problems, formulation, 309
- instability, Kelvin-Helmholtz, 219
- jet, 62, 220
- images, method of, 35, 125
- in sphere, 52
- impulse, constant in unbounded flow 224, 227
- fluid of nonuniform density, 270
- in two dimensions, 261
- of re-entrant vortex filament, 224
- total, 69
- impulsive, pressure, 18
- motion from rest, 18
- inertia coefficients, 70
- for sphere, 71
- intrinsic equations of motion, 19
- inverse point, 52, 121
- irrotational flow, from cylindrical duct, 62

- jet, contraction ratio, 67, 147, 149, 151
 - from funnel, 149
 - from source, 160
 - deflection by vortex, 165
 - instability, 62, 221
 - vortex, 233
- John, F., 306
- Joukowski airfoil, 175
- Joukowski transformation, 167
 - for an airfoil, 176
 - formula, 159, 162
 - inverse, 167
- kettle, flow from spout, 142
- kinetic energy, irrotational flow, 40
 - ideal fluid, 36
 - in terms of vorticity, 227
 - induced by translating sphere, 43
 - of rectilinear vortices, 127
 - of vortex pair, 128
- Kàrmàn, momentum integral method, 249
 - vortex street, 127
- Kelvin, definition of a vortex, 211
 - formula for vortex ring convection velocity, 226, 235
 - minimum energy theorem, 41, 429
 - ship wave angle, 346
 - stationary phase formula, 309
- Kelvin's circulation theorem, 14, 112, 171, 196
 - differential form, 217
- Kelvin-Helmholtz instability, 219
- Keller, J. B., 143
- Khrabrov, A., 180
- kinematic viscosity, 14
- Kirchhoff force formula, 256
 - arbitrary motion, 258
 - body without rotation, 259
 - irrotational flow, 258
 - large plate, 260
 - sphere at high Reynolds number, 266
 - Stokes drag, 259
 - two dimensions, 261
- Kirchhoff-Stokes boundary layer formula, 448
- Kirchhoff vector, 80
 - force formula, 256
 - in compact Green's function, 405
 - in far field Green's function, 80
 - sphere, 82
- Kirchhoff's solution of the wave equation, 403
- Kutta condition, 65
 - applied to cascade, 193
- Kutta-Joukowski, hypothesis, 62, 172
 - lift force, 117, 199, 275
- Lagrange multiplier, 43
- Lagrangian, average, 366
 - derivative, 2
- Lamb, H., 50
- Lamb vector, 215, 259
- laminar and turbulent flow contrasted, 248
- Landau, L. D., 7
- Laplace equation, axisymmetric form, 46
 - definition, 17
 - inhomogeneous, 24
- Laplacian, in spherical polar coordinates, 45
- leading edge suction, 118, 173
 - oscillating airfoil, 199
- Lee, Y. K., 305
- Legendre polynomials, 45
 - orthogonality relation, 46
- Lifshitz, E. M., 7
- lift force, airfoil, 173, 275
 - Blasius formula, 173
 - coefficient, 179, 192
 - cylinder, 117
 - developed by starting airfoil, 174
 - linear theory for separated flow, 183
 - Kirchhoff vector formula, 173
 - sphere, 267
 - unsteady, 198
- Lighthill, M. J., 198, 224
- line vortex, 109
 - equation of motion, 122
 - motion near an edge, 132
- Liouville's theorem, 161, 164
- lower function, 376
- Mach number, 440
- material derivative, 1
 - of arbitrary vector field, 13
- material surface element, 216
- micro-pressure wave, 439
- Miles, J. W., 305
- moment, in terms of potential, 73
 - in terms of vorticity, 273
 - rolling, 275
 - yawing, 276
- momentum, density, 7
 - flux tensor, 7
 - wake deficit, 263
- momentum equation, 3, 11, 14
 - Crocco's form, 214
 - linearisation in the far wake, 262
- monopole, 24
- monopole distribution, of zero strength, 29
- multipole expansion, 68
- Navier-Stokes equation, 7
- near-field, 22
 - acoustic, 398
 - of surface waves, 335
- non-reflecting junction, 412
- no-slip condition, 12
 - at a rotating boundary, 212
- nozzle flow, 60
- Ol, M., 180
- open end, admittance, 423

- flanged, 426
- input admittance, 424
- reflection coefficient, 423
- Oseen approximation, 245
 - correction to Stokes drag formula, 245
- parabolic transition region, 382
- Parseval's theorem, 315
- particle, fluid, 19
 - paths, 289
- penetration depth, 239
