Formula sheet

Math & numbers:

$$g = 9.81\,\mathrm{m/s^2}$$
$$ax^2 + bx^2 + c = 0 \Longrightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$
$$|\vec{F}\,| = \sqrt{F_x^2 + F_y^2} \quad \text{magnitude}$$
$$\theta = \tan^{-1}\left[\frac{F_y}{F_x}\right] \quad \text{direction}$$

Rotation: we use radians

$$s = \theta r \quad \leftarrow \text{arclength}$$
$$\omega = \frac{d\theta}{dt} = \frac{v}{r} \qquad \alpha = \frac{d\omega}{dt}$$
$$a_t = \alpha r \quad \text{tangential} \qquad a_r = \frac{v^2}{r} = \omega^2 r \quad \text{radial}$$
$$I = \sum_i m_i r_i^2 \Rightarrow \int r^2\,dm = kmr^2$$
$$I_z = I_{com} + md^2 \quad \text{axis } z \text{ parallel, dist } d$$
$$\tau_{net} = \sum \vec{\tau} = I\vec{\alpha} = \frac{d\vec{L}}{dt}$$
$$\vec{\tau} = \vec{r} \times \vec{F} \qquad |\vec{\tau}\,| = rF\sin\theta_{rF}$$
$$\vec{L} = \vec{r} \times \vec{p} = I\vec{\omega}$$
$$K = \frac{1}{2}I\omega^2 = L^2/2I$$
$$\Delta K = \frac{1}{2}I\omega_f^2 - \frac{1}{2}I\omega_i^2 = W = \int \tau\,d\theta$$
$$P = \frac{dW}{dt} = \tau\omega$$

1-D motion:

$$v(t) = \frac{\mathrm{d}}{\mathrm{d}t}x(t)$$
$$a(t) = \frac{\mathrm{d}}{\mathrm{d}t}v(t) = \frac{\mathrm{d}^2}{\mathrm{d}t^2}x(t)$$

const. acc.

$$x_f = x_i + v_{xi}t + \frac{1}{2}a_x t^2$$
$$v_{xf}^2 = v_{xi}^2 + 2a_x\Delta x$$
$$v_f = v_i + at$$

2-D motion:

$$\vec{r} = x(t)\,\hat{\imath} + y(t)\,\hat{\jmath}$$
$$x(t) = x_i + v_{ix}t + \frac{1}{2}a_x t^2$$
$$y(t) = y_i + v_{iy}t + \frac{1}{2}a_y t^2$$
$$v_x(t) = \frac{dx}{dt} = v_{xi} + a_x t$$
$$v_y(t) = \frac{dy}{dt} = v_{yi} + a_y t$$
$$a_c = \frac{v^2}{r} \quad \text{circular}$$

Force:

$$\Sigma\vec{F} = \vec{F}_{\text{net}} = m\vec{a}$$
$$\Sigma F_x = ma_x$$
$$\Sigma F_y = ma_y$$
$$F_{\text{grav}} = mg = \text{weight}$$
$$\vec{F}_{12} = -\vec{F}_{21}$$
$$f_s \le \mu_s n$$
$$f_{s,\text{max}} = \mu_s n$$
$$f_k = \mu_k n$$
$$|\vec{F}_{\text{drag}}| = -\frac{1}{2}C\rho A v^2$$
$$\vec{F}_c = -\frac{mv^2}{r}\,\hat{\boldsymbol{r}} \quad \text{circular}$$

Work-Energy-Potential:

$$K = \frac{1}{2}mv^2 = \frac{p^2}{2m}$$
$$\Delta K = K_f - K_i = W$$
$$W = \int F(x)\,dx = -\Delta U$$
$$U_g(y) = mgy$$
$$U_s(x) = \frac{1}{2}kx^2$$
$$F = -\frac{dU(x)}{dx}$$
$$K_i + U_i = K_f + U_f + W_{\text{ext}} = K_f + U_f + \int F_{\text{ext}}\,dx$$

Momentum, etc.:

$$x_{\text{com}} = \frac{1}{M_{\text{tot}}}\sum_{i=1}^{n} m_i x_i = \frac{m_1x_1 + m_2x_2 + \ldots m_nx_n}{m_1 + m_2 + \ldots m_n}$$
$$v_{\text{com}} = \frac{1}{M_{\text{tot}}}\sum_{i=1}^{n} m_i v_i = \frac{m_1v_1 + m_2v_2 + \ldots m_nv_n}{m_1 + m_2 + \ldots m_n}$$
$$F_{\text{net}} = M_{\text{tot}}a_{\text{com}} = \frac{dp}{dt}$$
$$p_{\text{tot}} = M_{\text{tot}}v_{\text{com}}$$
$$\Delta p = p_f - p_i = J = \int_{t_i}^{t_f} F(t)\,dt = F_{\text{avg}}\Delta t$$
$$\Delta p = 0 \quad \text{closed}$$
$$\sum_i m_i v_i = \sum_f m_f v_f$$

Isolated systems: $\vec{p}$, $E = K + PE$, L are all conserved.
Static equilibrium: $\sum F = 0$ and $\sum \tau = 0$ about any axis.
Elastic collision: KE and p are both conserved.
Inelastic collision: only p is conserved, not KE.

Derived unit	Symbol	equivalent to
newton	N	$\mathrm{kg{\cdot}m/s^2}$
joule	J	$\mathrm{kg{\cdot}m^2/s^2} = \mathrm{N{\cdot}m}$
watt	W	$\mathrm{J/s} = \mathrm{m^2{\cdot}kg/s^3}$