The Equations

1-D Kinematics → Simple Harmonic Motion

$$\Delta x = x - x_0$$
$$\bar{v} = \frac{x - x_0}{t}$$
$$a = \frac{v - v_0}{t}$$
$$\bar{v} = \frac{v_0 + v}{2}$$

$$v = v_0 + at$$
$$\Delta x = vt - \tfrac{1}{2}at^2$$
$$\Delta x = v_0 t + \tfrac{1}{2}at^2$$
$$\Delta x = \tfrac{1}{2}(v + v_0)t$$
$$v^2 = v_0^2 + 2a\Delta x$$
$$\Delta x = v_{0x}t$$

$$v_y = v_{0y} - gt$$
$$\Delta y = v_{0y}t - \tfrac{1}{2}gt^2$$
$$v_y{}^2 = v_{0y}^2 - 2g\Delta y$$
$$\Delta y = v_y t + \tfrac{1}{2}gt^2$$
$$y = \tan\theta x - \frac{g}{2v_0^2\cos^2\theta}x^2$$

$$\Sigma F = ma$$
$$G = mg$$
$$f = \mu_{s,k}N$$

$$F = -G\frac{m_1 m_2}{r^2}$$
$$a_R = \frac{v^2}{r}$$
$$ma_R = m\frac{v^2}{r}$$

$$f = \frac{1}{T}$$
$$v = \frac{2\pi r}{T}$$
$$v = 2\pi rf$$

$$F = k\frac{q_1 q_2}{r^2}$$
$$P = \frac{F}{A}$$

$$W = Fd\cos\phi$$
$$W = -\Delta U$$
$$F_s = -kx$$
$$P_{avg} = \frac{W}{\Delta t} = F\bar{v}$$

$$W = \Delta K$$
$$K = \tfrac{1}{2}mv^2$$
$$U_G = mgh$$
$$U_S = \tfrac{1}{2}kx^2$$

$$\Sigma E_0 = \Sigma E_1$$
$$K_0 + U_{S0} + U_{G0} = K_1 + U_{S1} + U_{G1}$$
$$W_{\text{NC}} = \Delta K + \Delta U$$

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$$\vec{\mathbf{p}} = m\vec{\mathbf{v}}$$
$$\Sigma\vec{\mathbf{F}} = \frac{\Delta\vec{\mathbf{p}}}{\Delta t}$$
$$\vec{\mathbf{F}}\Delta t = \Delta\vec{\mathbf{p}}$$
$$e = \frac{v_{\text{B}}' - v_{\text{A}}'}{v_{\text{A}} - v_{\text{B}}} = \sqrt{\frac{h'}{h}}$$

$$m_{\text{A}}\vec{\mathbf{v}}_{\text{A}} + m_{\text{B}}\vec{\mathbf{v}}_{\text{B}} = m_{\text{A}}\vec{\mathbf{v}}_{\text{A}}' + m_{\text{B}}\vec{\mathbf{v}}_{\text{B}}'$$
$$\tfrac{1}{2}m_{\text{A}}v_{\text{A}}^2 + \tfrac{1}{2}m_{\text{B}}v_{\text{B}}^2 = \tfrac{1}{2}m_{\text{A}}v_{\text{A}}'^2 + \tfrac{1}{2}m_{\text{B}}v_{\text{B}}'^2$$
$$x_{\text{CM}} = \frac{m_{\text{A}}x_{\text{A}} + m_{\text{B}}x_{\text{B}} + \cdots}{m_{\text{A}} + m_{\text{B}} + \cdots}$$

$$l = r\theta$$
$$\bar{\omega} = \frac{\Delta\theta}{\Delta t}$$
$$\bar{\alpha} = \frac{\Delta\omega}{\Delta t}$$
$$T = 1/f$$

$$v = r\omega$$
$$a = r\alpha$$
$$a_{\text{R}} = \omega^2 r$$
$$f = \frac{\omega}{2\pi}$$

$$\omega = \omega_0 + \alpha t$$
$$\Delta\theta = \omega_0 t + \tfrac{1}{2}\alpha t^2$$
$$\Delta\theta = \omega t - \tfrac{1}{2}\alpha t^2$$
$$\Delta\theta = \tfrac{1}{2}(\omega + \omega_0)t$$
$$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$$

$$\tau = r \times F$$
$$\tau = mr^2\alpha$$
$$\sum\tau = \sum(mr^2)\alpha$$
$$I = \sum mr^2$$

$$\sum F_{equilibrium} = 0$$
$$\sum \tau_{equilibrium} = 0$$
$$W = \tau\Delta\omega$$
$$L = I\omega$$

$$K_{Rotational} = \tfrac{1}{2}I\omega^2$$
$$K = \tfrac{1}{2}mv_{\text{CM}}^2 + \tfrac{1}{2}I_{\text{CM}}\omega^2$$

$$F_S = -kx$$
$$U_S = \tfrac{1}{2}kx^2$$
$$E_{Tot} = \tfrac{1}{2}mv^2 + \tfrac{1}{2}kx^2 = \tfrac{1}{2}kA^2$$
$$v = \pm v_{\max}\sqrt{1 - \frac{x^2}{A^2}}$$

