

Index

Symbols

α (angular acceleration), 107
 β (coefficient of volume expansion), 221
 δ (Stefan-Boltzman constant), 238
 ϵ (permittivity of free space), 272
 ω (angular velocity), 105
 τ (torque), 145
 Ω (ohms), 290

• A •

a (linear acceleration), 107
absolute zero
 definition, 217
 reaching, 263
acceleration
 calculating, 67–69
 description, 28–30
 harmonic motion, springs, 203–204
 inclined planes, 84–85, 94–95
 relating to displacement, 31–35
 relating to speed, 34–35
 tangential, 164–165
adiabatic processes, 256–258
adiabats, 256
algebra, 18–20
Ampere (A), 8, 289–290
angles
 angular acceleration, 109–111
 angular velocity, 109–111
 converting between, 101–102
angular acceleration (α), circular motion
 angles, 109–111
 circular motion, 111
 description, 107–108
 unit of measure, 107
angular acceleration (α), rotational kinematics, 166–167
angular frequency, harmonic motion, 199–201
angular momentum (**L**), 187–188
angular speed, harmonic motion, 200
angular velocity, circular motion
 angles, 109–111
 description, 104–106

angular velocity, rotational kinematics, 165–166
atoms per mole, calculating. *See* Avogadro's Number
Avogadro's Number (N)
 calculating atoms per mole, 239–241
 definition, 239
 and the ideal gas law, 241

• B •

barye (ba), 8
biot (Bi), 8
Boltzmann's constant (k), 241
Btu (British Thermal Unit), 223

• C •

C (Coulomb), 8, 271–272
Calorie (C), 223
calories *versus* Calories, 223
Carnot engines, 262
Celsius (C) scale, 217–218
centigrade scale. *See* Celsius (C) scale
centimeter (cm), 7
centripetal acceleration, 112–113
centripetal force, 114–115
CGS (centimeter-gram-second) system
 conversions, 12–14
 description, 7–9
 force, measuring, 62
 torque, measuring, 168
 units of measure, 7–8, 62
 work, measuring, 123–125
charge density, 277
circuits. *See* electric circuits
circular motion. *See also* frequency;
 period (T)
 centripetal acceleration, 112–113
 centripetal force, 114–115
 frequency, 103–104
 period, 103–104
circular motion, angles
 angular acceleration, 111
 angular velocity, 111
 degree/radian conversion, 101–102

circular motion, angular acceleration
 angles, 109–111
 description, 107–108
 unit of measure, 107

circular motion, angular velocity
 angles, 109–111
 description, 104–106

cm (centimeter), 7

coefficient of friction
 definition, 87
 description, 87–88
 kinetic, 88–89
 static, 88–89

coefficient of volume expansion (β), 221

collisions. *See also* kinetic energy
 elastic, 149–150
 two-dimensional, 151–163

common mistakes
 degree/radian conversion, 309
 Kirchhoff's laws, 311
 latent heat, 310
 loop rule, 311
 normal line, 310
 radian/degree conversion, 309
 ray diagrams, 312
 refraction angles, 310
 resistors, 311
 sine/cosine mixups, 310
 units of measure, 309
 vectors, 310

conduction, 234–237

conservation of
 energy, 249–250
 kinetic energy, 149–150
 momentum, 148–150

convection, 233–234

conversions
 Btus to Joules, 223
 CGS (centimeter-gram-second) system, 12–14
 degrees/radians, 101–102
 distance units, 14–15
 FPI (foot-pound-inch) system, 12–14
 measurement systems, 12–14
 MKS (meter-kilogram-second) system, 12–14
 time units, 16
 vector specification methods, 45–46

coordinate system for vectors, 42–43

Coulomb (C), 8, 271–272

current (I), 7–9, 289–290

• D •

deceleration, 29

degree/radian conversion, 101–102, 309

diameter (d), 103

direction. *See* vectors, direction

displacement
 description, 25–26
 relating to acceleration, 31–35
 relating to time, 31–33

distance. *See* displacement

distance units, conversions, 14–15

drag, inclined planes. *See* inclined planes, friction

dyne, 7

• E •

elastic collisions, 149–150, 241

electric charge
 Coulomb (C), 271–272
 negative, 271
 positive, 271
 unit of measure, 7–9

