Appendix A: Physical Constants and Conversion Factors

PHYSICAL CONSTANTS

Avogadro's number, $N_A = 6.023 \times 10^{26}$ molecules/kgmole
Boltzmann's constant, $k = 1.381 \times 10^{-23}$ J/(molecule·K)
Electron charge, $e = 1.602 \times 10^{-19}$C
Electron mass, $m_e = 9.110 \times 10^{-31}$ kg
Faraday's constant, F = 96,487 kC/kgmole electrons = 96,487 kJ/(V·kgmole electrons)
Gravitational acceleration (standard), $g = 32.174\ \text{ft/s}^2 = 9.807\ \text{m/s}^2$
Gravitational constant, $k_G = 6.67 \times 10^{-11}\text{m}^3/(\text{kg}\cdot\text{s}^2)$
Newton's second law constant, $g_c = 32.174\ \text{lbm}\cdot\text{ft}/(\text{lbf}\cdot\text{s}^2) = 1.0\ \text{kg}\cdot\text{m}/(\text{N}\cdot\text{s}^2)$
Planck's constant, $\hbar = 6.626 \times 10^{-34}$ J·s/molecule
Stefan-Boltzmann constant, $\sigma = 0.1714 \times 10^{-8}\ \text{Btu}/(\text{h}\cdot\text{ft}^2\cdot\text{R}^4) = 5.670 \times 10^{-8}\ \text{W}/(\text{m}^2\cdot\text{k}^4)$
Universal gas constant $\Re = 1545.35\ \text{ft}\cdot\text{lbf}/(\text{lbmole}\cdot\text{R}) = 8314.3\ \text{J}/(\text{kgmole}\cdot\text{K})$
$= 8.3143\ \text{kJ}/(\text{kgmole}\cdot\text{K}) = 1.9858\ \text{Btu}/(\text{lbmole}\cdot\text{R})$
$= 1.9858\ \text{kcal}/(\text{kgmole}\cdot\text{K}) = 1.9858\ \text{cal}/(\text{gmole}\cdot\text{K})$
$= 0.08314\ \text{bar}\cdot\text{m}^3/(\text{kgmole}\cdot\text{K}) = 82.05\ \text{L}\cdot\text{atm}/(\text{kgmole}\cdot\text{K})$
Velocity of light in a vacuum, $c = 9.836 \times 10^8$ ft/s $= 2.998 \times 10^8$ m/s

UNIT DEFINITIONS

1 coulomb (C) = 1 A·s	1 ohm (Ω) = 1 V/A
1 dyne = 1 g·cm/s^2	1 pascal (Pa) = 1 N/m^2
1 erg = 1 dyne·cm	1 poundal = 1 lbm·ft/s^2
1 farad (F) = 1 C/V	1 siemens (S) = 1 A/V
1 henry (H) = 1 Wb/A	1 slug = 1 lbf·s^2/ft
1 hertz (Hz) = 1 cycle/s	1 tesla (T) = 1 Wb/m^2
1 joule (J) = 1 N·m	1 volt (V) = 1 W/A
1 lumen = 1 candela·steradian	1 watt (W) = 1 J/s
1 lux = 1 lumen/m^2	1 weber (Wb) = 1 V·s
1 newton (N) = 1 kg·m/s^2	

CONVERSION FACTORS

Length	**Energy**
1 m = 3.2808 ft = 39.37 in = 10^2 cm = 10^{10} Å	1 J = 1 N·m = 1 kg·m^2/s^2 = 9.479 × 10^{-4} Btu
1 cm = 0.0328 ft = 0.394 in = 10^{-2} m = 10^8 Å	1 kJ = 1000 J = 0.9479 Btu = 238.9 cal
1 mm = 10^{-3} m = 10^{-1} cm	1 Btu = 1055.0 J = 1.055 kJ = 778.16 ft·lbf = 252 cal
1 km = 1000 m = 0.6215 miles = 3281 ft	1 cal = 4.186 J = 3.968 × 10^{-3} Btu
1 in = 2.540 cm = 0.0254 m	1 Cal (in food value) = 1 kcal = 4186 J = 3.968 Btu
1 ft = 12 in = 0.3048 m	1 erg = 1 dyne·cm = 1 g·cm^2/s^2 = 10^{-7} J
1 mile = 5280 ft = 1609.36 m = 1.609 km	1 eV = 1.602 × 10^{-19} J

(*Continued*)

CONVERSION FACTORS (*Continued*)

Area

$1\ m^2 = 10^4\ cm^2 = 10.76\ ft^2 = 1550\ in^2$

$1\ ft^2 = 144\ in^2 = 0.0929\ m^2 = 929.05\ cm^2$

$1\ cm^2 = 10^{-4}\ m^2 = 1.0764 \times 10^{-3}\ ft^2 = 0.155\ in^2$

$1\ in^2 = 6.944 \times 10^{-3}\ ft^2 = 6.4516 \times 10^{-4}\ m^2 = 6.4516\ cm^2$

Volume

$1\ m^3 = 35.313\ ft^3 = 6.1023 \times 10^4\ in^3 = 1000\ L = 264.171\ gal$

$1\ L = 10^{-3} m^3 = 0.0353\ ft^3 = 61.03\ in^3 = 0.2642\ gal$

$1\ gal = 231\ in^3 = 0.13368\ ft^3 = 3.785 \times 10^{-3}\ m^3$

$1\ ft^3 = 1728\ in^3 = 28.3168\ L = 0.02832\ m^3 = 7.4805\ gal$

$1\ in^3 = 16.387\ cm^3 = 1.6387 \times 10^{-5}\ m^3 = 4.329 \times 10^{-3}\ gal$

