

Index

- Acoustic equation, 12
- Acoustic radiation, 11–14
- Acoustic waves, 9–11
 - acoustic equation, 12
 - radiation from expanding piston, 11–14
 - similarity solution of acoustic equation, 12
- Alamogordo Test, 67
- Amplitude, finite, 14–16
- Area-Mach number rule, 65
- Asymptotic decay, 44
- Asymptotic weak shock regime, 132–134

- Basic equations, 1–30
 - acoustic radiation, 11–14
 - acoustic waves, 9–11
 - blast waves, 68–70
 - Brinkley–Kirkwood theory, 121–124
 - characteristic, 5–9
 - conservation, 2–5
 - converging blast waves, 181
 - deflagration waves, 26–30
 - detonation waves, 26–30
 - finite strength blast waves, 136–138
 - piston problem, 16–20
 - shock waves, 20–26
 - snow-plow approximation, 102–107
 - thermodynamics, 1–2
 - waves of finite amplitude, 14–16
- Blast energy, 121
- Blast waves, 67–86
 - basic equations, 68–70
 - closed form solution, 78–81
 - constant-energy, 107–113
 - converging, 180–194
 - defined, 67
 - density distribution, 73
 - energy integral, 70–75
 - explosion length, 71
 - finite strength. *See* Finite strength blasts
 - formation of, 67
 - integrals of similarity equations, 75–78
 - logarithmic plot of blast radius vs. time, 68
 - particle velocity distribution, 74
 - pressure distribution, 73
 - properties of constant energy solution, 81–83
 - temperature distribution, 74
 - temperature profile, 79
 - vacuum interface, 82–83
 - variable energy blasts, 83–86
- Boundary conditions
 - finite strength blast waves, 138, 154
 - implosions, 175
 - perturbation solutions, 142
 - shock front, 138, 158
- Brinkley–Kirkwood theory, 121–134
 - asymptotic shock decay, 132–134
 - basic equations of, 121–124
 - blast energy, 121
 - conservation equations, 122
 - continuity equation, 122–123
 - energy equation of, 127–128
 - energy integral, 124–127
 - overpressure work, 125–127
 - residual enthalpy, 126–127
 - shock decay equation, 128–131
 - shock front evolution equation, 121, 123
 - shock trajectory, 123
 - work done by particle path, 124–127
- C^+ characteristic, 64
- Caloric equation of state, 1
- CCW (Chester-Chisnell-Whitham) theory, 56
- Chandrasekhar's solution, for planar weak shock
 - decay, 38, 35–37, 44
- Chapman–Jouguet detonations, 28–29
 - Mach number, 92
 - particle velocity profiles, 95
 - piston driven explosion, 96–100
 - pressure distribution, 99
 - pressure profiles, 95
 - propagation of, 91–94
 - spherical, 92–93
 - Taylor wave, 92
- Chapman–Jouguet Mach number, 30
- Chapman–Jouguet velocity, 28, 29
- Characteristic equations, 5–9

