103 PHYS Formula Sheet

Motion in One Dimension

$$average\ speed \equiv \frac{total\ distance}{total\ time}$$

$$\Delta x \equiv x_f - x_i$$

$$\bar{v}_x \equiv \frac{\Delta x}{\Delta t}$$

$$v_x \equiv \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

$$\bar{a}_x \equiv \frac{\Delta v_x}{\Delta t}$$

$$a_x \equiv \lim_{\Delta t \to 0} \frac{\Delta v_x}{\Delta t} = \frac{dv_x}{dt}$$

$$v_{xf} = v_{xi} + a_x t$$

$$x_f - x_i = v_{xi} t + \tfrac{1}{2} a_x t^2$$

$$x_f - x_i = \bar{v}_x t = \tfrac{1}{2}(v_{xi} + v_{xf}) t$$

$$v_{xf}^{\ 2} = v_{xi}^{\ 2} + 2a_x (x_f - x_i)$$

Vectors

$$A_x = A\cos q$$

$$A_y = A\sin q$$

$$\vec{A} = A_x \hat{i} + A_y \hat{j}$$

$$A = \sqrt{A_x^2 + A_y^2}$$

$$q = \tan^{-1}\left(\frac{A_y}{A_x}\right)$$

Motion in Two Dimensions

$$\vec{r} = x\hat{i} + y\hat{j}$$

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

$$\vec{v}_{avg} \equiv \frac{\Delta\vec{r}}{\Delta t}$$

$$\vec{v} \equiv \lim_{\Delta t \to 0} \frac{\Delta\vec{r}}{\Delta t} = \frac{d\vec{r}}{dt}$$

$$\vec{v} = \frac{dx}{dt}\hat{i} + \frac{dy}{dt}\hat{j}$$

$$\vec{a}_{avg} \equiv \frac{\Delta\vec{v}}{\Delta t}$$

$$\vec{a} \equiv \lim_{\Delta t \to 0} \frac{\Delta\vec{v}}{\Delta t} = \frac{d\vec{v}}{dt}$$

$$\vec{v}_f = \vec{v}_i + \vec{a}t$$

$$\vec{r}_f = \vec{r}_i + \vec{v}_i t + \tfrac{1}{2}\vec{a}t^2$$

$$y = (\tan q_i)x - \left(\frac{g}{2v_i^2 \cos^2 q_i}\right)x^2$$

$$h = \frac{v_i^2 \sin^2 q_i}{2g} \qquad R = \frac{v_i^2 \sin 2q_i}{g}$$

$$a_r = \frac{v^2}{r}, \quad a_t = \frac{dv}{dt}$$

$$\vec{a} = \frac{d|\vec{v}|}{dt}\hat{q} - \frac{v^2}{r}\hat{r}$$

$$\vec{v}' = \vec{v} - \vec{v}_0$$

$$\vec{a}' = \vec{a}$$

The Laws of Motion

$$\sum \vec{F} = m\vec{a}$$

$$\vec{F}_{12} = -\vec{F}_{21}$$

$$\vec{F}_g = m\vec{g}$$

$$f_k = m_k n$$

$$f_s \le m_s n$$

$$F_{spring} = -kx$$

Circular Motion

$$\sum F_r = ma_r = \frac{mv^2}{r}$$

Work and Kinetic Energy

$$W \equiv Fd\cos q$$

$$\vec{A}\cdot\vec{B} \equiv AB\cos q = A_x B_x + A_y B_y + A_z B_z$$

$$W = \int_{x_i}^{x_f} F_x dx$$

$$K \equiv \tfrac{1}{2}mv^2$$

$$\sum W = \Delta K$$

$$K_i + \sum W_{other} - f_k d = K_f$$

$$\bar{\mathbf{P}} \equiv \frac{W}{\Delta t}$$

$$\mathbf{P} \equiv \lim_{\Delta t \to 0} \frac{W}{\Delta t} = \frac{dW}{dt} = \vec{F}\cdot\vec{v}$$

Potential Energy and Energy Conservation

$$\Delta U = U_f - U_i \equiv -\int_{x_i}^{x_f} F_x dx$$

$$U_g = mgy$$

$$U_s = \tfrac{1}{2}kx^2$$

$$E \equiv K + U$$

$$K_i + \sum U_i = K_f + \sum U_f$$

$$W_{app} = \Delta K + \Delta U$$

$$F_x = -\frac{dU}{dx}$$

Linear Momentum and Collisions

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

$$\vec{p}_{1i} + \vec{p}_{2i} = \vec{p}_{1f} + \vec{p}_{2f}$$

$$\vec{I} \equiv \int_{t_i}^{t_f} \vec{F}dt = \Delta\vec{p}$$

$$\vec{F}_{avg} = \frac{\vec{I}}{\Delta t} = \frac{\Delta\vec{p}}{\Delta t}$$

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

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

Rotation About a Fixed Axis

$$s = rq$$

$$\bar{w} \equiv \frac{\Delta q}{\Delta t}$$

$$w \equiv \lim_{\Delta t \to 0} \frac{\Delta q}{\Delta t} = \frac{dq}{dt}$$

$$v = w r$$

$$\bar{a} \equiv \frac{\Delta w}{\Delta t}$$

$$a \equiv \lim_{\Delta t \to 0} \frac{\Delta w}{\Delta t} = \frac{dw}{dt}$$

$$a_t = \frac{dv}{dt} = r a$$

$$a_r = \frac{v^2}{r} = w^2 r$$

$$w_f = w_i + a t$$

$$q_f = q_i + w_i t + \tfrac{1}{2} a t^2$$

$$q_f = q_i + \tfrac{1}{2}(w_i + w_f) t$$

$$w_f^{\,2} = w_i^{\,2} + 2a(q_f - q_i)$$

$$I = \sum m_i r_i^2$$

$$I = I_{CM} + MD^2$$

$$K_R = \tfrac{1}{2} I w^2$$

$$t \equiv rF \sin f = Fd$$

$$\sum t_{ext} = I a$$

$$\mathbf{P} = t w$$

$$\sum W = \tfrac{1}{2} I w_f^{\,2} - \tfrac{1}{2} I w_i^{\,2}$$

Rolling Motion
Momentum

$$K = \tfrac{1}{2} I_{CM} w^2 + \tfrac{1}{2} M v_{CM}^{\,2}$$

$$v_{CM} = R w$$

$$\vec{a} \equiv \frac{d\vec{w}}{dt}$$

$$\vec{t} \equiv \vec{r} \times \vec{F}$$

Static Equilibrium

$$\sum \vec{F} = 0$$

$$\sum \vec{t} = 0$$