Formula sheet

basics

$$g = |\vec{a}_{\text{free fall}}| = 9.81\,\text{m/s}^2 \quad \text{near earth's surface}$$

$$\text{sphere} \quad V = \frac{4}{3}\pi r^3$$

$$ax^2 + bx^2 + c = 0 \Longrightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\frac{d}{dx}\sin ax = a\cos ax \qquad \frac{d}{dx}\cos ax = -a\sin ax$$

$$\int \cos ax\,\text{dx} = \frac{1}{a}\sin ax \qquad \int \sin ax\,\text{dx} = -\frac{1}{a}\cos ax$$

$$\vec{A} = \vec{A}_x + \vec{A}_y = A_x\,\hat{\imath} + A_y\,\hat{\jmath}$$

$$\vec{A}\cdot\vec{B} = AB\cos\phi = A_xB_x + A_yB_y$$

$$|\vec{F}| = \sqrt{F_x^2 + F_y^2} \quad \text{magnitude}$$

$$\theta = \tan^{-1}\left[\frac{F_y}{F_x}\right] \quad \text{direction}$$

1D & 2D motion

$$\Delta\vec{r} = \vec{r}_f - \vec{r}_i$$

$$\text{speed} = v = |\vec{v}| \quad \vec{v}_{av} \equiv \frac{\Delta\vec{r}}{\Delta t} \quad \vec{v} = \lim_{\Delta t\to 0}\frac{\Delta\vec{r}}{\Delta t} \equiv \frac{d\vec{r}}{dt}$$

$$a_{x,av} \equiv \frac{\Delta v_x}{dt} \quad a_x = \lim_{\Delta t\to 0}\frac{\Delta v_x}{\Delta t} \equiv \frac{dv_x}{dt} = \frac{d}{dt}\left(\frac{dx}{dt}\right) = \frac{d^2x}{dt^2}$$

$$x_f = x_i + v_{x,i}\Delta t + \frac{1}{2}a_x(\Delta t)^2$$

$$v_{x,f} = v_{x,i} + a_x\Delta t$$

$$x(t) = x_i + v_{x,i}t + \frac{1}{2}a_xt^2$$

$$v_x(t) = v_{x,i} + a_xt$$

$$v_{x,f}^2 = v_{x,i}^2 + 2a_x\Delta x$$

$\downarrow$ launched from origin, level ground

$$y(x) = (\tan\theta_o)\,x - \frac{gx^2}{2v_o^2\cos^2\theta_o}$$

$$\text{max height} \;= H = \frac{v_i^2\sin^2\theta_i}{2g}$$

$$\text{Range} \;= R = \frac{v_i^2\sin 2\theta_i}{g}$$

momentum

$$\Delta\vec{p} = \vec{0} \quad \vec{p}_f = \vec{p}_i \quad \text{isolated system} \qquad \vec{p} = m\vec{v} \qquad \vec{J} = \Delta\vec{p}$$

$$v_{1f} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)v_{i1} + \left(\frac{2m_2}{m_1 + m_2}\right)v_{2i} \quad \text{1D elastic}$$

$$v_{2f} = \left(\frac{2m_1}{m_1 + m_2}\right)v_{1i} + \left(\frac{m_2 - m_1}{m_1 + m_2}\right)v_{2i} \quad \text{1D elastic}$$

$$\vec{v}_{12} = \vec{v}_2 - \vec{v}_1 \quad \text{relative velocity}$$

$$v_{12} = |\vec{v}_2 - \vec{v}_1| \quad \text{relative speed}$$

interactions

$$\Delta U^G = mg\Delta x \qquad \frac{a_{1x}}{a_{2x}} = -\frac{m_2}{m_1}$$

$$E_{\text{mech}} = K + U \quad K = \frac{1}{2}mv^2$$

$$\Delta E_{\text{mech}} = \Delta K + \Delta U = 0 \quad \text{non-dissipative, closed}$$

force

$$\vec{a} = \frac{\sum\vec{F}}{m} \qquad a_{\vec{cm}} = \frac{\sum\vec{F}_{\text{ext}}}{m} \qquad \sum\vec{F} \equiv \frac{d\vec{p}}{dt} \qquad \vec{F}_{12} \quad = -\vec{F}_{21}$$

$$\vec{J} = \left(\sum\vec{F}\right)\Delta t \quad \text{constant force}$$

$$\vec{J} = \int_{t_i}^{t_f}\sum\vec{F}(t)\,dt \quad \text{time-varying force}$$

$$F_{\text{so},x} = -k(x - x_o) \quad \text{small displacement}$$

work

$$\Delta E_{\text{mech}} = \Delta K + \Delta U = W \quad \leftarrow \text{not closed} \qquad \Delta U_{\text{spring}} = \frac{1}{2}k\,(x - x_o)^2$$

$$P = \frac{dE}{dt} \quad P = F_{\text{ext,x}}\,v_x \quad \text{one dimension}$$

$$W = \left(\sum\vec{F}\right)\Delta x_F \quad \text{constant foce 1D}$$

$$W = \sum_n\left(F_{\text{ext,x}}\,\Delta x_{Fn}\right) \quad \text{const nondiss., many particles, 1D}$$

$$W = \int_{x_i}^{x_f}F_x(x)\,dx \quad \text{nondiss. force, 1D}$$

$$(F_{12}^s)_{\max} = \mu_sF_{12}^n \quad \text{static} \qquad F_{12}^k = \mu_kF_{12}^n \quad \text{kinetic}$$

$$W = \vec{F}\cdot\Delta\vec{r}_F \quad \text{const non-diss force}$$

$$W = \int_{\vec{r}_i}^{\vec{r}_f}\vec{F}(\vec{r})\cdot d\vec{r} \quad \text{variable nondiss force}$$

sundry bits

Power	Prefix	Abbreviation
10^{-9}	nano	n
10^{-6}	micro	µ
10^{-3}	milli	m
10^{-2}	centi	c
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G

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