electric circuits
 ampere (A), 289–290
 current (I), 7–9, 289–290
 junction rule, 298
 Kirchhoff's laws, 297–299, 311
 loop rule, 298, 311
 ohms (ω), 290
 Ohm's Law, 290–292
 parallel, 295–297
 resistance (R), 290–292
 series, 293–295

electric circuits, resistors
 common mistakes, 311
 heat production, 292–293
 in parallel, 296
 in series, 294

electric fields. *See also* electric circuits
 charge density, 277
 description, 275–276
 parallel plate capacitors, 277–278
 point charges, 275, 281–282
 voltage, 279–282

electric forces
 description, 272–273
 permittivity of free space, 272
 as vectors, 274–275

electric potential. *See* voltage

emissivity, 238
 energy
 conservation of, 249–250
 potential, 131–132, 206–207. *See also* kinetic energy
 units of measure, 7–9
 equilibrium, 72–73, 170–172
 erg, 8, 123–125

• **F** •

Fahrenheit (F) scale, 217–218
 Fear of Physics's Problem Solver, 314
 first law of thermodynamics, 249–250
 foot-pound. *See also* FPI (foot-pound-inch) system
 torque unit, 168
 work unit, 124
 force. *See also* Newton's Three Laws of Motion; torque (τ)
 acceleration, calculating, 67–69
 equilibrium, 72–73
 of gravity, 69–72
 inertia, 61
 mass *versus* weight, 69–72
 net, calculating, 67–69, 126–127
 units of measure, 7–9, 62
 as a vector, 65–67
 work, measuring, 126–127
 FPI (foot-pound-inch) system
 conversions, 12–14
 description, 7
 torque, measuring, 168
 FPS (foot-pound-second) system
 force, measuring, 62
 mass, unit of measure, 61
 slugs, 61
 work, measuring, 124–125
 franklin (Fr), 8
 frequency
 circular motion, 103–104
 harmonic motion, 199–201
 unit of measure, 200
 friction, inclined planes. *See* inclined planes, friction

• **G** •

gases
 Boltzmann's constant (k), 241
 elastic collisions, 241
 ideal, 241

ideal gas law, 241–242
 kinetic energy of molecules, 243
 universal gas constant (R), 241
 gases, thermodynamic processes
 adiabatic, 256–258
 adiabats, 256
 constant heat, 256–258
 constant pressure, 250–252
 constant temperature, 254–255
 constant volume, 253–254
 isobaric, 250–252
 isochoric, 253–254
 isothermal, 254–255
 isotherms, 256
 gauss (G), 8
 gram (g), 7, 61
 graphing vectors, 42–43
 gravity (g)
 force of, on inclined planes, 82–83
 mass *versus* weight, 69–72

• **H** •

harmonic motion (springs)
 acceleration, 203–204
 angular frequency, 199–201
 angular speed, 200
 example, 197–199
 frequency, 199–201
 Hooke's constant, 195, 204–206
 Hooke's Law, 195–197
 pendulums, 207–208
 period, 199–201, 204–206
 potential energy, 206–207
 spring constant, 195, 204–206
 velocity, 201–202
 heat. *See* thermodynamics
 heat engines, 259–261
 Hertz (Hz), 200
 Hooke's constant, 195, 204–206
 Hooke's Law, 195–197
 HyperPhysics, 313
 hypotenuse, 20

• **I** •

I (current), 7–9, 289–290
 ideal gas, 241
 ideal gas law, 241–242
 impulse. *See* kinetic energy, impulse

inclined planes
 acceleration, 84–85
 breaking into vectors, 81–83
 definition, 81
 normal force, 82
 rotational dynamics, 185–187
 work, measuring, 126–127

inclined planes, friction
 acceleration, 94–95
 coefficient of, 87–88
 kinetic, 89–90, 92–93
 kinetic coefficient of, 88–89
 static, 90–92
 static coefficient of, 88–89

inclined planes, sliding objects
 acceleration, 94–95
 coefficient of friction, 87–88
 kinetic coefficient of friction, 88–89
 kinetic friction, 89–90, 92–93
 speed of, 85–86
 static coefficient of friction, 88–89
 static friction, 90–92

