**Formula Sheet**

Acceleration and velocity:

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

Constant acceleration:

$$\Delta x = v_{ix}\Delta t + \tfrac{1}{2}a_x(\Delta t)^2$$
$$v_x = v_{ix} + a_x \Delta t$$
$$v_{fx}^2 = v_{ix}^2 + 2a_x \Delta x$$

Newton's second law:

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

Friction:

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

Circular motion:

$$\omega = \lim_{\Delta t \to 0} \frac{\Delta \theta}{\Delta t},$$
$$\alpha = \lim_{\Delta t \to 0} \frac{\Delta \omega}{\Delta t},$$
$$a_{\text{in}} = \frac{v^2}{r}$$

Newton's third law:

$$\vec{F}_{\text{A on B}} = -\vec{F}_{\text{B on A}}$$

Momentum:

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

Work-energy:

$$
\begin{aligned}
W_{A\to B} &= \int_{s_A}^{s_B} ds\, F_s \\
E_B - E_A &= W_{\text{non-conservative},A\to B} \\
E &= K + U_{\text{grav}} + U_{\text{spring}} \\
K &= \tfrac{1}{2}mv^2 \\
U_{\text{grav}} &= mgh \quad \text{(near earth's surface)} \\
U_{\text{spring}} &= \tfrac{1}{2}k(\Delta s)^2
\end{aligned}
$$

Newton's law of gravity:

$$
\begin{aligned}
F_{\text{grav 1 on 2}} &= \frac{Gm_1m_2}{r_{12}^2} \\
U_{\text{grav}} &= -\frac{Gm_1m_2}{r_{12}}
\end{aligned}
$$

Rotation about a fixed axis:

$$
\begin{aligned}
\tau &= I\alpha \\
\tau &= rF_\perp = \text{torque} \\
I &= \sum_i m_i r_i^2 = \text{moment of inertia} \\
K_{\text{rot}} &= \tfrac{1}{2}I\omega^2 = \text{rotational kinetic energy} \\
L &= I\omega = \text{angular momentum}
\end{aligned}
$$