

Index

- accretion, 45, 47, 49, 50, 58, 158, 171, 191, 196
- accretion discs, 125, 171, 174, 191, 196
- acoustic waves, 19, 21, 22, 24, 25, 86, 103, 109, 116, 124, 130, 134, 145
- adiabatic flow, 7, 8
- advection, 11, 12, 156
 - of magnetic field, 12
 - of vortex lines, 11, 12, 16
- Alfvén velocity, 22, 39
- Alfvén waves, 24
- angular frequency, 21
- atmosphere, 16, 48, 50, 57, 62, 85–88, 97–100, 102, 107–110, 178
 - plane-parallel, 78, 79, 87, 88
 - polytropic, 84, 88, 98
- axisymmetric flow, 150, 162, 172
- axisymmetric instability, 175, 191
- axisymmetric perturbations, 161, 165, 167, 171, 175
- axisymmetric r-modes, 186, 194
- axisymmetric stability, 196
- axisymmetric stability of an incompressible rotating fluid, 162
- barotropic fluid, 11, 15, 151, 152, 154, 157, 176
- Bernoulli constant, 47
- Bernoulli equation, 11, 45
- Bernoulli theorem, 35
- Bessel equation, 185
- Bessel function, 86, 87, 185, 186
 - modified, 185
- blast wave, Taylor-Sedov solution, 57
- Bondi, 46–50, 58
- Bondi accretion, 45, 46, 50, 58, 59
- Bondi radius, 49, 50
- boundary conditions, 47, 48, 56, 62, 87, 105, 112, 122, 136, 137, 144, 148, 162, 186, 194
- Brunt–Väisälä frequency, 79
- buoyancy, 78, 84–86, 102, 107, 127, 144, 145
 - magnetic, 102, 109
- Cepheid, 90
- Chandrasekhar, 77, 111, 112, 145, 148, 171, 176, 182, 195
- Chandrasekhar–Friedmann–Schutz instability, 182, 195
- characteristic curves, 28–30, 32
- charge density, 10
- circular shear flow, 158, 162
 - with a magnetic field, 167
 - with self-gravity, 172
- compressibility, 111, 145, 186
- compressible media, 17–43
- conductivity, 1, 10, 92–94, 97, 98, 100, 103, 113, 116–121
 - electrical, 6
 - thermal, 6, 92, 100, 113, 119–121
- conservation
 - of angular momentum, 16, 150
 - of energy, 5, 6, 12, 13
 - of entropy, 7, 26
 - of magnetic flux, 37
 - of mass, 2
 - of momentum, 3, 4, 41, 45, 52, 134
- convection, 62, 73, 74, 98, 107, 110, 156
 - instability, 74, 90, 163
- Schwarzschild criterion, 74, 79, 85, 107, 162, 165, 167
- cooling, 2, 113–118, 120, 121
 - of astrophysical gases, 113, 114
 - slow, 116, 117
- cooling front, 120
- cooling function, 114, 115
- d’Alembert’s principle, 164
- damping, 90, 93–95, 97, 101, 183
- diffusivity, 15
 - magnetic, 15
- dispersion relation, 20–23, 82–84, 89, 106, 108–110, 116, 120, 124, 130, 131, 146, 170, 173, 174, 188
- displacement current, 9
- divergence theorem, 3, 33, 34, 36

