Some Useful/Useless Equations and Constants

Kinematic Equations

$x_f = x_i + v_{ix}t + \frac{1}{2}a_x t^2$

$y_f = y_i + v_{iy}t + \frac{1}{2}a_y t^2$

$v_{fx} = v_{ix} + a_x t$

$v_{fy} = v_{iy} + a_y t$

${v_{fx}}^2 = {v_{ix}}^2 + 2a_x \Delta x$

${v_{fy}}^2 = {v_{iy}}^2 + 2a_y \Delta y$

Rotational/Circular Motion Equations

$\theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2$

$\omega_f = \omega_i + \alpha t$

${\omega_f}^2 = {\omega_i}^2 + 2\alpha(\theta_f - \theta_i)$

$v_t = \omega r$

$a_t = \alpha r$

$a_c = \frac{{v_t}^2}{r} = \omega^2 r$

$\sum \tau = I\alpha$

$\boldsymbol{\tau} = \boldsymbol{F} \times \boldsymbol{r}$

$\tau = F_\perp r$

$\tau = |F| \cdot |r| \sin\theta$

$I = \sum_i m_i {r_i}^2$

$I = \int r^2 dm$

Thermal Equations

$\Delta Q = mc\Delta T$

$Q = mL_f$

$Q = mL_v$

$W = P\Delta V$

$W = \int PdV$

$K = \frac{3}{2}k_B T$

$T_F = \frac{9}{5}T_C + 32$

$T_C = \frac{5}{9}(T_F - 32)$

$T_K = T_C + 273$

$PV = nRT$

$PV = Nk_B T$

$\Delta L = L_o \alpha \Delta T$

$\Delta A = A_o \gamma \Delta T$

$\Delta V = V_o \beta \Delta T$

$\Delta U = Q - W$

$\Delta U = \frac{3}{2}nR\Delta T$

Circuits Equations

$V = IR$

$R_T = \sum R_i$

$\frac{1}{R_T} = \sum \frac{1}{R_i}$

$C = \frac{Q}{V}$

$C_T = \sum C_i$

$\frac{1}{C_T} = \sum \frac{1}{C_i}$

$C = \kappa \frac{\epsilon_o \cdot A}{d}$

$P = IV$

$E = \frac{Q}{\epsilon_o \cdot A}$

Force Equations

$\Sigma \boldsymbol{F} = m\boldsymbol{a}$

$w = mg$

$F_f = \mu F_N$

$F_s = -kx$

$F_G = G\frac{m_1 m_2}{r^2}$

$F_C = k_e \frac{|q_1||q_2|}{r^2}$

$F_B = q\boldsymbol{v} \times \boldsymbol{B}$

$F_B = qvB \sin\varphi$

Work and Energy Equations

$W = \boldsymbol{F} \cdot \Delta \boldsymbol{r}$

$W = \int \boldsymbol{F} \cdot \boldsymbol{dr}$

$W = |\boldsymbol{F}| \cdot |\boldsymbol{r}| \cos\theta$

$K_t = \frac{1}{2}mv^2$

$K_r = \frac{1}{2}I\omega^2$

$W = \Delta K$

$U_g = mgh$

$U_s = \frac{1}{2}kx^2$

$\Delta K = -\Delta U$

$K_i + U_i = K_f + U_f$

Momentum and Impulse Equations

$Impluse = \boldsymbol{F} \cdot \Delta \mathrm{t}$

$\boldsymbol{p} = m\boldsymbol{v}$

$Impluse = \Delta \mathbf{p}$

$\sum \boldsymbol{p}_i = \sum \boldsymbol{p}_f$

$\boldsymbol{L} = \boldsymbol{p} \times \boldsymbol{r}$

$L = I\omega$

Electricity Equations

$E = k_e \frac{|q|}{r^2}$

$V = k_e \frac{q}{r}$

$\boldsymbol{E} = \frac{\boldsymbol{F}}{q}$

$\Delta V = Ed$

$\Delta U = -q\Delta V$

$\Phi_E = EA_\perp$

$\Phi_E = \frac{q_{enc}}{\epsilon_o}$

Wave & S.H.O. Equations

$\omega = 2\pi f$ $\quad T = \frac{1}{f}$ $\quad k = \frac{2\pi}{\lambda}$ $\quad v = f\lambda$

$y(x,t) = A\sin[kx - \omega t + \varphi]$

$v(x,t) = -A\omega\cos[kx - \omega t + \varphi]$

$a(x,t) = -A\omega^2\sin[kx - \omega t + \varphi]$

$x(t) = A\cos[\omega t + \varphi]$ $\quad v(t) = -A\omega\sin[\omega t + \varphi]$

$a(t) = -A\omega^2\cos[\omega t + \varphi]$ $\quad \omega = \sqrt{\frac{k}{m}}$

$n = 1,2,3, \ldots \begin{cases} f_n = \frac{nv}{2L} \\ \lambda_n = \frac{2}{n}L \end{cases}$ $\quad n = 1,3,5 \ldots \begin{cases} f_n = \frac{nv}{4L} \\ \lambda_n = \frac{4}{n}L \end{cases}$

$v = \sqrt{\frac{T}{\mu}}$ $\quad \lambda_n = \frac{2L}{n}$ $\quad \mu = \frac{m}{L}$ $\quad f_n = \frac{n}{2L}\sqrt{\frac{T}{\mu}}$

$\omega = \sqrt{\frac{g}{L}}$ $\quad f' = f\frac{v \pm v_o}{v \mp v_s}$

Universal Constants

$G = 6.674 \times 10^{-11}\,\frac{N \cdot m^2}{kg^2}$ $\quad k_B = 1.38 \times 10^{-23} J/K$