- Chemical energy, 26
 Chester's function, 65
 Chester's theory, 56–60
 area-Mach number relationship, 58–59
 Chester function, 65
 small perturbation equations, 57
 solution for perturbations, 59–60
 Chisnell's theory, 60–64
 Chisnell's area-Mach No. relationship, 60–62
 shock interaction with step area change, 63
 Compression shock, 21, 23, 25
 Compression waves, 16–20
 Conservation equations, 2–5
 Brinkley–Kirkwood theory, 122
 characteristic equations, 5–9
 converging blast waves, 181, 183, 192
 Euler's equations, 3
 finite strength blast waves, 152
 homentropic flow, 3
 implosions, 164, 169
 Lagrangian form of equation, 4, 103
 Conservation of energy
 blast waves, 67, 70, 107
 Brinkley–Kirkwood theory, 124
 Conservation of mass, 125, 126
 Constant energy blast waves, 107–113
 density profile, 112–113
 particle velocity, 112
 Constant energy solution, 81–83
 Continuity equation
 Brinkley–Kirkwood theory, 122–123
 converging blast waves, 182
 finite strength blast waves, 156
 implosions, 175, 178
 Converging blast waves, 180–194. *See also* Blast waves; Implosions
 basic equations, 181
 blast wave variables, 181
 boundary conditions, 186–188
 characteristic time, 183
 collapse near center of symmetry, 189–193
 conservation equations, 181, 183, 192
 continuity equation, 182
 early time shock propagation, 180–181
 energy integral, 182
 first order solution, 194
 perturbation equations and solutions, 65, 193
 perturbation solution near initial radius, 180–181, 181
 regularity condition, 192
 shock radius, 192
 shock trajectory, 192
 shock velocity, 183, 188
 similarity solution, 180
 solution near center of convergence, 189–193
 strong shock, 182
 Converging shock waves, 169
 Guderley's solution, 65
 similarity equations, 164–165, 167–168
 singularity and regularity conditions, 169, 165–167
 solution in state variables, 167–169
 strong planar shock amplification in density gradient, 169–172
 Cyclic rule, 14, 123
 Cylindrical shocks, 167
 Cylindrical waves, 10–11
 asymptotic pressure decay, 133
 Deflagration waves, 26–30
 Density
 constant energy blast waves, 109–111, 112–113
 finite strength blast waves, 142, 155, 157, 158
 implosions, 175, 178
 piston driven explosion, 118–119
 piston problem, 19
 Detonation waves, 26–30
 Detonations, Chapman–Jouguet, 28–29
 Mach number, 92
 particle velocity profiles, 95
 piston driven explosion, 96–100
 pressure distribution, 99
 pressure profiles, 95
 propagation of, 91–94
 spherical, 92–93
 Taylor wave, 92
 Energy equation, 26
 Energy integral
 blast waves, 70–75, 80
 Brinkley–Kirkwood theory, 124–127
 converging blast waves, 182
 finite strength blast waves, 137–138, 139–140, 149–150, 157, 159–161
 implosions, 173, 177
 variable energy blasts, 83–84
 Enthalpy, 24, 27, 126–127
 Entropy, 2
 blast waves, 68
 homentropic flow, 3
 shock propagation in non-uniform cross sectional area tube, 57
 snow-plow approximation, 106
 weak shocks, 33
 Escape velocity, 19
 Eulerian coordinates, 109, 113
 Euler's equations, 3, 14
 Expansion fan, 19
 homentropic explosions, 89
 weak shocks, 38
 Expansion waves, 16–20
 Explosions. *See also* Implosions

- finite spherical charge, 113–115
 - equation for, 113
 - mass swept by shock in, 114
 - piston driven explosion, 115–120
 - pressure of charge at any instant, 114
 - pressure of charge subsequent to energy release, 113
- homotropic, 87–101
 - Chapman–Jouguet detonations, 91–94
 - defined, 87
 - piston driven explosion, 94–101
 - shock tube problem, 88–91
- length
 - blast waves, 71, 72, 85
 - finite strength blast waves, 137
- piston driven, 94–101
 - Chapman–Jouguet detonations, 96
 - density distribution, 118–119
 - density ratio across the shock, 98
 - first-order coefficients, 96
 - Mach number, 98
 - particle path, 119
 - particle velocity, 119
 - piston path in, 117
 - piston velocity in, 117
 - pressure distribution, 101, 118
 - secondary shock velocity, 100
 - shock decay, 45–48
 - shock strength, 100, 101
 - snow-plow approximation, 115–120
 - strong shock, 96
 - velocity profile, 119
 - weak shock, 94–95
- Finite amplitude waves, 14–16
 - piston problem, compression and expansion solutions, 16–20
 - Riemann's solution, 14–16
- Finite spherical charge, explosion of, 113–115
 - equation for, 113
 - mass swept by shock in, 114
 - piston driven explosion, 115–120
 - pressure of charge at any instant, 114
 - pressure of charge subsequent to energy release, 113
- Finite strength blasts, 136. *See also* Blast waves
 - basic equations, 136–138
 - density and velocity at shock front, 159
 - density profile, 155, 157, 158
 - energy integral, 137–138, 139–140, 149–150, 157, 159–161
 - equations for different orders solutions, 140–141
 - explosion length, 137
 - integral method, 155–163
 - non-dimensional dependent variables, 136
 - non-similar solutions for, 136
 - particle velocity, 155, 156
 - perturbation solution, 138–144
 - perturbations, 138–144
 - pressure profiles, 157, 158, 159
 - quasi-similar solution, 144–155
 - shock decay coefficient, 145, 152, 153
 - shock decay equation, 157, 162
 - shock front evolution equation, 147–148
 - shock radius, 146
 - shock strength, 146, 163
 - shock trajectory, 144, 146, 152, 155, 157, 161–162
 - shock velocity, 137, 151
 - strong shock, 156, 156, 159
- Flow perturbations, 57
- Friedrich theory for planar shock decay, 31, 41–45
 - decay of piston driven shock, 45–48
- Homotropic explosions, 87–101
 - defined, 87
 - expansion solution near Chapman–Jouguet front, 93–94
 - piston driven explosion, 98
 - piston motion behind Chapman–Jouguet detonations, 96–100
 - pressure and particle velocity profiles behind Chapman–Jouguet, 95, 95
 - propagation of Chapman–Jouguet detonations (planar, cylindrical and spherical), 91–94
 - shock tube problem, 88–91
 - similarity equations for homotropic flow, 87
- Homotropic flow, 3, 4
- Hugoniot equation, 22, 24, 25, 26
- Ideal gas, equation of state for, 1
- Implosions, 164–194. *See also* Explosions
 - conservation equations, 164, 169
 - continuity equation, 175, 178
 - converging blast waves, 180–194
 - perturbation equations and solutions, 165–167
 - perturbation solution near initial radius, 181
 - solution near center of convergence, 189–193
 - converging shock waves, 169
 - first order solution, 194
 - Guderley's solution, 167
 - similarity equations, 164–165, 167–168
 - singularity and regularity conditions, 165–166, 169, 165–167
 - solution in state plane, 167–169
 - strong planar shock amplification in density gradient, 169–172
 - cylindrical shocks, 167
 - density profile, 175, 178
 - determination of A in, 177–180
 - energy integral, 173, 177
 - equations, 164–167

