

INDEX

The numbers refer to the pages

- Air-waves, plane, 476, 479
 spherical, 489
 general, 492
 in two dimensions, 524
 due to a vibrating sphere or cylinder, 508, 510
 of finite amplitude, 481, 483, 484
 due to a local disturbance, 502
 in variable medium, 541, 545
 effect of viscosity and heat-conduction on, 646, 648, 654
 incidence of, on narrow obstacles, or on screens with narrow apertures, 513, 517, 519, 529, 531, 532, 533, 537
- Analysis of the motion of a fluid element, 31
- Annulus, liquid, rotating, 707
 motion of a solid, in frictionless liquid, 183
- Apertures, irrotational flow of a liquid through
 rectilinear, circular, and elliptic, 73
 transmission of sound-waves through, 518
- Atmospheric oscillations, 541, 547, 551, 556, 557
- Atmospheric tides, 558, 559
- Basin, tidal oscillations in a circular, 284
 tides in a rotating, 320, 326
- Bernoulli's theorem, 21, 23
- Bessel's functions, 134, 136, 275, 285, 287, 527
 of the 'second kind,' 293, 528
- Bifurcation, forms of, 711, 715
- Blasius' theorems, 91
- Bobyleff's problem, 104
- Borda's mouthpiece, 25, 97
- Bore, in canal, 280
- Boundary layer, 684, 687, 689
- Bubble, collapse of a, 122
 vibrations of a, 475
- Canal, 'long' waves in, 254, 278, 445
 effect of variation of section, 262
 waves of finite amplitude in, 262, 278, 280
- Canal-theory of the tides, 267
 effect of friction, 565
- Capillarity, 455
- Capillary waves, 456, 458
- Cauchy-Poisson wave-problem, 384, 387
- Cavity, expanding, 122
- Circular sheet of water, tidal oscillations in, 284
 case of variable depth, 291
 influence of rotation, 320, 326
- Circulation defined, 33
 constancy of, in moving circuit, 36, 203
- Clebsch's transformation of the hydrodynamical equations, 248
- Coaxial circles, flow in, 70
- Collapse of a bubble, 122
- Communication of vibrations to a gas, 508
- Complex variable, 67
- Conduction of heat, effect on sound-waves, 487, 646
- Confocal conics, flow in, 73
- Conformal representation, 68
- Continuity, equation of (Eulerian), 5
 Lagrangian, 13, 15
 in cylindrical co-ordinates, 158
 in spherical co-ordinates, 112
 in general orthogonal co-ordinates, 148, 156
 in ellipsoidal co-ordinates, 150
- Convective equilibrium, vibrations of atmosphere in, 549, 557
- Critical velocity in turbulent motion, 664
- Currents, action of wind on, 593
- Curved stratum of liquid, irrotational flow in, 108
- Curvilinear co-ordinates, 148, 156
- Cyclic constants, 51, 180, 193
- Cyclic motion in multiply-connected spaces, 51, 69
- Cylinder (circular), moving in frictionless liquid, without and with, circulation round it, 76, 79, 187
 in viscous fluid, 615
 (elliptic), moving in frictionless liquid, translation and rotation, 84, 88
 steady motion of a, with circulation, 78
- Cylindrical co-ordinates, 157
 harmonics, 134
 expansions in terms of, 135
- Dedekind's ellipsoid, 723
- Determinateness, conditions of, 41, 42, 207, 208
- Diffraction of sound-waves, 517, 529, 531, 533, 537, 538
- Diffusion of vorticity, 578
- Dimensions, theory of, 682
- Dirichlet's ellipsoids, 719
- Discontinuities at wave-fronts, 522
- Discontinuous motions, 105
 instability of, 373
- Disk (circular), moving in frictionless liquid, 144
 steady motion of, in viscous liquid, 605
 (elliptic), in frictionless liquid, 154
- Dissipation of energy by viscosity, 579
 a minimum in slow steady motion, 617
- Dissipation-Function, 580
- Dissipative systems, vibrations of, 562
- Distortion of a fluid element, 32
- Divergence of a vector-field, 5, 45
- Diverging waves, on water, 293, 296
 in air, 489, 496, 654
- Eddy viscosity, 593
- Edge-waves, 446

