Formula Sheet

Velocity and acceleration:

$$\vec{v} = \frac{d\vec{x}}{dt} \qquad \vec{a} = \frac{d\vec{v}}{dt}$$

Constant acceleration:

$$\vec{v} = \vec{v}_0 + \vec{a}t$$
$$\vec{x} = \vec{x}_0 + \vec{v}_0 t + \tfrac{1}{2}\vec{a}t^2$$
$$v^2 = v_0^2 + 2a(x - x_0)$$

Center of mass:

$$\vec{r}_{\rm cm} = \frac{1}{m_{\rm tot}}(m_1\vec{r}_1 + \cdots + m_N\vec{r}_N) \qquad m_{\rm tot} = m_1 + \cdots + m_N$$

Newton's laws:

$$\vec{p} = m\vec{v},$$
$$N2: \ \vec{F}_{\rm tot} = \frac{d\vec{p}_{\rm tot}}{dt} = m\vec{a}_{\rm cm}$$
$$N3: \ \vec{F}_{12} = -\vec{F}_{21}$$

Friction:

$$f_k = \mu_k N \qquad f_{s,\max} = \mu_s N$$

Springs:

$$F_{\rm spring} = -kx$$

Circular motion:

$$a_{\rm in} = \frac{v^2}{R}$$

Work and energy:

$$W_{i\to f}^{(\rm tot)} = K_f - K_i$$
$$W_{i\to f} = \sum \vec{F}\cdot\Delta\vec{r}$$
$$K = \tfrac{1}{2}mv^2$$
$$U^{(\rm grav)} = mgh$$
$$U^{(\rm spring)} = \tfrac{1}{2}kx^2$$

Rotation about a fixed axis:

$$\omega = \frac{d\theta}{dt} \qquad \alpha = \frac{d\omega}{dt}$$
$$v = \omega r$$
$$N2: \quad \tau = I\alpha$$
$$\tau = F_\perp r = F r_\perp$$
$$I = \sum_i m_i r_i^2$$
$$K_{\text{rot}} = \tfrac{1}{2} I \omega^2$$
$$L = I\omega$$

General rotations:

$$N2: \quad \vec{\tau} = \frac{d\vec{L}}{dt}$$
$$\vec{\tau} = \vec{r} \times \vec{F}$$
$$\vec{L} = \vec{r} \times \vec{p}$$

Gravitation:

$$F_{\text{grav}} = \frac{G m_1 m_2}{r_{12}^2}$$
$$U_{\text{grav}} = -\frac{G m_1 m_2}{r_{12}}$$