- Eddington–Sweet circulation, 155
- eigenfunction, 70, 87, 94, 95, 99, 100, 137
- eigenvalue, 56, 70, 87, 89, 94, 99, 120, 137, 161, 162, 170, 194
- electric charge density, 4
- electric current, 186
- electric field, 4, 10
- energy, 5–7, 12–14
- energy density, 13, 14, 41, 152
- energy density equation, 12–14
- energy flux, 14, 61
- energy generation, 7, 14, 61, 62, 96, 101, 152
- energy input, 51, 56
- energy internal, 5, 6, 35, 76, 91, 92, 163
- energy kinetic, 6, 13, 14, 35, 57, 71, 76, 88, 108, 163
- energy loss, 134
- energy magnetic, 6, 13, 14, 76, 106, 108, 109
- energy nuclear, 6, 95, 96, 152
- energy production, 61, 95–97
- enthalpy, 176
- entropy, 5, 7, 8, 19, 35, 40, 54, 67, 74, 85, 102, 162–164, 176
- equation of motion, 4
- equation of state, 6–7
- equation of continuity, 165, 169, 179
- Eulerian, perturbation, 18, 19, 38, 64–67, 75, 80, 160, 164, 179, 189, 193
- Eulerian vs. Lagrangian, 63
- evanescent, 79, 137
- exchange of stabilities, 70, 127
- explosion, 38, 50, 51, 53, 57, 58
 - in uniform medium, 50
 - supernova, 38, 50, 57
- fast/slow magnetosonic waves, 25, 39
- Ferraro’s law of isorotation, 156
- field lines, magnetic, 12, 16, 24, 25, 36, 38, 59, 110, 156, 157, 169
- flow
 - barotropic, 8
 - compressible, 17, 26, 162
 - isentropic, 8, 45
 - non-linear, 26, 38
 - spherically symmetric, 44, 50, 58, 60
 - steady inflow, 44
 - steady outflow, 50
 - of traffic, 38
- fluid
 - definition of, 1, 2
 - magnetic, 36
- force
 - electric, 4
 - electromagnetic, 10
- pressure, 26, 46
- Fourier transform, 20, 22, 68, 79, 80, 94, 104, 108, 135, 138, 142
- frequency
 - epicyclic, 173
 - rotational splitting, 182, 187
- frequency wave, 21
- g-mode, 79, 83, 84, 89, 103, 178, 181, 182, 184, 187, 188, 194
- galaxy, 44
- gas
 - compressible, 29, 30, 120
 - perfect, 6–8, 20, 40, 41, 54, 56, 62, 96, 98, 115, 121, 152
- gas law, 20, 40, 41
- gravitational collapse, 124, 150
- gravitational field, 76, 88, 103, 106, 111, 142, 144–146, 162, 182, 197
- gravitational force, 3, 131, 162, 172, 192
- gravitational potential, 3
 - effective, 152
- gravitational radiation, 182, 183, 186
- group velocity, 21, 23, 38, 84, 189
- heat, 5–8, 35, 38, 61, 93, 94, 97, 99, 100, 103, 113, 152–155
 - conduction of, 5, 14, 19, 61, 93
 - generation of, 6
- heating/cooling front, 117
- hydromagnetic shock, 41
- incompressible flow, 15, 17
- induction equation, 10, 22, 104, 107, 147, 156, 168
- initial-value problem, 29, 138, 187
- instability, 135, 175
 - Balbus–Hawley, 171, 175, 176
 - buoyancy, 102, 106
 - Chandrasekhar–Friedmann–Schutz, 183, 186, 187
 - epsilon mechanism, 95–97
 - Field criterion, 114, 117, 118
 - gravitational, 123, 129, 130, 175
 - Hertzsprung–Russell diagram, 90, 101
 - Jeans, 123–125
 - kappa mechanism, 97, 98
 - of linear shear flow, 196
 - magnetic buoyancy, 106
 - MRI (magnetorotational), 171
 - Papaloizou–Pringle, 187, 195, 197
 - Parker, 102, 107, 108
 - Rayleigh criterion, 196

- incompressible flow (*contd.*)
 - Richardson criterion, 144
 - Schwarzschild criterion, 73
 - of self-gravitating fluid, 150
 - shear, 141
 - Solberg–Høiland criterion, 162, 165, 176
 - of stratified fluid, 162
 - strip, 90, 101
 - thermal, 113
 - of thin slab, 129
 - Toomre, 172, 174, 176
- internal energy, 35
- inviscid fluid, 171
- isothermal gas, 130

- Jeans criterion, 97, 101
- Jeans instability, 123–125
- Jeans length, 124, 128–130
- Jeans mass, 124
- jump conditions, 34, 36, 41, 51

- Kelvin–Helmholtz instability, 155
- Kelvin–Helmholtz timescale, 155, 174
- Kelvin’s circulation theorem, 15
- kinetic energy density, 13
- Knudsen number, 2

- Lagrangian derivative, 4, 5, 65, 119
- Lagrangian displacement, 64, 105, 160, 193
- Lagrangian perturbation, 18, 66, 86, 103, 105, 142, 168, 179
- Lagrangian vs. Eulerian, 18, 38, 63–66, 74
- Lamb wave, 83
- Laplace equation, 104, 105, 187
- Laplace transform, 138
- Legendre equation, 128
- Legendre polynomials, 128
- Liapunov functional, 121
- linear perturbations, 114
- linear shear flow, 134
 - bounded, 148
 - stratified, 142, 144
- linear wave equation, 19
- local analysis, 82, 170
- Lorentz force, 10
- Lorentz transformation of fields, 9

- Mach number, 35, 40, 42, 52
- magnetic energy density, 13
- magnetic field, 3, 8–14
- magnetorotational instability (MRI), 171

- magnetohydrodynamics (MHD) approximation, 8–10, 12–14, 17, 24, 33, 35, 36
- magnetohydrodynamic equation, 26, 41
- magneto sonic waves, 24, 25
- mass conservation equation, 2, 3
- Maxwell equation, 9, 10, 13, 157
 - displacement current, 9
- Maxwell stress tensor, 3, 4
- mean free path, 1, 2, 4, 6, 31, 33, 37
- meridional circulation, 154, 155, 157
- MHD, *see* magnetohydrodynamics, 8, 14, 15
- modes
 - g-modes, 79, 83, 84, 89, 103, 178, 181, 182, 184, 187, 188, 194
 - normal, 4, 33, 34
 - p-modes, 78, 84, 86, 178, 188
 - in rotating stars, 178
 - of self-gravitating incompressible cylinder, 181, 184
 - of self-gravitating incompressible sphere, 187
 - spheroidal, 188

