TABLE: SELECTED DIMENSIONAL EQUIVALENTS

Length	1 m = 3.280 ft 0 39.37 in 1cm =10^{-2} m = 0.394 in = 0.038 ft 1 mm = 10^{-3} m 1 micron (m) = 10^{-10} m 1 Angstrom (ºA) 10^{-6} m
Time	1 hr = 3600 sec = 60 min 1 milisec = 10^{-3}sec 1 microsec (μsec) = 10^{-6} sec 1 nanosec (nsec) = 10^{-9} sec
Mass	1 kg = 1000 gr = 2.2046 lbm = 6.8521x10^{-2} slugs 1 slugs = 1 lbf.sec^{-2}/ft = 32.174 lbm 1 amu = 1.66x10^{-27} kg
Force	1 newton = 1 kg.m/sec^2 1 dyne = 1 gr.cm/sec^2 1 lbf = 4.448x10^5 dyne = 4.448 newtons
Energy	1 joule = 1 kg.m^2/sec^2 = 0.239 cal= 0.738 ft.lb = 2.78x10^{-7} kwh 1 joule = 10^7 erg 1 Btu = 778.18 ft.lbf= 1.055x10^{15} erg = 252 cal 1 cal = 4.186 joule 1 erg = 1 gr.cm^2/sec^2 1 eV = 1.602x10^{-19} joules = 160x10^{-12} erg
Power	1 Watt = 1 kg.m^2/sec^3 = 1 joule/sec 1 hp = 550 ft.lbf/sec 1 hp = 2545 Btu/hr = 746 Watts 1 kWatt = 1000 Watts = 3413 Btu/hr
Pressure	1 atm = 14.696 lbf/in^2 = 760 torr 1 mmHg = 0.01931 lbf/in^2 = 1 torr 1 dyne/cm^2 = 145.04x10^{-7} 1 bar = 14.504 lbf/in^2 = 10^6 dynes/cm^2 1 micron (μ) = 10^{-6} mHg = 10^{-3} mmHg 1 pascal (Pa) = 1 N/m^2 = 1 kg/(m·s^2) 1 hPa = 1 mb 1 hPa = 100 Pa
Volume	1 gal = 0.13368 ft^3 1 liter = 1000.028 cm^3
Temperature	1 ºK = 1 ºC = 1.8 ºF = 1.8 ºR 0 ºC corresponds to 32 ºF, 273.16 ºK, and 491.69 ºR 1 eV = 11600 ºK
Magnetic Quantities	1 Gauss = 1 $g^{1/2}$/$cm^{1/2}$.sec 1 Gauss = 10^3 coul/m.sec for M 1 Gauss = (1/4π)x10^3 coul/m.sec for H 1 Gauss = 10^{-4} Tesla for B 1 Tesla = 1 kg/coul.sec 1 Tesla = 1 kg/A.sec^2 1 nT = 10^{-9} Tesla 1 nT = 10^{-5} Gauss 1 gamma = 1 g = 1 nT Magnetic Flux: $\phi_B = \int B \bullet dA$, 1 Weber = 1 kg.m^2/coul.sec $\left\|\vec{B}\right\|$ = kg/sec.coul
Electrical Quantities	E-potential: $\varepsilon, d\varepsilon = \vec{E} \bullet dl$ E, 1 volt = 1 kg.m^2/coul.sec^2 $\left\|\vec{E}\right\|$ = kg.m/coul.sec Current Density: coul/m^2.sec Current: coul/sec Resistance (R): 1 ohm = 1 kg.m^2/$coul^2$.sec

Source: mainly Hallyday and Resnick, University Physics and several other books and internet sources for conversion tables.