inertia, 61

isobaric processes, 250–252

isochoric processes, 253–254

isothermal processes, 254–255

isotherms, 256

• **J** •

Joules (J)
 converting to Btus, 223
 measuring work, 123–125
 unit of measure, 8

junction rule, 298

• **K** •

k (Boltzmann’s constant), 241

Kelvin (K) scale, 217–218

Kenneth R. Koehler’s Tutorial Page, 314

kilogram (kg), 8, 61

kilogram meters² (kg·m²), 178

kilogram-meters/second (kg·m/sec), 145

kinetic coefficient of friction, 88–89

kinetic energy. *See also* potential energy;
 work
 conserving, 149–150
 description, 127–130
 elastic collisions, 149–150
 of molecules, 243

rotational dynamics, 183–184

two-dimensional collisions, 151–163

kinetic energy, impulse
 definition, 143
 description, 144–145
 momentum, 146–147
 unit of measure, 143

kinetic energy, momentum
 conserving, 148–150
 definition, 145
 impulse, 146–147
 unit of measure, 145

kinetic friction, 89–90, 92–93

Kirchhoff’s laws, 297–299, 311

• **L** •

L (angular momentum), 187–188

latent heat, 226–227, 310

Laws of Motion. *See* Newton’s Three Laws of Motion

length, units of measure, 7–9

linear acceleration (a), 107

linear expansion, 219–221

liquid-to-gas change, 226–227

loop rule, 298, 311

• **M** •

magnetism, units of measure, 7–9

mass
 definition, 61
 units of measure, 7–9, 61
versus weight, 69–72

measurement units. *See* units of measure

meter (m), 8

MKS (meter-kilogram-second) system
 conversions, 12–14
 description, 7–9
 force, measuring, 62
 moment of inertia, measuring, 178
 momentum, measuring, 145
 torque, measuring, 168
 units of measure, 8, 62
 work, measuring, 123–125

mole, 239

moment of inertia, 178–181

momentum (**p**). *See also* kinetic energy,
 momentum
 angular momentum (**L**), 187–188
 conservation of, 148–150

kinetic energy, impulse, 146–147
 measuring, 145
 motion as vector, 53–54

• **N** •

N (Avogadro's Number)
 calculating atoms per mole, 239–241
 definition, 239
 and the ideal gas law, 241
 negative electric charge, 271
 net force, calculating, 67–69, 126–127. *See also* force
 Newton (N), 8
 Newton's Three Laws of Motion. *See also* force
 First Law, 61–62
 Second Law, 62–65
 Third Law, 72–73
 Newton-second, 143–144
 normal force, 82
 normal line, 310
 numbers
 rounding, 17–18
 scientific notation, 10–11
 significant figures, 17–18

• **O** •

ohms (Ω), 290
 Ohm's Law, 290–292
 online resources, 313–314
 origins of vectors, 42

• **p** •

p (momentum). *See* momentum (**p**)
 parallel circuits, 295–297
 parallel plate capacitors, 277–278
 Pascal (P), 8
 pendulums, 207–208
 period (T)
 circular motion, 103–104
 harmonic motion, 199–201, 204–206
 permittivity of free space (ϵ), 272
 phase changes, 226–227
 physical work. *See* work
 The Physics Classroom, 313
 Physics 24/7 Tutorial, 314
 point charges, 275, 281–282
 positive electric charge, 271

potential energy, 131–132, 206–207. *See also*
 kinetic energy
 power, 133–134
 pressure, units of measure, 7–9

• **R** •

R (universal gas constant), 241
 radian/degree conversion, 101–102, 309
 radiation, 237–239
 radius (r), 103
 ramps. *See* inclined planes
 ray diagrams, 312
 refraction angles, 310
 resistance (R), 290–292
 resistors
 common mistakes, 311
 heat production, 292–293
 in parallel, 296
 in series, 294
 resources, online, 313–314
 right triangles, 20–21
 Roman Goc's Physics Tutorial, 313
 rotational dynamics. *See also* torque (τ)
 angular momentum, 187–188
 inclined planes, 185–187
 kinetic energy, 183–184
 moment of inertia, 178–181
 work, 182–183
 rotational kinematics
 angular acceleration, as a vector, 166–167
 angular velocity, as a vector, 165–166
 equilibrium, 170–172
 tangential acceleration, 164–165
 tangential speed, 161–163
 torque, 168–170
 rounding numbers, 17–18