Mass

$1\ kg = 1000\ g = 2.2046\ lbm = 0.0685\ slug$

$1\ lbm = 453.6\ g = 0.4536\ kg = 3.108 \times 10^{-2}\ slug$

$1\ slug = 32.174\ lbm = 1.459 \times 10^4\ g = 14.594\ kg$

Force

$1\ N = 10^5\ dyne = 1\ kg \cdot m/s^2 = 0.225\ lbf$

$1\ lbf = 4.448\ N = 32.174\ poundals$

$1\ poundal = 0.138\ N = 3.108 \times 10^{-2}\ lbf$

Power

$1\ W = 1\ J/s = 1\ kg \cdot m^2/s^3 = 3.412\ Btu/h = 1.3405 \times 10^{-3}\ hp$

$1\ kW = 1000\ W = 3412\ Btu/h = 737.3\ ft \cdot lbf/s = 1.3405\ hp$

$1\ Btu/h = 0.293\ W = 0.2161\ ft \cdot lbf/s = 3.9293 \times 10^{-4}\ hp$

$1\ hp = 550\ ft \cdot lbf/s = 33000\ ft \cdot lbf/min = 2545\ Btu/h = 746\ W$

Pressure

$1\ Pa = 1\ N/m^2 = 1\ kg/(m \cdot s^2) = 1.4504 \times 10^{-4}\ lbf/in^2$

$1\ lbf/in^2 = 6894.76\ Pa = 0.068\ atm = 2.036\ in\ Hg$

$1\ atm = 14.696\ lbf/in^2 = 1.01325 \times 10^5\ Pa$

$= 101.325\ kPa = 760\ mm\ Hg$

$1\ bar = 10^5\ Pa = 0.987\ atm = 14.504\ lbf/in^2$

$1\ dyne/cm^2 = 0.1\ Pa = 10^{-6}\ bar = 145.04 \times 10^{-7}\ lbf/in^2$

$1\ in\ Hg = 3376.8\ Pa = 0.491\ lbf/in^2$

$1\ in\ H_2O = 248.8\ Pa = 0.0361\ lbf/in^2$

MISCELLANEOUS UNIT CONVERSIONS

Specific Heat Units

$1\ Btu/(lbm \cdot °F) = 1\ Btu/(lbm \cdot R)$

$1\ kJ/(kg \cdot K) = 0.23884\ Btu/(lbm \cdot R) = 185.8\ ft \cdot lbf/(lbm \cdot R)$

$1\ Btu/(lbm \cdot R) = 778.16\ ft \cdot lbf/(lbm \cdot R) = 4.186\ kJ/(kg \cdot K)$

Energy Density Units

$1\ kJ/kg = 1000\ m^2/s^2 = 0.4299\ Btu/lbm$

$1\ Btu/lbm = 2.326\ kJ/kg = 2326\ m^2/s^2$

Energy Flux

$1\ W/m^2 = 0.317\ Btu/(h \cdot ft^2)$

$1\ Btu/(h \cdot ft^2) = 3.154\ W/m^2$

Heat Transfer Coefficient

$1\ W/(m^2 \cdot K) = 0.1761\ Btu/(h \cdot ft^2 \cdot R)$

$1\ Btu/(h \cdot ft^2 \cdot R) = 5.679\ W/(m^2 \cdot K)$

Thermal Conductivity

$1\ W/(m \cdot K) = 0.5778\ Btu/(h \cdot ft \cdot R)$

$1\ Btu/(h \cdot ft \cdot R) = 1.731\ W/(m \cdot K)$

Temperature

$T(°F) = \frac{9}{5} T(°C) + 32 = T(R) - 459.67$

$T(°C) = \frac{5}{9}[T(°F) - 32] = T(K) - 273.15$

$T(R) = \frac{9}{5} T(K) = (1.8)T(K) = T(°F) + 459.67$

$T(K) = \frac{5}{9} T(R) = T(R)/1.8 = T(°C) + 273.15$

Density

$1\ lbm/ft^3 = 16.0187\ kg/m^3$

$1\ kg/m^3 = 0.062427\ lbm/ft^3 = 10^{-3}\ g/cm^3$

$1\ g/cm^3 = 1\ kg/L = 62.4\ lbm/ft^3 = 10^3\ kg/m^3$

Viscosity

$1\ Pa \cdot s = 1\ N \cdot s/m^2 = 1\ kg/(m \cdot s) = 10\ poise$

$1\ poise = 1\ dyne \cdot s/cm^2 = 1\ g/(cm \cdot s) = 0.1\ Pa \cdot s$

$1\ poise = 2.09 \times 10^{-3}\ lbf \cdot s/ft^2 = 6.72 \times 10^{-2}\ lbm/(ft \cdot s)$

$1\ centipoise = 0.01\ poise = 10^{-3}\ Pa \cdot s$

$1\ lbf \cdot s/ft^2 = 1\ slug/(ft \cdot s) = 47.9\ Pa \cdot s = 479\ poise$

$1\ stoke = 1\ cm^2/s = 10^{-4}\ m^2/s = 1.076 \times 10^{-3}\ ft^2/s$

$1\ centistoke = 0.01\ stoke = 10^{-6}\ m^2/s = 1.076 \times 10^{-5}\ ft^2/s$

$1\ m^2/s = 10^4\ stoke = 10^6\ centistoke = 10.76\ ft^2/s$