

Equations

$$\rho = M/V$$

$$\mathbf{v}_{xf} = \mathbf{v}_{xi} + \mathbf{a}_x(t_f - t_i)$$

$$x_f = x_i + \frac{1}{2}(\mathbf{v}_{xi} + \mathbf{v}_{xf})(t_f - t_i)$$

$$x_f = x_i + \mathbf{v}_{xi}(t_f - t_i) + \frac{1}{2}\mathbf{a}_x(t_f - t_i)^2$$

$$\mathbf{v}_{xf}^2 = \mathbf{v}_{xi}^2 + 2\mathbf{a}_x(x_f - x_i)$$

$$\mathbf{v}_{yf} = \mathbf{v}_{yi} + \mathbf{a}_y(t_f - t_i)$$

$$y_f = y_i + \frac{1}{2}(\mathbf{v}_{yi} + \mathbf{v}_{yf})(t_f - t_i)$$

$$y_f = y_i + \mathbf{v}_{yi}(t_f - t_i) + \frac{1}{2}\mathbf{a}_y(t_f - t_i)^2$$

$$\mathbf{v}_{yf}^2 = \mathbf{v}_{yi}^2 + 2\mathbf{a}_y(y_f - y_i)$$

$$\cos\theta = x/h$$

$$\sin\theta = y/h$$

$$\tan\theta = y/x$$

$$h = \sqrt{x^2 + y^2}$$

$$\Delta x = x_f - x_i$$

$$\mathbf{v}_{x,avg} = \frac{x_f - x_i}{t_f - t_i}$$

$$\mathbf{a}_{avg} = \frac{\mathbf{v}_f - \mathbf{v}_i}{t_f - t_i}$$

$$\mathbf{v}_x = \lim_{\Delta t \rightarrow 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

$$\mathbf{a}_x = \lim_{\Delta t \rightarrow 0} \frac{\Delta \mathbf{v}_x}{\Delta t} = \frac{d\mathbf{v}_x}{dt}$$

$$az^2 + bz + c = 0 \quad z = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

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

$$|F_G| = \frac{Gm_1m_2}{r^2} = mg$$

$$f_S^{\max} = \mu_S n$$

$$f_k = \mu_k n$$

$$a_r = v^2 / r$$

$$T = 2\pi r / v = 2\pi r^{3/2} / \sqrt{GM}$$

$$s = r\theta$$

$$\omega_{avg} = \frac{\theta_f - \theta_i}{t_f - t_i}$$

$$\omega = \lim_{\Delta t \rightarrow 0} \frac{\Delta \theta}{\Delta t} = \frac{d\theta}{dt}$$

$$\alpha_{avg} = \frac{\omega_f - \omega_i}{t_f - t_i}$$

$$\alpha = \lim_{\Delta t \rightarrow 0} \frac{\Delta \omega}{\Delta t} = \frac{d\omega}{dt}$$

$$T = \frac{2\pi}{\omega}$$

$$\mathbf{v}_t = r\omega$$

$$\mathbf{a}_t = r\alpha$$

$$\vec{\mathbf{v}}' = \vec{\mathbf{v}} - \vec{\mathbf{v}}_o$$

$$\vec{\mathbf{r}}' = \vec{\mathbf{r}} - \vec{\mathbf{v}}_o t$$

$$\theta_f = \theta_i + \frac{1}{2}(\omega_i + \omega_f)(t_f - t_i)$$

$$\theta_f = \theta_i + \omega_i(t_f - t_i) + \frac{1}{2}\alpha(t_f - t_i)^2$$

$$\omega_f = \omega_i + \alpha(t_f - t_i)$$

$$\omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i)$$

$$g = 9.80 \text{ m/s}^2 = 32.2 \text{ ft/s}^2$$

$$k_b = 1.38 \times 10^{-23} \text{ J/K}$$

$$G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$$

$$\vec{p} = m\vec{v} \quad \vec{J} = \vec{F}_{avg} \Delta t \quad \vec{J} = \int_{t_i}^{t_f} \vec{F} dt = \vec{p}_f - \vec{p}_i$$

$$x_{cm} = \frac{\sum m_i x_i}{\sum m_i} \quad \vec{v}_{cm} = \frac{\sum m_i \vec{v}_i}{\sum m_i} \quad \sum \vec{F}_{ext} = \frac{d\vec{p}}{dt}$$

$$K = \frac{1}{2} m v^2 \quad W = F \cos \phi s = K_f - K_i \quad \int x^n dx = x^{n+1} / (n+1), \text{ for } n \neq -1$$

$$W = \int_{s_i}^{s_f} \vec{F} \cdot d\vec{s} = -\Delta U \quad \vec{A} \cdot \vec{B} = A_x B_x + A_y B_y + A_z B_z = AB \cos \phi$$

$$U_g = mgy \quad E = K + U \quad F_s = -kx \quad F_x = -\frac{dU}{dx}$$

$$P_{avg} = W / \Delta t \quad P = dW / dt \quad W_{NC} = E_f - E_i$$

$$v_{1f} = \frac{m_1 - m_2}{m_1 + m_2} v_{1i} \quad v_{2f} = \frac{2m_1}{m_1 + m_2} v_{1i}$$

$$U_s = \frac{1}{2} kx^2 \quad P = \vec{F} \cdot \vec{v} \quad \tau = rF \sin \phi \quad \sum \tau = I\alpha$$

$$I = \sum m_i r_i^2 = \int r^2 dm \quad I = I_{CM} + MD^2 \quad \lambda = M / L$$

$$x_{cm} = \frac{1}{M} \int x dm \quad K_R = \frac{1}{2} I \omega^2 \quad L = I\omega \quad W_R = \tau\theta$$

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

$$\text{For } \vec{C} = \vec{A} \times \vec{B} \quad C = AB \sin \phi \quad \vec{A} \times \vec{B} = -\vec{B} \times \vec{A}$$

$$\vec{A} \times \vec{B} =$$

$$(A_y B_z - A_z B_y) \hat{i} - (A_x B_z - A_z B_x) \hat{j} + (A_x B_y - A_y B_x) \hat{k}$$

Moments of inertia about axes through the center of mass:

$$I_{hoop} = MR^2 \quad I_{disk} = \frac{1}{2} MR^2 \quad I_{rod} = \frac{1}{12} ML^2$$

$$I_{hollow sphere} = \frac{2}{3} MR^2 \quad I_{solid sphere} = \frac{2}{5} MR^2$$

$$x = A \cos(\omega t + \phi_0) \quad \omega = 2\pi f \quad f = 1/T$$

$$v = -A\omega \sin(\omega t + \phi_0) \quad a = -A\omega^2 \cos(\omega t + \phi_0)$$

$$\omega = \sqrt{k/m} \quad \omega = \sqrt{g/L} \quad T = \frac{2\pi}{\omega} = 2\pi \sqrt{I/MgL}$$

$$U_g = -\frac{Gm_1 m_2}{r} \quad v = \lambda/T \quad v = \sqrt{\gamma k_B T/m} \quad y(x, t) = A \sin(kx \pm \omega t + \phi_0)$$

$$k = 2\pi / \lambda \quad n = c/v \quad f_o = f_s \left(1 \pm \frac{v_o}{v} \right) / \left(1 \mp \frac{v_s}{v} \right)$$