$R = 8.314\ \frac{J}{mol \cdot K}$ $\quad R = 0.082057\ \frac{L \cdot atm}{mol \cdot K}$

$1\ atm = 101\ kPa$ $\quad N_A = 6.022\ \times 10^{23}$

$1\ L = 0.001\ m^3$ $\quad k_e = 8.99\ \times 10^9 \frac{N \cdot m^2}{C^2}$

$\epsilon_o = 8.85\ \times 10^{-12}\,\frac{C^2}{N \cdot m^2}$ $\quad k_e = \frac{1}{4\pi\epsilon_o}$

$e = 1.602\ \times 10^{-19}\ C$ $\quad m_p = 1.67 \times 10^{-27} kg$

$m_n = 1.67 \times 10^{-27} kg$ $\quad m_e = 9.11 \times 10^{-31} kg$

$c = 3.0\ \times 10^8\ m/s$ $\quad v_{sound} = 340\ m/s$

$\mu_o = 4\pi \times 10^{-7}\ \frac{T \cdot m}{A}$

Lens/Mirror Equations

$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'}$ $\quad M = -\frac{s'}{s}$ $\quad M = \frac{y'}{y}$

$n_1\sin\theta_1 = n_2\sin\theta_2$ $\quad n = \frac{c}{v_m}$

$\theta_c = \sin^{-1}\frac{n_2}{n_1}$

Magnetism Equations

$\boldsymbol{F} = q\boldsymbol{v} \times \boldsymbol{B}$ $\quad F = |q|vB\sin\theta$

$B = \frac{\mu_o I}{2\pi r}$ $\quad \frac{F}{L} = \frac{\mu_o I I'}{2\pi r}$

$B_x = \frac{N\mu_o I a^2}{2[x^2 + a^2]^{\frac{3}{2}}}$

General Equations

$C = 2\pi r$ $\quad P = \frac{F}{A}$ $\quad \rho = \frac{m}{V}$

$x = \frac{-b\ \pm\sqrt{b^2 - 4ac}}{2a}$

$N = N_o e^{-\frac{\ln 2}{T_{1/2}}t}$

TABLE 17.3 Approximate Specific Heats and Molar Heat Capacities (Constant Pressure)

Substance	Specific Heat, c (J/kg · K)	Molar Mass, M (kg/mol)	Molar Heat Capacity, C (J/mol · K)
Aluminum	910	0.0270	24.6
Beryllium	1970	0.00901	17.7
Copper	390	0.0635	24.8
Ethanol	2428	0.0461	111.9
Ethylene glycol	2386	0.0620	148.0
Ice (near 0°C)	2100	0.0180	37.8
Iron	470	0.0559	26.3
Lead	130	0.207	26.9
Marble ($CaCO_3$)	879	0.100	87.9
Mercury	138	0.201	27.7
Salt (NaCl)	879	0.0585	51.4
Silver	234	0.108	25.3
Water (liquid)	4190	0.0180	75.4
Steam (100°C)	2 010		

TABLE 17.4 Heats of Fusion and Vaporization

Substance	Normal Melting Point		Heat of Fusion, L_f (J/kg)	Normal Boiling Point		Heat of Vaporization, L_v (J/kg)
	K	°C		K	°C	
Helium	*	*	*	4.216	−268.93	20.9×10^3
Hydrogen	13.84	−259.31	58.6×10^3	20.26	−252.89	452×10^3
Nitrogen	63.18	−209.97	25.5×10^3	77.34	−195.8	201×10^3
Oxygen	54.36	−218.79	13.8×10^3	90.18	−183.0	213×10^3
Ethanol	159	−114	104.2×10^3	351	78	854×10^3
Mercury	234	−39	11.8×10^3	630	357	272×10^3
Water	273.15	0.00	334×10^3	373.15	100.00	2256×10^3
Sulfur	392	119	38.1×10^3	717.75	444.60	326×10^3
Lead	600.5	327.3	24.5×10^3	2023	1750	871×10^3
Antimony	903.65	630.50	165×10^3	1713	1440	561×10^3
Silver	1233.95	960.80	88.3×10^3	2466	2193	2336×10^3
Gold	1336.15	1063.00	64.5×10^3	2933	2660	1578×10^3
Copper	1356	1083	134×10^3	1460	1187	5069×10^3

*A pressure in excess of 25 atmospheres is required to make helium solidify. At 1 atmosphere pressure, helium remains a liquid down to absolute zero.

TABLE 17.1 Coefficients of Linear Expansion

Material	α [K^{-1} or $(C°)^{-1}$]
Aluminum	2.4×10^{-5}
Brass	2.0×10^{-5}
Copper	1.7×10^{-5}
Glass	$0.4–0.9 \times 10^{-5}$
Invar (nickel–iron alloy)	0.09×10^{-5}
Quartz (fused)	0.04×10^{-5}
Steel	1.2×10^{-5}

TABLE 17.2 Coefficients of Volume Expansion

Solids	β [K^{-1} or $(C°)^{-1}$]	Liquids	β [K^{-1} or $(C°)^{-1}$]
Aluminum	7.2×10^{-5}	Ethanol	75×10^{-5}
Brass	6.0×10^{-5}	Carbon disulfide	115×10^{-5}
Copper	5.1×10^{-5}	Glycerin	49×10^{-5}
Glass	$1.2–2.7 \times 10^{-5}$	Mercury	18×10^{-5}
Invar	0.27×10^{-5}		
Quartz (fused)	0.12×10^{-5}		
Steel	3.6×10^{-5}		