

Formula Sheet

Acceleration and velocity:

$$\vec{v} = \lim_{\Delta t \rightarrow 0} \frac{\Delta \vec{r}}{\Delta t}$$
$$\vec{a} = \lim_{\Delta t \rightarrow 0} \frac{\Delta \vec{v}}{\Delta t}$$

Constant acceleration:

$$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$\Delta v = a \Delta t$$

$$v_f^2 = v_i^2 + 2a \Delta x$$

Relative velocity:

$$\vec{v}_{AC} = \vec{v}_{AB} + \vec{v}_{BC}.$$

Newton's laws:

$$\vec{F}_{\text{net}} = m \vec{a}$$

$$\vec{F}_{AB} = -\vec{F}_{BA}$$

Friction and springs:

$$f_k = \mu_k N$$

$$f_{s,\text{max}} = \mu_s N$$

$$F_{\text{spring}} = -k \Delta x$$

Circular motion:

$$a_{\text{in}} = \frac{v^2}{r}$$

Work-energy:

$$W_{i \rightarrow f} = F_{\parallel} \Delta s$$

$$E_f - E_i = W_{\text{non-conservative}, i \rightarrow f}$$

$$E = K + U_{\text{grav}} + U_{\text{spring}}$$

$$K = \frac{1}{2} m v^2$$

$$U_{\text{grav}} = mgh$$

$$U_{\text{spring}} = \frac{1}{2} k (\Delta x)^2$$

$$K_{\text{rot about cm}} = \frac{1}{2} I_{\text{cm}} \omega^2$$

Center of mass, moment of inertia:

$$\begin{aligned}\vec{r}_{\text{cm}} &= \frac{1}{M} (m_1 \vec{r}_1 + m_2 \vec{r}_2 + \dots), & M &= m_1 + m_2 + \dots \\ \vec{F}_{\text{tot}} &= M \vec{a}_{\text{cm}}, \\ I &= m_1 r_1^2 + m_2 r_2^2 + \dots\end{aligned}$$

Rotational Dynamics

$$\begin{aligned}\tau &= r F_{\perp} = r_{\perp} F \\ \tau_{\text{net}} &= I \alpha.\end{aligned}$$

Angular momentum:

$$\begin{aligned}\vec{L} &= \vec{r} \times \vec{p} \\ L_{\text{symmetry axis}} &= I \omega \\ \vec{\tau} &= \vec{r} \times \vec{F}, \\ \frac{d\vec{L}}{dt} &= \vec{\tau}_{\text{tot}}\end{aligned}$$

Newton's law of gravity:

$$\begin{aligned}F_{\text{grav}} &= \frac{G m_1 m_2}{r^2} \\ V_{\text{grav}} &= -\frac{G m_1 m_2}{r}\end{aligned}$$

Special Relativity:

$$\begin{aligned}L' &= \frac{L}{\gamma}, & \gamma &= \frac{1}{\sqrt{1 - v^2/c^2}}, \\ T' &= \gamma T, \\ x' &= \gamma(x - vt), & t' &= \gamma(t - vx/c^2).\end{aligned}\tag{0.1}$$