PHYSICAL CONSTANTS

Avogadro's Number	$N = 6.025x10^{23}$ /g.mole
Bolzman's Constant	$k = 1.38x10^{-23}$ joule /^oK
Stefan Boltzmann Constant	$\sigma = 5.7x10^{-5}$ erg/cm^2.sec.$^oK^4$ $\sigma = 5.67x10^{-8}$ joule/m^2.sec.$^oK^4$
Gas Constant	R = 1545.33 ft.lbf/lb.mole.^oR R = 8.317 joule/g-mole.^oK R = 8317 joule/kg-mole.^oK R = 1.986 Btu/lb.mole.^oR R = 1.986 cal/g.mole.^oK
Planck's Constant	$h = 6.625x10^{-34}$ joule.sec
Biot-Savart Constant	$1/4\pi\varepsilon_o = 8.987x10^9$ kg.m^3/coul^2.sec^2 $\mu_o/4\pi = 1.000x10^{-7}$ kg.m/coul^2
Electronic Charge	$e = -1.6021x10^{-7}$ coul
Proton Mass	$m_p = 1.67x10^{-27}$ kg
Electron Mass	$m_e = 9.1x10^{-31}$ kg
Speed of Light	$c = 2.998x10^8$ m/sec
Newton's Constant	$g_c = 32.174$ ft.lbm/lbf.sec^2
Gravitational Constant	$k_G = 6.67x10^{-11}$ m^3/kg.sec^2
Wienn's Constant	c = 0.28 cm.^oK
Sun-Earth Distance	1 AU = $1.5x10^8$ km
Solar Constant for Earth	$I_o = 1.94$ cal/cm^{2}min $I_o = 1370$ Watt/m^2
Sun's Radius	$R_{sun} = 7x10^5$ km
Sun's Mass	$M_{sun} = 2x10^{30}$ kg
Sun's Surface Temperature	T = 6000 ^oK
Sun's Luminosity	$L = 4x10^{26}$ Watt
Earth's Radius	$R_{Earth} = 6378$ km
Earth's Albedo	A or α = % 33 or 0.33
Magnetic Field at the Earths's Equator	$B_o = 0.36$ Gauss (CGS) $B_o = 0.3x10^{-4}$ Tesla (MKS)
μ_o	$\mu_o = 4\pi x10^{-7}$ (MKS, Henry/m, or kg.m/coul^2, Henry = kg.m^2/coul^2)
R : Universal Gas Constant R^* : Specific Gas Constant $R^* =(Rx10^{3)}/M$, M = 29 amu for Air $R^* = (8.317x10^3)/29 = 286$ (MKS) $P = \rho R^* T$ or PV=RT	

Symbol	MKS (SI)	CGS (Gaussian System)
Length	1 m	10^2 cm
Mass	1 kg	10^3 g
Time	1 s, 1 sec	1 s, 1 sec
Force	1 N	10^5 dynes
Work or Energy	1 J	10^7 erg
Power	1 W	10^7 ergs/s
Charge	1 C	$3x10^9$ statcoul
Current	1 A	$3x10^9$ statamp
Electric Field Strength	1 V/m	$(1/3)x10^{-4}$ statvolt/cm
Electric Potential	1 V	(1/300) statvolt
Electric Polarization	1 C/m^2	$3x10^5$ statcoul/cm^2
Electric Displacement	1 C/m^2	$12\pi x10^5$ statvolt/cm^2
Resistance	1 Ω	$(1/9)x10^{-11}$ s/cm
Capacitance	1 F	$9x10^{11}$ cm
Magnetic Flux	1 Wb	10^8 Maxwells
Magnetic Induction	1 T	10^4 Gauss
Magnetic Field Strength	1 A-turn/m	$4\pi x10^3$ Gauss

To convert to	Multiply by
kilo	10^3
mega	10^6
giga	10^9
centri	10^{-2}
mili	10^{-3}
micro	10^{-6}
nano	10^{-9}
pico	10^{-12}
ppmv = one per million	10^{-6}
ppbv = one per billion	10^{-9}
pptv = one per trillion	10^{-12}

A

UNITS, CONVERSIONS, AND ABBREVIATIONS

LENGTH

1 kilometer (km) = 1000 meters (m)
= 3281 feet (ft)
= 0.62 mile (mi)

1 mile (mi) = 5280 feet (ft)
= 1609 meters (m)
= 1.61 kilometers (km)

1 centimeter (cm) = 0.39 inch (in.)
= 0.01 meter (m)

1 inch (in.) = 2.54 cm
= 0.08 ft

1 meter (m) = 100 cm
= 3.28 ft
= 39.37 in.