• **S** •

scalar equations, 53
 scalar values, 145
 scientific notation, 10–11
 second (s), 7, 8
 second law of thermodynamics, 259
 series circuits, 293–295
 significant figures, 17–18
 sine/cosine mixups, 310
 slug, 61
 solid-to-gas change, 226–227
 solid-to-liquid change, 226–227

specific heat capacity, 223–226
 speed. *See also* acceleration; velocity
 description, 27–28
 on inclined planes, 85–86
 relating to acceleration, 34–35
 tangential, 161–163
 spring constant, 195, 204–206
 spring motion. *See* harmonic motion (springs)
 static coefficient of friction, 88–89
 static friction, 90–92
 Stefan-Boltzman constant (δ), 238
 storing energy. *See* potential energy

• T •

T (period)
 circular motion, 103–104
 harmonic motion, 199–201, 204–206
 tangential acceleration, 164–165
 tangential speed, 161–163
 temperature scales, converting, 217–218
 Tesla (T), 8
 thermal expansion, 219–223
 thermodynamics. *See also* gases, thermodynamic processes
 absolute zero, definition, 217
 absolute zero, reaching, 263
 Btu (British Thermal Unit), 223
 calories *versus* Calories, 223
 Celsius (C) scale, 217–218
 coefficient of volume expansion, 221
 conservation of energy, 249–250
 definition, 217–218
 Fahrenheit (F) scale, 217–218
 first law, 249–250
 Kelvin (K) scale, 217–218
 latent heat, 226–227, 310
 linear expansion, 219–221
 liquid-to-gas change, 226–227
 phase changes, 226–227
 second law, 259
 solid-to-gas change, 226–227
 solid-to-liquid change, 226–227
 specific heat capacity, 223–226
 temperature scales, converting, 217–218
 thermal expansion, 219–223
 third law, 263
 volume expansion, 221–223
 thermodynamics, heat transfer
 Carnot engines, 262

conduction, 234–237
 convection, 233–234
 direction of flow, 259
 emissivity, 238
 heat engines, 259–261
 maximum efficiency, 262
 radiation, 237–239
 Stefan-Boltzman constant (δ), 238
 ThinkQuest, 313
 third law of thermodynamics, 263
 time
 relating to displacement, 31–33
 unit conversion, 16
 unit of measure, 7–9
 torque (τ). *See also* force; rotational dynamics
 definition, 168
 rotational kinematics, 168–170
 unit of measure, 168
 trigonometry, 20–21
 Tutor4Physics, 314
 tutorials, 313–314
 two-dimensional collisions, 151–163

• U •

units of measure. *See also* CGS (centimeter-gram-second) system; FPI (foot-pound-inch) system; FPS (foot-pound-second) system; MKS (meter-kilogram-second) system
 angular acceleration, 107
 common mistakes, 309
 force, 62
 frequency, 200
 Hertz (Hz), 200
 impulse, 143
 kilogram-meters/second (kg-m/sec), 145
 moment of inertia, 178
 momentum, 145
 Newton-second, 143–144
 torque, 168
 work, 123–125
 units of measure, conversions
 distance, 14–15
 multiple, 14–15
 between systems, 12–14
 time, 16
 universal gas constant (R), 241
 University of Guelph's Tutorial, 314

• U •

Vector Resolver, 314

vectors

adding, 49–52

angular acceleration as, 166–167

angular velocity as, 165–166

breaking inclined planes into, 81–83

common mistakes, 310

components, 43–46

coordinate system for, 42–43

definition, 41

force as, 65–67

graphing, 42–43

motion as, 53–54

origins, 42

vectors, direction

converting to coordinate system, 45–46

definition, 41

finding, 47–49

specifying a vector, 41–43

vectors, magnitude

converting to coordinate system, 45–46

definition, 41

finding, 47–49

specifying a vector, 41–43

vectors, specifying

converting between methods, 45–46

coordinates from the origin, 43–46

magnitude and direction, 43–46

velocity, 201–202. *See also* speed

voltage, 279–282

volume expansion, 221–223

• W •

weight

definition, 61

versus mass, 69–72

work. *See also* kinetic energy; potential

energy; power

definition, 123

measuring, 123–125

potential energy, 131–132

power, 133–134

rotational dynamics, 182–183