- Efflux of liquids, 23
 of gases, 27
- Elasticity of gases, 6
- Electric analogies, 65, 210
- Electromagnetic rotation of a liquid, 30
- Ellipsoid, Maclaurin's, 701
 Jacobi's, 704
 Dirichlet's, 719
 Dedekind's, 723
- Ellipsoid moving in frictionless liquid, 152, 154
 in a viscous liquid, 604
- Ellipsoidal co-ordinates, 139, 149
 harmonics, 139, 142
- Ellipsoidal mass of liquid rotating under its
 own gravitation, precession of, 728
- Ellipsoidal shell, irrotational motion of a
 liquid in, 147
 motion of a liquid of uniform vorticity in,
 containing liquid, precession of, 727
- Elliptic basin, tidal oscillations in, 290, 293
- Elliptic co-ordinates, 84
- Elliptic cylinder in frictionless liquid, circula-
 tion round, 74
 motion due to an, 84, 87
- Energy, equation of, 8, 21, 167
- Energy of irrotationally moving liquid, 46, 56, 66
 of long waves, 260
 of vortex systems, 216
 of surface-waves, 369
 of capillary waves, 457, 460
 of air-waves, 479, 495
- Equation of continuity, *see* Continuity
- Equations of motion, of frictionless fluid, 2,
 12, 156
 of viscous fluid, 576
 of a gas, 476
 of solids in a frictionless liquid, 168, 180,
 184, 187, 192
- Equilibrium (relative), of a rotating system,
 311
- Equilibrium theory of tides, 358
- Eulerian form of the hydrodynamical equa-
 tions, 2
- Exchange of stabilities, 712
- Expansion defined, 5
 and vorticity, velocities expressed in terms
 of, 208
- Expansion, waves of, *see* Air-waves
- Figures of equilibrium of rotating liquid, 707
- Finite amplitude, waves of, on water, 262, 278,
 417, 421, 426
 in air, 483, 484, 650
- Finite oscillations of a liquid globe about the
 spherical form, 719
- Fish-line problem, 468
- Flapping of sails and flags, 374
- Flow, defined, 33
- Flux, defined, 38, 62
- Forced oscillations about equilibrium, 252
 of a rotating system, 316
- Fourier's theorem, 384
- Free oscillations, 250, 562
 of a rotating system, 310, 570
- Free stream-lines, 94
- Friction, effect of, on tides, 565
 fluid, *see* Viscosity
- Gases, elasticity of, 6
 viscosity of, 645
- Generalized co-ordinates, 187, 194
- Gerstner's waves, 421
- Globe, oscillations of a liquid, 450, 719
- Globule, vibrations of a, 473
- Grating, flow of a liquid through a, 533
 reflection and transmission of sound-waves
 by a, 536
- Green's theorem, 43
 Kelvin's extension to cyclic regions, 54
 Helmholtz' extension to sound-vibrations,
 498
- Group-velocity (of waves), 380, 393, 460
- Gyrostal, stability of a liquid, 724
- Gyrostatic systems, equations of motion of,
 195
 small oscillations of, 310
 with friction, 570
- Hamiltonian principle, 187
- Harmonic analysis of tidal observations, 361
- Harmonics, spherical, 110
 cylindrical, 134
 ellipsoidal, 139, 142
- Helicoidal solid moving in frictionless liquid,
 179
- Heterogeneous liquid, waves on, 378
- Highest waves on water, 418
- Hydrokinetic symmetry, 172
- Ignorance of co-ordinates, 195
- Image, of a source in a cylinder, 71
 in a sphere, 129
 of a double source in a sphere, 129
 of a vortex-ring, 243
- Impulse, of a solid moving in a frictionless
 liquid, 161, 162
 of a vortex-system, 214
- Impulsive generation of motion, 10
- Inertia-coefficients, of a circular cylinder, 77
 of an elliptic cylinder, 85, 88
 of a sphere, 124
 of an ellipsoid, 153, 155
 general, 166
 in cases of symmetry, 172
- Instability, of surfaces of discontinuity, 373
 of linear flow of a liquid in a pipe, 663
- Irreducible circuits, 49
- Irrotational motion, general theory of, 35
 in cyclic spaces, 50
 in two dimensions, 62
 in three dimensions, 110
 of a liquid ellipsoid, 723
- Jacobi's ellipsoids, 704
- Jets, theory of, in two dimensions, 97, 98, 374
 capillary phenomena of, 471, 472
- Kármán's 'vortex-street,' 225, 680
- Kelvin's theorem of minimum energy, 47
- Kinematic coefficient of viscosity, 575
- Kinetic energy, of an irrotationally moving
 liquid, 46, 56
 of a solid moving through a liquid, 166, 181,
 185
 of a vortex-system, 216
See also Energy