1 micrometer (μm) = 0.0001 cm
= 0.000001 m

AREA

1 square centimeter (cm^2) = 0.15 $in.^2$
1 square inch ($in.^2$) = 6.45 cm^2
1 square meter (m^2) = 10.76 ft^2
1 square foot (ft^2) = 0.09 m^2

VOLUME

1 cubic centimeter (cm^3) = 0.06 $in.^3$
1 cubic inch ($in.^3$) = 16.39 cm^3
1 liter (l) = 1000 cm^3

SPEED

1 knot = 1.15 mph
= 0.51 mps
= 1.85 kph

1 mile per hour (mph) = 0.87 knot
= 0.45 mps
= 1.61 kph

1 kilometer per hour (kph) = 0.54 knot
= 0.62 mph
= 0.28 mps

1 meter per second (mps) = 1.9 knots
= 2.2 mph
= 3.6 kph

MASS

1 gram (g) = 0.035 ounce
= 0.002 lb

1 kilogram (kg) = 1000 g
= 2.2 lb

ENERGY

1 joule (J) = 0.239 cal
1 calorie (cal) = 4.187 J

PRESSURE

1 millibar (mb) = 1000 dynes/cm^2
= 0.75 millimeter of mercury
= 0.03 inch of mercury
= 0.01 pound per square inch (psi)
= 100 pascals (Pa)

1 standard atmosphere = 1013.25 mb
= 760 millimeters of mercury
= 29.92 inches of mercury
= 14.7 psi

Appendix A
Conversion to SI Units

Physical quantity	Unit	SI (MKS) equivalent
Length	ft	0.305 m
	μm	10^{-6} m
	nm	10^{-9} m
Time	day	8.64×10^{4} s
Mass	lb	0.454 kg
Temperature	°F	273 + (°F − 32)/1.8 K
Volume	liter	10^{-3} m^{3}
Velocity	mph	0.447 m s^{-1}
	knots	0.515 m s^{-1}
	km hr^{-1}	0.278 m s^{-1}
	fps	0.305 m s^{-1}
Force	kg m s^{-2}	1 N
	lb	0.138 N
	dyne	10^{-5} N
Pressure	N m^{-2}	1 Pa
	bar	10^{5} Pa
	mb	10^{2} Pa = 1 hPa
Energy	kg m^{2} s^{-2}	1 J
	Nm	1 J
	erg	10^{-7} J
	cal	4.187 J
Power	kg m^{-2} s^{-3}	1 W
	J s^{-1}	1 W
	Langley day^{-1}	4.84×10^{-1} W m^{-2}
Specific heat	cal gm^{-1}	4.184×10^{3} J kg^{-1}
Energy flux	cal cm^{-2} min^{-1}	6.97×10^{2} W m^{-2}