- Implosions (*cont.*)
 impulse and energy imparted to gas by piston, 178
 momentum equation, 178
 momentum integral, 176–177
 particle velocity, 167
 pressure-time profile, 179
 self-similar solutions, 164–165
 sharp blow problem, 172–175
 shock propagation in non-uniform density
 medium, 169–172
 shock trajectory, 165, 171, 180
 shock velocity, 171
 similarity equations, 167–168, 171, 173
 singularity equation, 175
 sonic singularity, 165–166, 169
 sound speed, 167
 spherical shocks, 167
 strong shock, 168, 171
 velocity profile, 175, 175
- Integral method, 155–163
 energy integral, 159–161
 momentum equation, 156, 158
 power law density profile, 155
 pressure profile, 158
- Integrals of similarity equations, 75–78
- Integrating factors, 156
- Internal energy, 27
 constant energy blast waves, 108
 isentropic flow, 3
 shock, 25
- Isentropic flow, 3–4, 5, 6, 87
- Isentropic process, 2, 33, 49, 62
- Karman-Polhausen integral method, 136, 155
- Kinematic equation, 38, 35, 39, 46
- Kinetic energy, 107, 125
- Lagrangian coordinate of particle, 79
- Lagrangian form of equation, 4
- Lagrangian variable, 120
- Limiting pressure ratio, 25
- Linear velocity profile, 83
- Linear wave equation, 10
- Mach number, 25. *See also* sound speed
 blast waves, 85
 Chapman–Jouguet detonations, 30, 92
 converging blast waves, 182
 finite strength blast waves, 136, 152
 homentropic explosions, 91
 piston driven explosion, 98
 Rankine–Hugoniot equations, 99
 shock propagation in non-uniform cross sectional
 area tube, 58–59
 weak shocks, 55
- Mass, conservation of, 4
- Mass balance, 102
- Mass integral, 151, 155, 157
- Modified acoustic theory, 48–55
- Momentum, 3
 finite strength blast waves, 156, 158
 implosions, 176–177, 178
- Moving shock, 20
- Multipliers, 5–6
- Newton flow approximation, 116
- Newtonian approximation, 102
- Newton's law, 102
- Non-similar equations, 136
 basic formulation, 136–138
 perturbation solutions, 138–144
 quasi-similar solution, 144–155
- Non-steady flow, quasi-one dimensional equations
 of motion for, 56
- Non-uniform cross sectional area tube, shock wave
 propagation in, 56–66
 Chester's theory, 56–60
 Chisnell's theory, 60–64
 Whitham's theory, 64–66
- Non-uniform region, 7–9
- Order of unity, 72
- Oswatitch solution, for triangular shock pulse, 31,
 37–40
- Overpressure, 125–127
- Particle isentropic flow, 3–4, 5, 6
- Particle velocity, 70
 blast waves, 72
 Chapman–Jouguet detonations, 95
 constant energy blast waves, 112
 finite strength blast waves, 155, 156
 implosions, 167
 piston driven explosion, 119
 shock, 21, 24, 25, 26
 snow-plow approximation, 104
 weak shocks, 36, 49
- Perfect gas, 24, 27
 enthalpy, 24, 27
 entropy, 2, 3
 equation of state, 1
 internal energy, 3, 25, 27
 Isentropic relationships, 2, 3–4, 5, 6
 sound speed, 2, 3, 19. *See also* Mach number
- Perturbation solutions, 138–144
 converging blast waves, 193
 perturbation equations for different order,
 140–141
 shock trajectory, 144, 146
- Perturbations, 9–11
 boundary conditions, 142
 density, 142