- Kinetic stability, 311, 570
 Kineto-statics, 197
 Kirchhoff's integral of the general equation of sound, 501
- Lagrangian equations in generalized co-ordinates, 187, 190
 Lagrangian form of the hydrodynamical equations, 12
- Lamina, impact of a frictionless stream on a lamina, 100, 102
- Laminar motion, 32
 in viscous liquids, 581
 stability of, 663
- Laplace's dynamical theory of the tides, 330
- Lift due to circulation, 79, 92, 681, 690
- Limiting forms of relative equilibrium of a rotating liquid, 620
- Limiting velocity, 22
- Lines of motion, *see* Stream-lines
- Long waves in canals, 254, 278, 445
- Lubrication, theory of, 583
- Maclaurin's ellipsoid, 701
- Mean value of potential over a spherical surface, 39, 496
- Minimum dissipation, Korteweg's theorem of, 617
- Minimum energy, Kelvin's theorem of, 47
- Minimum velocity of water-waves, 459
- Modulus of decay, 563
 of water-waves, 624
 of air-waves, 648
- Momentum, transfer of, 10
- Moving axes, 12, 20
 motion of a solid referred to, 161
- Multiply-connected regions, 49
- Newtonian velocity of sound, 477
- Normal modes of oscillation, 251
 of water in rectangular and circular basins, 284, 320, 326, 329
 in a channel of uniform section, 264, 445
 of air in a spherical or cylindrical envelope, 506
 of an ocean of uniform depth, 348, 349, 350
- Obstacles, scattering of sound-waves by, 513, 517
- Oil, effect of a thin film of, on water-waves, 631
- Orbits of particles in water-waves, 367
- Ordinary and secular stability, 311, 571
- Orthogonal co-ordinates, 148, 156
- Oscillating plane in viscous fluid, 620
- Oscillations, *see* Small oscillations and Waves
- Pear-shaped figure of equilibrium of a rotating liquid, 716
- Pendulum, in air, 510
 impact of air-waves on, 515
 in viscous fluid, 642
- Periodic motion of a viscous fluid, 619, 632
- Periphractic regions, 40
- Permanent type, waves of, on water, 417, 421, 423, 427
 in air, 483, 484, 650
- Physical equations, 6
- Pipe, flow of viscous liquid in a, 585
 turbulent motion in a, 663
- Pitot tube, 25
- Poiseuille's experiments, theory of, 585
- Polar co-ordinates, 15, 158, 579
- Porous bodies, absorption of sound by, 652
- Precession of an ellipsoidal shell containing liquid, 725
 of a liquid ellipsoid, 728
- Pressure-equation, 19, 21
- Pressures on solids moving through frictionless liquid, 168, 184
- Prismatic vessel, irrotational motion of a liquid in rotating, 87
- Progressive waves, tidal, 256
 on deep water, 366, 375
 in air, 476
- Reflection, of waves, 262
 and transmission of air-waves by a grating, 536
- Relative equilibrium, condition for, 311
 linear series of configurations of, 710
- Resistance, of fluids, 678, 680
 influence of compressibility, 691, 693, 695
 due to waves, 415, 438
 in a viscous fluid, 682
- Retardation and acceleration of tides by inertia, 355
 by friction, 566
- Revolution, solid of, moving in frictionless liquid, 174
- Ring moving in frictionless liquid, 183
- Ring-shaped figure of equilibrium, 707
- Ripples and waves, 459, 466
- Rotating dynamical system, small oscillations of, 307, 313
- Rotating liquid, 320
 approximate calculation of periods of vibration, 326
- Rotating sheet of water, tides on, 307, 320, 326
- Rotation of a fluid element, 32
- Rotation of a liquid mass under its own gravitation, 697
- Rotational motion, 202
- Rotationally moving liquid, motion of a solid in, 233
- Scattering of air-waves by spherical and other obstacles, 513, 517
- Schwarz' method of conformal representation, 95
- Secular stability, 311, 355, 571
- Semi-infinite screen, diffraction of sound by, 538
- Shallow-water tides, 280
- Ship-waves, 438
- Simple source, 57, 64
 of sound, 491
- Simply-connected regions, 37
- Skin-resistance, 682, 684
- Slipping, resistance to, at the surface of a solid, 576
- Small oscillations, 250
 of a gyrostatic system, 307
 of a dissipative system, 562
 of a liquid ellipsoid, 717
- Smoke-rings, 242