Appendix B

Thermodynamic Properties of Air and Water

Dry Air	
Mean molecular weight	$M_d = 28.96\ \mathrm{g\,mol^{-1}}$
Specific gas constant	$R = 287.05\ \mathrm{J\,kg^{-1}\,K^{-1}}$
Density	$\rho = 1.293\ \mathrm{kg\,m^{-3}}$ (at STP*)
Number density (Loschmidt number)	$n = 2.687 \times 10^{25}\ \mathrm{m^{-3}}$ (at STP)
Isobaric specific heat capacity	$c_p = 1.005 \times 10^3\ \mathrm{J\,kg^{-1}\,K^{-1}}$ (at 273 K)
Isochoric specific heat capacity	$c_v = 7.19 \times 10^2\ \mathrm{J\,kg^{-1}\,K^{-1}}$ (at 273 K)
Ratio of specific heats	$\gamma = c_p/c_v = 1.4$
	$\kappa = (\gamma - 1)/\gamma = R/c_p = 0.286$
Coefficient of viscosity	$\mu = 1.73 \times 10^{-5}\ \mathrm{kg\,m^{-1}\,s^{-1}}$ (at STP)
Kinematic viscosity	$\nu = 1.34 \times 10^{-5}\ \mathrm{m^2\,s^{-1}}$ (at STP)
Coefficient of thermal conductivity	$k = 2.40 \times 10^{-2}\ \mathrm{W\,m^{-1}\,K^{-1}}$ (at STP)
Sound speed	$c_s = 331\ \mathrm{m\,s^{-1}}$ (at 273 K)
Water	
Mean molecular weight	$M_v = 18.015\ \mathrm{g\,mol^{-1}}$
	$\epsilon = M_v/M_d = 0.622$
Specific gas constant	$R = 461.51\ \mathrm{J\,kg^{-1}\,K^{-1}}$
Density (liquid water)	$\rho = 10^3\ \mathrm{kg\,m^{-3}}$ (at STP)
Density (ice)	$\rho = 9.17 \times 10^2\ \mathrm{kg\,m^{-3}}$ (at STP)
Isobaric specific heat capacity (vapor)	$c_p = 1.85 \times 10^3\ \mathrm{J\,kg^{-1}\,K^{-1}}$ (at 273 K)
Isochoric specific heat capacity (vapor)	$c_v = 1.39 \times 10^3\ \mathrm{J\,kg^{-1}\,K^{-1}}$ (at 273 K)
Ratio of specific heats (vapor)	$\gamma = c_p/c_v = 1.33$
Specific heat capacity (liquid water)	$c = 4.218 \times 10^3\ \mathrm{J\,kg^{-1}\,K^{-1}}$ (at 273 K)
Specific heat capacity (ice)	$c = 2.106 \times 10^3\ \mathrm{J\,kg^{-1}\,K^{-1}}$ (at 273 K)
Specific latent heat of fusion	$l_f = 3.34 \times 10^5\ \mathrm{J\,kg^{-1}}$
Specific latent heat of vaporization	$l_v = 2.50 \times 10^6\ \mathrm{J\,kg^{-1}}$
Specific latent heat of sublimation	$l_s = l_f + l_v$

*Standard temperature and pressure (STP) = 1013 mb and 273 K.

Appendix C
Physical Constants

Avogadro's number	$N_A = 6.022 \times 10^{26}\ \mathrm{mol^{-1}}$
Universal gas constant	$R^* = 8.314\ \mathrm{J\,mol^{-1}\,K^{-1}}$
Boltzmann constant	$k = 1.381 \times 10^{-23}\ \mathrm{J\,K^{-1}}$
Planck constant	$h = 6.6261 \times 10^{-34}\ \mathrm{J\,s^{-1}}$
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\ \mathrm{W\,m^{-2}\,K^{-4}}$
Speed of light	$c = 2.998 \times 10^{8}\ \mathrm{m\,s^{-1}}$
Solar constant	$F_s = 1.372 \times 10^{3}\ \mathrm{W\,m^{-2}}$
Radius of the earth	$a = 6.371 \times 10^{3}\ \mathrm{km}$
Standard gravity	$g_0 = 9.806\ \mathrm{m\,s^{-2}}$
Earth's angular velocity	$\Omega = 7.292 \times 10^{-5}\ \mathrm{s^{-1}}$