- non-axisymmetric disturbances, 174
- non-axisymmetric instability, 191
- non-axisymmetric perturbations, 176, 191
- nozzle, subsonic/supersonic flow transition, 29, 42, 50, 58, 118, 119, 134

- Ohm’s Law, 9, 10
- opacity, 61, 62, 97, 100, 152
- orthogonality, 87, 100
- oscillation, 78–83, 86–88, 90–97, 99–101, 178, 181, 184, 185, 187–190, 198
 - damping, 100
 - by conduction, 154, 155
 - excitation, 90, 93, 97, 101, 113
 - the epsilon mechanism, 96
 - the kappa mechanism, 97
 - hanging chain, 86
 - stellar, 21, 62, 63, 78, 83, 87, 93, 97, 101
 - oscillation mode, 97, 99, 190
 - overstability, 97

- p-mode, 78, 84, 86, 178, 188
- perfect gas law, 56, 62, 91, 98, 103
- perturbation
 - adiabatic, 20, 66, 67, 75, 129, 166
 - Eulerian, 99, 123, 142, 143
 - irrotational, 21
 - Lagrangian, 63–65, 67, 68
- phase velocity, 21, 39, 84, 142, 144, 182
- piston, 31, 32, 37, 42
- Poisson’s equation, 3, 61, 75, 123, 126, 127, 129, 153, 173, 179, 188

- polytropic fluid, 8, 58, 84, 85, 87, 88, 97, 98, 197
- potential gravitational, 11, 14, 60, 162
 - velocity, 17, 146
- Poynting flux, 14
- pressure, 1, 4, 8, 17–21
 - gas, 25, 37
 - magnetic, 25, 107, 110
- r-mode, 183, 185–187, 189
- radiation, 38, 61, 93, 94, 113, 152
 - cooling, 6, 113, 114
 - radiative transfer, 6, 61, 62, 154
- Rankine–Hugoniot jump conditions, 41, 51
- rarefaction wave, 42, 43
- ratio of specific heats, 59
- Rayleigh, 167
- Rayleigh criterion, 139, 140, 161, 162, 165, 171, 175, 177, 191, 192, 196
- Rayleigh discriminant, 161, 169, 173, 184
- Rayleigh equation, 137, 141
- Rayleigh inflection point theorem, 136, 137, 139
- Richardson criterion, 145
- Rayleigh number, 146
- Riemann invariants, 27, 32
- rocket nozzle, 58
- rotating flows, 150
- rotating fluid equilibria, 150
- rotating stellar models, 151
- rotating thin disc, 134, 172
- Schwarz inequality, 72
- Schwarzschild criterion, 74
- Sedov–Taylor equations, 54
- self-gravity, 60, 63, 75, 88, 123, 127–131, 174, 178, 193
- shear flow
 - cylindrical, 177, 191
 - non-axisymmetric instability, 191
- shock wave, 31, 37, 38, 41, 51, 57, 63
 - generation of, 51
 - jump conditions, 33, 34
 - reflection, 157
- similarity assumption, 54
- similarity solution, 58, 121
- similarity variable, 52, 53, 55–57, 122
- singular limit, 171
- sound, speed of, 32, 124
- specific enthalpy, 80
- specific heat, 7
 - constant pressure, 7, 121, 129
 - constant volume, 7
- specific heats, ratio, 7, 45, 88
- speed, 37
- Alfvén, 25, 26, 103, 169
 - phase, 195
 - of sound, 7, 17–21
- spherical blast wave, 57
 - outflow, 44
- spherical symmetric flows, 44–59
- Squire’s theorem, 136
- stability criterion, 73, 102, 117, 143, 161, 165, 171, 175
 - Schwarzschild, 75, 102
- star, 44, 60–63
 - cylindrical, 186
 - flat, 63, 78
 - square, 63
- stress tensor, 4
- Sturm–Liouville problem, 70, 94, 95, 99, 141, 162
- supersonic flow, 59
- Taylor–Goldstein equation, 144
- Taylor–Proudman theorem, 157
- Taylor–Sedov equations, 54–56
- Taylor–Sedov solution, 57
- thermodynamic relations, 14
- thin cylindrical shell, 196
- transverse wave, 25
- variational principle, 66, 70, 77, 102, 111
- velocity group, 131
- velocity potential, 104
- virial theorem, 76, 155
- viscosity, 1, 6, 156, 171
- von Zeipel law of gravity
 - darkening, 152
- von Zeipel theorem, 153
- vorticity, 12, 15, 17, 104, 139–141, 187
- vorticity equation, 12, 15, 104, 176
- vorticity source in non-barotropic fluid, 176
- wave
 - buoyancy, 84, 109, 189
 - deep water, 188
 - electromagnetic, 9, 186
 - Lamb longitudinal, 21, 25
 - in magnetic media, 38, 187
 - magneto sonic number, 82, 128, 130, 173, 174
 - p-modes, propagation speed, 19, 26
 - sound, 7, 17–21
 - water, 78, 178, 195
- wave vector, 1, 23, 39, 81, 82, 84, 109, 131