- phase, solution of Hamilton-Jacobi equation, 353
 - speed on deep water, 289
 - velocity, 220
 - water of finite depth, 290
- pipe flow, laminar, 248
 - transition to turbulence, 248
- Poiseuille flow, 247
- Plasma dispersion function, 381
- potential, axisymmetric flow, 45
 - core, 61
 - flow at an edge, 118
 - scalar and vector, 221
- power dissipated in wake, 201
- pressure, drag in creeping flow, 244
 - dynamic, 17
 - impulsive, 18
 - in terms of total enthalpy, 276
 - near wall aperture, 280
 - reduced, 292
 - thermodynamic, 6
 - transient, 17
- principal, value integral, 182
 - normal, 19
 - rates of strain, 5
- quadrupole, 24, 26, 30
- quarter-wave resonator, 415
- radiation condition, 334
- radius of curvature 19
- Rankine, ovoid, 58
 - solid, 56
- rate of strain tensor, 4
- rays, critical, 364
 - kinematic theory, 354
 - tracing in an inhomogeneous medium, 357
 - on sloping beach, 357, 360
- Rayleigh, calculation of end correction, 429
 - low frequency expansion method, 421
 - proof that energy propagates at group velocity, 317
 - scattering, 407
- reciprocal problem, 78
- reciprocal theorem, 76, 404
 - applied to compact Green's function, 404, 436
- reflection of sound at a junction, 412
- reflection principle, 161
 - Schwarz, 185
 - refraction, at sloping beach, 357, 360
 - by wind, 362
 - resonance frequency, Helmholtz resonator, 418
 - open-ended pipe, 425
 - wine bottle, 418
 - retarded, potential, 397
 - time, 303
- Reynolds, equation, 7
 - stress, 7
- Reynolds number, 14
 - bluff body drag, 261
 - dependence of drag coefficient, 263
 - train entering tunnel, 440
 - transition in pipe, 248
- rigid-body rotation of frozen fluid particle, 4
- rolling moment, 275
- rudder, 178
- Runge-Kutta integration, 133
- saddle point, 380
- scalar potential, definition, 221
- scattering, by change of depth, 303
 - by dock, 306
 - Rayleigh, 407
- Schwarz-Christoffel transformation, 135
 - semi-infinite closed channel, 137
 - semi-infinite duct, 138
 - wall aperture, 140
- Schwarz reflection principle, 185
- Sedov, L. I., 183
- Sedov's method, 183
 - flows with sources and vortices, 192
 - for cascade, 193
 - integral formula, 185
- separable solution, 45
- separation, 65
 - from an airfoil, 179
 - in aperture flow, 147
 - linear theory, 180
- shallow water waves, 299
 - on water of variable depth, 300
 - sloping beach, 307, 360
- ship waves, caustic, 351
 - Kelvin wave angle, 349
 - one dimensional, 342
 - point-like pressure source, 345
- shock wave, 439
- Simmons, N., 165
- sink, line 53
- skin friction, 259
- slotted flap, 191
- snub-nosed train, 443
- sound waves, from vibrating sphere, 397
 - generated by a piston, 393
 - in pipe open at both ends, 395
 - propagation through a junction, 411
 - reflected at a closed end, 393
 - reflected at an open end, 394

- source, adjacent to a wall, 34
 - near solid boundaries, 75
 - point, 22
 - volume, 22
- speed of sound, 391
- sphere, dipole strength, 26
 - pulsating, 21
 - vibrating, 26
- spherical boundaries, treatment of, 45
- spherical cavity, 96
- spinning vortex pair, 124
- stagnation point, in jet, 163
 - on cylinder, 107
- stall, 175, 179
 - linear theory, 180
- state, equation of, 11
- starting vortex, 171, 274
- stationary phase, approximation, 309
 - compared with ‘exact’ numerical calculation, 314, 321, 324, 328, 341, 343, 385
 - diffraction by breakwater, 379
 - failure at caustic, 326, 351
 - failure due to pole, 379
 - failure near shallow water wavefront, 326
 - formula for three dimensions, 387
 - formula for two dimensions, 322
 - wave crest envelope, 347
 - used to plot wave crests, 349
- steady flow, 19
- steepest descents, method, 379
 - path, 380
- Stegun, I. A., 202
- Stokes, drag, 259
 - theorem, 15
 - interpretation of group velocity, 295
- Stokes stream function, 53
 - for dipole, 55