Appendix D
Vector Identities

$$\boldsymbol{A} \times (\boldsymbol{B} \times \boldsymbol{C}) = (\boldsymbol{A} \cdot \boldsymbol{C})\boldsymbol{B} - (\boldsymbol{A} \cdot \boldsymbol{B})\boldsymbol{C} \tag{D.1}$$

$$\boldsymbol{A} \cdot (\boldsymbol{B} \times \boldsymbol{C}) = (\boldsymbol{A} \times \boldsymbol{B}) \cdot \boldsymbol{C} = \boldsymbol{B} \cdot (\boldsymbol{C} \times \boldsymbol{A}) \tag{D.2}$$

$$(\boldsymbol{A} \times \boldsymbol{B}) \cdot (\boldsymbol{C} \times \boldsymbol{D}) = (\boldsymbol{A} \cdot \boldsymbol{C})(\boldsymbol{B} \cdot \boldsymbol{D}) - (\boldsymbol{A} \cdot \boldsymbol{D})(\boldsymbol{B} \cdot \boldsymbol{C}) \tag{D.3}$$

$$\nabla(fg) = f\nabla g + g\nabla f \tag{D.4}$$

$$\nabla \cdot (f\boldsymbol{A}) = \nabla f \cdot \boldsymbol{A} + f\nabla \cdot \boldsymbol{A} \tag{D.5}$$

$$\nabla \times (f\boldsymbol{A}) = \nabla f \times \boldsymbol{A} + f\nabla \times \boldsymbol{A} \tag{D.6}$$

$$\nabla \cdot (\boldsymbol{A} \times \boldsymbol{B}) = \boldsymbol{B} \cdot (\nabla \times \boldsymbol{A}) - \boldsymbol{A} \cdot (\nabla \times \boldsymbol{B}) \tag{D.7}$$

$$\nabla \cdot \nabla \times \boldsymbol{A} = 0 \tag{D.8}$$

$$\nabla \times \nabla f = 0 \tag{D.9}$$

$$\nabla \cdot \nabla f = \nabla^2 f \tag{D.10}$$

$$\nabla \times \nabla \times f = \nabla(\nabla \cdot f) - \nabla^2 f \tag{D.11}$$

$$\nabla(\boldsymbol{A} \cdot \boldsymbol{B}) = \boldsymbol{A} \cdot \nabla\boldsymbol{B} + \boldsymbol{B} \cdot \nabla\boldsymbol{A} + \boldsymbol{A} \times \nabla\boldsymbol{B} + \boldsymbol{B} \times \nabla \times \boldsymbol{A} \tag{D.12}$$

$$\nabla(\boldsymbol{A} \times \boldsymbol{B}) = \boldsymbol{B} \cdot \nabla\boldsymbol{A} - \boldsymbol{A} \cdot \nabla\boldsymbol{B} + \boldsymbol{A}(\nabla \cdot \boldsymbol{B}) - \boldsymbol{B}(\nabla \cdot \boldsymbol{A}) \tag{D.13}$$

$$\boldsymbol{A} \cdot \nabla\boldsymbol{A} = \frac{1}{2}\nabla(\boldsymbol{A} \cdot \boldsymbol{A}) - \boldsymbol{A} \times (\nabla \times \boldsymbol{A}) \tag{D.14}$$

Appendix E
Curvilinear Coordinates

Spherical Coordinates (λ, ϕ, r)

$$\nabla\psi = \frac{1}{r\cos\phi}\frac{\partial\psi}{\partial\lambda}\boldsymbol{e}_\lambda + \frac{1}{r}\frac{\partial\psi}{\partial\phi}\boldsymbol{e}_\phi + \frac{\partial\psi}{\partial r}\boldsymbol{e}_r$$

$$\nabla\cdot\boldsymbol{A} = \frac{1}{r\cos\phi}\frac{\partial A_\lambda}{\partial\lambda} + \frac{1}{r\cos\phi}\frac{\partial}{\partial\phi}(\cos\phi A_\phi) + \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 A_r)$$

