Possibly Useful Formulae

For constant acceleration in one dimension:

$$\mathrm{v} = at + \mathrm{v}_0$$

$$x = \tfrac{1}{2}at^2 + \mathrm{v}_0 t + x_0$$

$$\mathrm{v}^2 - \mathrm{v}_0^2 = 2a\Delta x$$

Momentum — linear and angular:

$$\vec{p} = m\vec{\mathrm{v}} \qquad \vec{L} = \vec{r} \times \vec{p} = I\vec{\omega}$$

Newton's Second Law:

$$\vec{\mathbf{F}} = m\vec{\mathbf{a}} \qquad \vec{\tau} = \vec{r} \times \vec{F} = \frac{d\vec{L}}{dt} = I\vec{\alpha}$$

Circular Accelerations:

$$a_c = \frac{\mathrm{v}^2}{R} = \omega^2 R \qquad a_t = \frac{d\mathrm{v}}{dt} = \alpha R$$

Circular Accelerations:

$$a_r = \frac{\mathrm{v}^2}{R} = \omega^2 R$$

$$a_t = \frac{d\mathrm{v}}{dt}$$

Friction:

$$f_k = \mu_k N$$

$$f_s \le \mu_s N$$

Moment of Inertia:

$$I = \sum m_i r_i^2 = \int_{body} r^2 dm$$

$$I_{c.m.} = MR^2 \quad (ring)$$

$$I_{c.m.} = \frac{1}{2} MR^2 \quad (disc)$$

$$I_{c.m.} = \frac{1}{12} ML^2 \quad (thin\ rod)$$

$$I_{c.m.} = \frac{2}{5} MR^2 \quad (sphere)$$

Parallel axis theorem:

$$I = I_{c.m.} + Mh^2$$

Kinetic Energy — rotational and translational:

$$K = \frac{1}{2} m\mathrm{v}^2 + \frac{1}{2} I_{c.m.}\omega^2$$

Work:

$$W_{i\to f} = \int_i^f \vec{F} \cdot d\vec{s}$$

Potential Energy:

$$U(\vec{r}) - U(ref) = -\int_{ref}^{\vec{r}} \vec{F} \cdot d\vec{s}$$

$$U(y) = mgy \quad \text{(gravity, near Earth)}$$

$$U(r) = -\frac{Gm_1 m_2}{r} \quad \text{(gravity, generally)}$$

$$U(x) = \frac{1}{2} kx^2 \quad \text{(spring)}$$

Condition for rolling without slipping for a round object of radius R:

$$s = R\theta \qquad |\vec{\mathrm{v}}| = R|\vec{\omega}| \qquad |\vec{a}| = R|\vec{\alpha}|$$

Oscillations:

$$\frac{d^2x}{dt^2} = -\omega^2 x \qquad \frac{\omega}{2\pi} = f = \frac{1}{T} \qquad x(t) = A\cos(\omega t + \phi) \qquad \omega = \sqrt{\frac{k}{m}}$$

Temperature Scale T(K) = T(°C) + 273.15

First Law of Thermodynamics: $\Delta E = Q + W = Q - W_S$

W = Work done by environment

W_s = Work done by system

Ideal Gas Equations: $PV = nRT$ and $E = \left(\frac{3}{2}, \frac{5}{2}, or\ \frac{6}{2}\right) nRT$

Specific Heat: $C_V = \left(\frac{3}{2}, \frac{5}{2}, \text{ or } \frac{6}{2}\right) R$

Adiabatic Index: $\gamma = \frac{C_P}{C_V}$

Elementary Thermodynamic Processes

Process	Constants During Process	Change of Energy ΔE	Heat Given to System Q	Work Done by System $dW_s = PdV$	Change of Entropy dS = dQ/T
1. Isochoric dV = 0	P/T	$nC_V\,\Delta T$	$nC_V\,\Delta T$	0	$nC_V \ln\left(\frac{T_f}{T_i}\right)$
2. Isobaric dP = 0	V/T	$nC_V\,\Delta T$	$nC_P\,\Delta T$ $= n(C_V + R)\,\Delta T$	$P\,\Delta V$ $= nR\,\Delta T$	$nC_P \ln\left(\frac{T_f}{T_i}\right)$
3. Isothermal dT = 0	PV	0	$nRT \ln\left(\frac{V_f}{V_i}\right)$	$nRT \ln\left(\frac{V_f}{V_i}\right)$	$nR \ln\left(\frac{V_f}{V_i}\right)$
4. Adiabatic Q = 0 (Isentropic)	PV^{γ} $TV^{\gamma-1}$ $T^{\gamma}P^{1-\gamma}$	$nC_V\,\Delta T$	0	$\frac{C_V}{R}\Delta(PV)$ $= -nC_V\Delta T$	0

Efficiency of a Heat Engine:

$$\eta = \frac{W_S}{Q_H} = 1 - \frac{|Q_C|}{Q_H} \quad \rightarrow \quad 1 - \frac{T_C}{T_H} \quad (Carnot)$$

Heat Transfer:

$$I = \frac{\Delta Q}{\Delta x} = kA\frac{\Delta T}{\Delta x} \qquad I = e\sigma AT^4$$