 - for monopole, 55
 - for vortex ring, 232
 - in terms of potential, 56
 - in terms of vector potential, 232
- Stokesian fluid, 6
- stream function, Stokes, 53
 - two dimensions, 102
- streamline, definition, 19
 - flow past a sphere, 47
 - flow past circular, elliptic cylinder, 168
 - flow past flat-plate airfoil, 88, 170
 - for monopole and dipole, 28
 - free, 142
 - from duct in two dimensions, 139
 - from duct in three dimensions, 63
 - through aperture, 141
- Strouhal number, 265
- suction, at nozzle lip, 64, 140
 - Coanda edge flow, 146
 - general formula, 119
 - leading edge, 118, 173, 199
 - on cylinder, 122
 - superposition, linear, 24
- surface wave energy, 291, 356
 - equation, 292
 - flux, 294
- surface waves produced by:
 - localised surface pressure, 302
 - periodic sources on deep water, 333
- tailplane, 178
- tandem airfoils, 187
- test function, 23
- terminal velocity, 246
- Theodorsen function, 199
- thermal boundary layer approximation, 449
- thermo-viscous damping of sound, 450
- thin airfoil theory, 195
- thrust producing wake, 200
- torsion, 19
- total enthalpy equation, 277
 - general solution, 279
- transition region, parabolic, 382
- tsunami, 332
- turbulent, convection, 62
 - diffusion, 62
 - mixing, 61
- uniqueness of potential flow 36
- upper function, 376
- vector potential, definition, 221
 - relation to Stokes stream function, 232
- velocity potential, 16
 - in terms of Legendre polynomials, 50
 - moving sphere, 38, 46
- viscous, boundary layer, 20
 - damping of surface waves, 297
 - drag in creeping flow, 244
 - stress tensor, 3
 - stress tensor for Stokesian fluid, 5
 - rotating sphere, 246
- viscosity, bulk, 6
 - kinematic, 14
 - shear, 6
- volume flux, 20
 - in terms of Stokes stream function, 54
 - in terms of two dimensional stream function, 102
- volume source, 22
- vortex, continuous shedding of rings, 61
 - core, 123
 - drag in two dimensions, 268
 - generated by exit-flow, 440
 - horseshoe, 274
 - jet, 233, 235
 - Kelvin’s definition, 211
 - motion near a cylinder, 125
 - pair, 124, 128

- self-induction, 225
- starting, 171, 274
- street, 127
- strength, 109
- surface interactions, 276
- tube, 212
- wake, 195
- vortex line, 109, 212
 - stretching and rotating, 215
- vortex ring, 225
 - convection speed, 226
 - formed from cylindrical vortex sheet, 235
 - shed from sphere, 265
 - Stokes stream function, 232
- vortex sheet, 61, 175, 218
 - instability, 219
- vorticity, convection velocity, 219
 - definition, 4
 - diffusion, 216
 - equation, 211
 - generated at solid boundaries, 216
 - impulsively started plane wall, 239
 - in axisymmetric flow, 55
 - in terms of stream function, 103
 - in two dimensional flow, 103
 - near wall aperture, 281
 - rate of production at a nozzle, 233
- Wagner, H., 174
- wall drag, boundary layer, 252
 - unsteady plane wall, 240
- wave, action, 364, 368
 - fully dispersed group, 365
 - energy defined relative to moving medium, 367
- wave crests, determined by Hamilton-Jacobi equation, 355
 - kinematic theory, 354
- wave making, power, 352
 - resistance, 343
- wave-particle duality, 369
- wave problems, initial value formulation, 309
- wavenumber, hydrodynamic, 197
 - Fourier transform variable, 301
- waves on deep water, 288
 - dispersion relation, 288
 - phase speed, 289
- waves, amplitude calculated from energy equation, 340
 - amplitude calculated from power, 354
 - approaching sloping beach, 307, 357, 360
 - calculation of power, 339
 - generated by motion of seabed, 328
 - generated by undersea earthquake, 332
 - generated by undersea explosion, 319
 - periodic in two dimensions, 336
 - water of finite depth, 291
 - variable depth, 300
- Webster's equation, 432
- Wiener-Hopf method, 376
- Whitham, G. B., 339, 352, 365
- wine bottle, resonance frequency, 418
- yawing moment, 276