- finite strength blast waves, 138–144
- flow, 57
- pressure, 142
- shock propagation in non-uniform cross sectional area tube, 59–60
- shock trajectory, 144
- Pfriem's formula for weak shock, 33, 39
- Piston driven explosion, 94–101
 - Chapman–Jouguet detonations, 96
 - density distribution, 118–119
 - density ratio across the shock, 98
 - first-order coefficients, 96
 - Mach number, 98
 - particle path, 119
 - particle velocity, 119
 - piston path in, 117
 - piston velocity in, 117
 - pressure distribution, 101, 118
 - secondary shock velocity, 100
 - shock decay, 45–48
 - shock strength, 100, 101
 - snow-plow approximation, 115–120
 - strong shock, 96
 - velocity profile, 119
 - weak shock, 94–95
- Piston problem, 16–20
- Piston velocity, 117
- Planar explosion, shock tube problem, 88–91
- Planar flow, 7
- Planar geometry, 66
- Planar motion, similarity equations for, 173
- Planar waves
 - acoustic waves, 10–11
 - asymptotic pressure decay, 133
 - decay of, 41–45
 - weak shocks, 40
- Power series
 - blast waves, 81
 - converging blast waves, 183
 - Finite spherical charge explosion, 114
 - piston driven explosion, 96
 - snow-plow approximation, 103
- Pressure
 - constant energy blast waves, 109–111
 - finite strength blast waves, 142, 158, 159
 - first order solution, 107
 - perturbations, 49
 - piston driven explosion, 118
 - piston problem, 19
 - snow-plow approximation, 104
- Pulse width, 39–40
- Quasi-similar solution, 144–155
 - energy integral, 149–150
 - quasi-similar approximations, 147, 150
 - quasi-similar equations, 147–149
- Rankine–Hugoniot equations
 - Brinkley–Kirkwood theory, 124
 - converging blast waves, 194
 - finite strength blast waves, 138, 142, 147, 149, 151, 154, 158, 159
 - in overpressure, 32
 - piston driven explosion, 95, 98
 - shock decay equation, 130
 - shock propagation in non-uniform cross sectional area tube, 58, 59, 60–62, 63
 - shock tube problem, 90
 - shock waves, 26, 28–29
 - snow-plow approximation, 102
 - strong shock, 69
 - weak shocks, 42–43, 51
- Rankine–Hugoniot relationships, 29
 - Brinkley–Kirkwood theory, 124
 - converging blast waves, 182, 186
 - homotropic explosions, 88
 - in overpressure, 33
 - shock propagation in non-uniform cross sectional area tube, 64
 - weak shocks, 36
- Rarefaction fan, 19
 - Chapman–Jouguet detonations, 92
 - piston driven shock, decay of, 46
- Rayleigh line, 21, 24, 25, 27, 29
- Reflected wave, 60
- Residual internal energy, 126–127
- Riemann invariants, 7
 - shock propagation in non-uniform cross sectional area tube, 62
 - weak shocks, 33, 45
- “Saw tooth” shock, 37
- Sharp blow problem of Zeldovich, 172–175
 - exact solution of von Hoerner, 175–177
 - impulsive piston motion, 179
 - non-uniform validity of similar solution, 177–180
 - similarity solution, 173
- Shock decay coefficient, finite strength blast waves, 145, 152, 153, 162
- Shock decay equation, 128–131, 157
- Shock front evolution equation, 121, 123, 158
- Shock overpressure, 37, 40, 44, 51–52, 53, 54, 54
- Shock path, 48, 52
- Shock pressure
 - blast waves, 71, 85
 - as function of shock radius, 75
- Shock pulse, 44
- Shock radius, 75, 76, 83, 192
- Shock strength-area relationships, 63
- Shock temperature, 71