$$\nabla\times\boldsymbol{A} = \frac{1}{(r^2\cos\phi)}\left\{r\cos\phi\left[\frac{\partial A_r}{\partial\phi} - \frac{\partial(rA_\phi)}{\partial r}\right]\boldsymbol{e}_\lambda\right.$$
$$+ r\left[\frac{\partial}{\partial r}(r\cos\phi A_\lambda) - \frac{\partial A_r}{\partial\lambda}\right]\boldsymbol{e}_\phi$$
$$\left.+\left[\frac{\partial(rA_\phi)}{\partial\lambda} - \frac{\partial}{\partial\phi}(r\cos\phi A_\lambda)\right]\boldsymbol{e}_r\right\}$$

$$\nabla^2\psi = \frac{1}{r^2\cos^2\phi}\frac{\partial^2\psi}{\partial\lambda^2} + \frac{1}{r^2\cos\phi}\frac{\partial}{\partial\phi}\left(\cos\phi\frac{\partial\psi}{\partial\phi}\right) + \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial\psi}{\partial r}\right)$$

$$\nabla^2\boldsymbol{A} = \left[\nabla^2 A_\lambda - \frac{A_\lambda}{r^2\cos^2\phi} + \frac{2}{r^2\cos\phi}\frac{\partial A_r}{\partial\lambda} + \frac{2}{r^2}\frac{\sin\phi}{\cos^2\phi}\frac{\partial A_\phi}{\partial\lambda}\right]\boldsymbol{e}_\lambda$$
$$+\left[\nabla^2 A_\phi - \frac{A_\phi}{r^2\cos^2\phi} + \frac{2}{r^2}\frac{\partial A_r}{\partial\phi} - \frac{2}{r^2}\frac{\sin\phi}{\cos^2\phi}\frac{\partial A_\lambda}{\partial\lambda}\right]\boldsymbol{e}_\phi$$
$$+\left[\nabla^2 A_r - \frac{2}{r^2}A_r - \frac{2}{r^2\cos\phi}\frac{\partial}{\partial\phi}(\sin\phi A_\phi) - \frac{2}{r^2\cos\phi}\frac{\partial A_\lambda}{\partial\lambda}\right]\boldsymbol{e}_r$$

Cylindrical Coordinates (r, ϕ, z)

$$\nabla\psi = \frac{\partial\psi}{\partial r}\boldsymbol{e}_r + \frac{1}{r}\frac{\partial\psi}{\partial\phi}\boldsymbol{e}_\phi + \frac{\partial\psi}{\partial z}\boldsymbol{e}_z \tag{E.6}$$

$$\nabla\cdot\boldsymbol{A} = \frac{1}{r}\frac{\partial}{\partial r}(rA_r) + \frac{1}{r}\frac{\partial A_\phi}{\partial\phi} + \frac{\partial A_z}{\partial z} \tag{E.7}$$

$$\nabla\times\boldsymbol{A} = \left[\frac{1}{r}\frac{\partial A_z}{\partial\phi} - \frac{\partial A_\phi}{\partial z}\right]\boldsymbol{e}_r + \left[\frac{\partial A_r}{\partial z} - \frac{\partial A_z}{\partial r}\right]\boldsymbol{e}_\phi + \left[\frac{1}{r}\frac{\partial(rA_\phi)}{\partial r} - \frac{1}{r}\frac{\partial A_r}{\partial\phi}\right]\boldsymbol{e}_z \tag{E.8}$$

$$\nabla^2\psi = \frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial\psi}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2\psi}{\partial\phi^2} + \frac{\partial^2\psi}{\partial z^2} \tag{E.9}$$

$$\nabla^2\boldsymbol{A} = \left[\nabla^2 A_r - \frac{A_r}{r^2} - \frac{2}{r^2}\frac{\partial A_\phi}{\partial\phi}\right]\boldsymbol{e}_r + \left[\nabla^2 A_\phi - \frac{A_\phi}{r^2} + \frac{2}{r^2}\frac{\partial A_r}{\partial\phi}\right]\boldsymbol{e}_\phi + \nabla^2 A_z\boldsymbol{e}_z \tag{E.10}$$

Source: mainly Hallyday and Resnick, University Physics and several other books and internet sources for conversion tables.