$$v_{\max} = 2\pi A/T = 2\pi Af = A\sqrt{k/m}$$
$$T = 2\pi\sqrt{m/k} = 2\pi\sqrt{L/g}$$
$$f = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$$
$$a_{\max} = Ak/m$$

$$x_{SHM} = A\cos(\omega t)$$
$$v_{SHM} = -v_{\max}\sin(2\pi ft)$$
$$a_{SHM} = -a_{\max}\cos(2\pi t/T)$$

$$F_{damping} = -bv$$
$$\Sigma F_{DHM} = ma = -kx - bv$$
$$x_{DHM} = Ae^{-(b/2m)t}\cos(\omega' t)$$
$$v_{DHM} = -\alpha Ae^{-\alpha t}\cos(\omega' t) - \omega' Ae^{-\alpha t}\sin(\omega' t)$$
$$a_{DHM} = \alpha^2 Ae^{-\alpha t}\cos(\omega' t) + 2\alpha\omega' Ae^{-\alpha t}\sin(\omega' t) - \alpha\omega'^2 Ae^{-\alpha t}\cos(\omega' t)$$

$$m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + kx = 0$$
$$\alpha = \frac{b}{2m}$$
$$\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$$

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$
$$v_{\sin usoidal} = \lambda f$$
$$v_{cord} = \sqrt{\frac{F_T L}{m}}$$
$$I = \frac{P}{A_{surface}}$$

$$E = \tfrac{1}{2}kA^2 = 2\pi^2 mf^2A^2$$
$$E = 2\pi^2\rho Svtf^2A^2$$
$$P = \frac{E}{t} = 2\pi^2\rho Svf^2A^2$$
$$I = \frac{P}{S} = 2\pi^2\rho vf^2A^2$$

$$L = \frac{n\lambda_n}{2}$$
$$\lambda_n = \frac{2L}{n}$$
$$f_n = nf_1$$

$$\frac{\sin\theta_2}{\sin\theta_1} = \frac{v_2}{v_1}$$
$$\theta \approx \frac{\lambda}{L}$$
$$y = A\sin\left(\frac{2\pi}{\lambda}x\right)$$

The Constants

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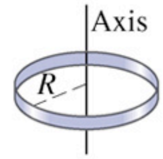
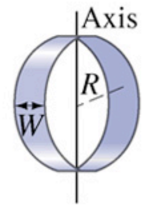
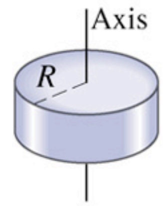
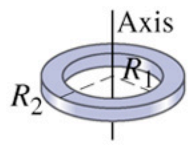
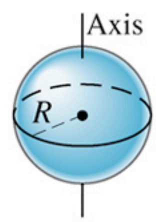
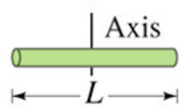
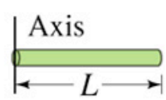
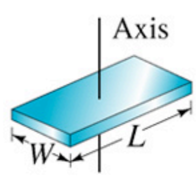
$$g_{Earth's\ Surface} = 9.802\ \text{m/s}^2$$

$$m_{Earth} = 5.98 \text{ x } 10^{24}\ \text{kg}$$
$$r_{Earth} = 6.38 \text{ x } 10^{6}\ \text{m}$$
$$d_{Earth-Moon} = 3.84 \text{ x } 10^{8}\ \text{m}$$
$$m_{Moon} = 7.35 \text{ x } 10^{22}\ \text{kg}$$
$$r_{Moon} = 1.74 \text{ x } 10^{6}\ \text{m}$$
$$d_{Earth-Sun} = 1.496 \text{ x } 10^{11}\ \text{m}$$
$$m_{Sun} = 1.99 \text{ x } 10^{30}\ \text{kg}$$
$$r_{Sun} = 6.96 \text{ x } 10^{8}\ \text{m}$$
$$G = 6.67 \text{ x } 10^{-11}\ \frac{N\bullet m^2}{kg^2}$$

$$k = 8.988 \text{ x } 10^{9}\ \frac{N\bullet m^2}{C^2}$$

Moments of Inertia

Rotational Motion

	Object	Location of axis		Moment of inertia
(a)	**Thin hoop,** radius R	Through center		MR^2
(b)	**Thin hoop,** radius R width W	Through central diameter		$\frac{1}{2}MR^2 + \frac{1}{12}MW^2$
(c)	**Solid cylinder,** radius R	Through center		$\frac{1}{2}MR^2$
(d)	**Hollow cylinder,** inner radius R_1 outer radius R_2	Through center		$\frac{1}{2}M(R_1^2 + R_2^2)$
(e)	**Uniform sphere,** radius R	Through center		$\frac{2}{5}MR^2$
(f)	**Long uniform rod,** length L	Through center		$\frac{1}{12}ML^2$
(g)	**Long uniform rod,** length L	Through end		$\frac{1}{3}ML^2$
(h)	**Rectangular thin plate,** length L, width W	Through center		$\frac{1}{12}M(L^2 + W^2)$