- Shock temperature ratio, 71
- Shock trajectory
 blast waves, 71, 84, 85
 Brinkley–Kirkwood theory, 123
 constant energy blast waves, 109
 converging blast waves, 192
 finite strength blast waves, 144, 146, 152, 155, 157, 161–162
 as function of shock radius, 76
 implosions, 165, 171, 180
 perturbation solutions, 144
 weak shocks, 48, 53
- Shock tube problem, 88–91. *See also* Homentropic explosions
 non-steady expansion region, 89–90
 non-steady flow, 89
- Shock velocity, 21, 23
 blast waves, 80
 constant energy blast waves, 109
 converging blast waves, 183, 188
 finite strength blast waves, 137, 151
 implosions, 171
 shock propagation in non-uniform cross sectional area tube, 59
- Shock waves, 20–26
 Chapman–Jouguet solution, 28–29
 detonations and deflagrations, 26–30
 equations across detonation waves, 29
 Hugoniot equation, 22, 24, 25
 in non-uniform cross sectional area tube, 56–66
 Chester’s theory, 56–60
 Chisnell’s theory, 60–64
 Whitham’s theory, 64–66
 planar, decay of, 41–45
 Rankine–Hugoniot equations, 26, 28–29
 Rayleigh line, 21, 24, 25, 27, 29
 strong shock limit, 24
- Shocked density, 24
- Shocked state, 25
- Shocked velocity, 25
- Similarity equations
 blast waves, 75–78
 implosions, 167–168
 Implosions, 171
 implosions, 173
 integrals of, 75–78
 planar, cylindrical and spherical symmetries, 87
- Similarity solution, 66
- Simple waves, 9, 17, 34, 41, 45
- Singularity equation, 175
- Snow-plow approximation, 102–120
 basic equations, 102–107
 equation in Lagrangian form, 103
 explosion of finite spherical charge, 113–115
 particle velocity, 104
 piston driven explosion, 115–120
 pressure, 104
 snow plow solution for constant energy blast waves, 107–113
 zeroth order solution, 104, 105
- Sonic singularity, 165–166, 169
- Sound speed, 2, 2. *See also* Mach number
 across shock, 64
 homentropic explosions, 87
 implosions, 167
 isentropic flow, 3
 piston problem, 19
 temperature profile, 79
- Specific heat, 2
- Spherical blast, 82, 83
- Spherical piston, acoustic radiation, 11–14
- Spherical shocks, 167
- Spherical waves, 10–11
 asymptotic pressure decay, 133
- Stationary shock, 20
- Strong point blast waves
 closed form solution for strong point blast, 78–81
 decay of shock overpressure, 73, 75, 83
 density profile behind blast wave, 73, 72–75
 energy integral, 70–75
 explosion length, 71, 72, 85
 integrals of similarity equations, 75–78
 properties of constant energy blast, 81–83
 shock decay coefficient (θ), 69
 shock particle velocity decay, 72, 74
 shock temperature decay with radius, 71
 shock trajectory, 71, 85
 similarity variables, 68
 temperature profile behind blast wave, 74, 79, 72–75
 time exponent of shock trajectory, 76, 84, 85
 vacuum interface, 82–83
 variable energy blasts, 83–86
- Strong shocks, 24, 26. *See also* Weak shocks
 boundary conditions, 104
 converging blast waves, 182
 density ratio, 102
 finite strength blast waves, 156, 159
 implosions, 168, 171
 piston driven explosion, 96
 Rankine–Hugoniot equations, 69
 shock propagation in non-uniform cross sectional area tube, 65
- Taylor, G.I., 54
- Taylor wave, 92
- Thermodynamics, 1–2
- Triangular shock pulse, 31, 37–40
- Uniform region, 7–9
- Variable energy blasts waves, 83–86
 similarity solution, 75, 83
- Velocity potential, 49

- Velocity profile
 - implosions, 175
 - piston driven explosion, 119
- Waves
 - acoustic, 9–11
 - deflagration, 26–30
 - detonation, 26–30
 - finite amplitude, 14–16
 - shock, 20–26
- Weak shocks, 31–55. *See also* Strong shocks
 - Chandrasekhar's solution, 38, 35–37
 - decay of piston driven shock, 45–48
 - Friedrich theory, 31, 41–45
 - Oswatitch solution, 31, 37–40
 - Pfrieim's formula for, 33
 - properties of, 31–35
 - pulse width, 39–40
 - and simple waves, 34
 - transition, 22
 - Whitham's modified acoustic theory, 48–55
 - Whitham's theory, 31
- Whitham's solution for weak shock decay, 48–55
 - modified acoustic solution, 49
- Whitham's theory, 60–62, 64–66
 - area-Mach number rule, 65
 - converging shock solution, 65
 - shock trajectory and characteristic equation, 64
 - strong shock propagation in density gradient, 66
 - weak shocks, 31
- Zero particle velocity, 151
- Zeroth order density, 105, 109
- Zeroth order equations, 104, 105, 106
- Zeroth order pressure, 109, 119