- Solid of revolution, motion of a, 174
 Solids moving in frictionless liquid, 160
 with cycloids, 180, 187
 Solitary wave, Scott Russell's, 423
 Sound, velocity of, 477
 Sound-waves, *see* Air-waves
 Sources and sinks, 57, 71
 Sources of sound, simple and double, 496, 497
 Speed of an oscillation defined, 251
 Sphere moving in frictionless liquid, 92
 inertia-coefficient of, 93
 in viscous fluid, steady motion, 598
 oscillatory motion, 642
 Spheres, motion of two, in frictionless liquid, 130, 133
 Spherical harmonics, 110
 zonal, 113
 tesseral and sectorial, 117
 conjugate property of, 118
 expansions in terms of, 118
 application to sound-waves, 503
 to steady and periodic motions of a viscous fluid, 594, 632
 Spherical mass of liquid, free and forced oscillations, 450
 influence of viscosity, 639
 Spherical sheet of water, tidal oscillations of, 301, 304
 Spherical vessel, decay of motion in, 637
 Spherical vortex, Hill's, 245
 Stability, ordinary and secular, 311
 of a solid moving in frictionless liquid, 177
 of vortex-systems, 225
 of a cylindrical vortex, 230
 of a jet, 472
 of the ocean, 355, 455
 of a rotating mass of liquid, 710
 of a rotating annulus, 708
 of Maclaurin's and Jacobi's ellipsoids, 714, 715
 Standing waves on water, 364, 440
 See also Normal modes
 Stationary phase, principle of, 395
 Steady motion of a frictionless liquid, 20
 with a free surface, 94
 general conditions for, 243
 of a viscous fluid, 581
 Steady motion of a solid in frictionless liquid (possible types), 169, 170
 stability of, 170, 177
 of a solid of revolution, 178
 Stokes' theorem, 35
 Stream-function, Lagrange's, 62
 Stokes', 125
 Stream-lines, 18
 in two dimensions, 63
 of a circular cylinder, 76, 78, 79
 of an elliptic cylinder (translation and rotation), 84, 88
 of a sphere, 128
 of a circular disk, 145
 of a vortex-pair, 221
 of a row of vortices, 225
 of a vortex-ring, 238
 of a spherical vortex, 246
 of standing waves on deep water, 366
 of a liquid globe, 452
 of a sphere in viscous liquid, 599
 Stresses in a viscous fluid, 574
 Superposed liquids, oscillations of, 370
 Surface-conditions, 6
 Surface-distributions of sources, 59
 Surface-disturbance of a stream, 398, 403, 406, 465
 Surface-energy and surface-tension, 455
 Surface-waves, 363
 due to a local disturbance, 384, 387, 429, 432
 due to a travelling disturbance, 413, 433, 437
 due to a submerged cylinder, 410
 of finite height, 426
 Surfaces of discontinuity, *see* Discontinuous motions
 Symmetry, hydrokinetic, 172
 Tangential stress, 564
 Tension, surface-, *see* Capillarity and Surface-energy
 Terminal velocity, of a sphere, 599
 of a cylinder, 616
 Tidal waves, defined, 250
 in uniform canal, 254
 in canal of variable section, 262
 on open sheets of water, 282
 on a spherical ocean, 301, 302
 on a rotating sheet of water, 307, 320, 326
 on a rotating globe, 330
 of finite height, 262, 278
 Tide-generating forces, 358
 Tides, diurnal, 341, 351
 semi-diurnal, 342, 343, 351
 of long period, 338
 spring- and neap-, 354
 of second order, 280
 equilibrium theory of, 358
 correction to, 360
 Laplace's theory, 330
 Hough's theory, 347
 effect of friction on, 567
 Torricelli's theorem, 23
 Torsional oscillations, of a spherical shell containing viscous liquid, 638
 of a sphere surrounded by liquid, 642
 Travelling disturbance, waves due to a, 398, 413, 433, 466
 Trochoidal waves, 421
 Tube, flow of viscous fluid in a, 585
 critical velocity in a, 664
 Tubes of flow, 38
 Turbulence in atmosphere, 669
 Turbulent motion, 663
 Velocity-potential, defined, 17
 kinematical property of, 18
 persistence of, in frictionless fluids, 17
 mean value of, over a spherical surface, 39
 in simply and multiply-connected spaces 41, 50
 of an isolated vortex, 211
 Vena contracta, 24, 99
 Viscosity, 571
 stresses due to, 574
 coefficient of, 575
 of gases, 645
 effect on sound-waves, 646

738

Index

- Viscous fluid, equations of motion of, 576
 steady motion of, 581
 periodic motion of, 619
 flow between parallel plates, 581
 through narrow tubes, 585
 steady motions of a sphere and of an ellipsoid in, 598, 604
 pendulum oscillating in, 642
- Vortex-lines and filaments, 202
 vortex-sheet, 212
 vortex-pair, 221
- Vortex-rings, 236
 mutual influence of, 242
- Vortex-system, impulse of, 214
 energy of, 216
- Vortices, motion due to isolated, 210
 persistence in frictionless liquid, 203
 rectilinear, 219
 cylindrical, 219, 230
 elliptic, 232
 circular, 236
- Vortices, 219, 236
 spherical, 245
- Vorticity, defined, 32
 diffusion of, 578
- Water-waves, effect of viscosity on, 624, 625
 effect of oil on, 631
 See also Capillary waves, Surface-waves, Tidal waves
- Wave-patterns due to a travelling disturbance, 433, 439
- Wave-propagation in one, two, and three dimensions, 525
- Wave-resistance, 415, 438
- Wave-velocities, 368
- Waves, *see* Air-waves, Tidal-waves, and Water-waves
- Weber's transformation of the hydrodynamical equations, 14
- Wind, action of, in generating water-waves, 625, 629