Fundamental Concepts and Principles

$$\vec{p} = m\vec{v} \qquad \sum \vec{F} = \frac{d\vec{p}}{dt} = m\vec{a} \qquad \vec{a} = \frac{d\vec{v}}{dt} \qquad \vec{v} = \frac{d\vec{r}}{dt} \qquad \vec{a}_c = -\frac{v^2}{r}\hat{r}$$

$$\vec{L} = \vec{r} \times \vec{p} = I\vec{\omega} \qquad \sum \vec{\tau} = \frac{d\vec{L}}{dt} = I\vec{\alpha} \qquad \vec{\alpha} = \frac{d\vec{\omega}}{dt} \qquad \vec{\omega} = \frac{d\vec{\theta}}{dt} \qquad \vec{\tau} = \vec{r} \times \vec{F}$$

$$\vec{p}_f - \vec{p}_i = \int \vec{F} dt \quad \vec{L}_f - \vec{L}_i = \int \vec{\tau} dt \quad r_{cm} = \frac{\sum_i m_i r_i}{\sum_i m_i} = \frac{\int_{object} r dm}{\int_{object} dm} \qquad I = \sum_i m_i r_i^2 = \int_{object} r^2 dm$$

$$KE = \tfrac{1}{2} m v^2 \qquad E_f - E_i = \Delta E_{transfer}$$

Under Certain Conditions

$$\vec{x} = \vec{x}_o + \vec{v}_o t + \tfrac{1}{2}\vec{a}\, t^2 \qquad \vec{F} = \mu_k \vec{F}_N \quad \vec{F} \le \mu_s \vec{F}_N \qquad \Delta E_{transfer} = \int \vec{F} \cdot d\vec{r}$$

$$\vec{\theta} = \vec{\theta}_o + \vec{\omega}_o t + \tfrac{1}{2}(\vec{\alpha})t^2 \qquad v = r\omega \quad a = r\alpha \qquad I = I_{cm} + md^2$$

$$KE_R = \frac{1}{2} I\omega^2 \qquad PE_G = -\frac{Gm_1 m_2}{r} \quad PE_G \cong mgy \qquad \vec{F} = \frac{d(PE_G)}{dr} \quad PE_S = \tfrac{1}{2} kx^2 \quad F_S = -kx$$

$$\text{If } \frac{d^2}{dt^2}\left[\vec{x}(t)\right] = -A\left[\vec{x}(t)\right] \text{ then } \omega^2 = A \qquad \omega = 2\pi f \qquad \frac{1}{T} = f$$

Useful Constants

Radius of the Earth R_E = 6370 km, mass of the Earth $M_E = 5.98\text{x}10^{24}$ kg, charge on an electron e = $-1.6\text{x}10^{-19}$ C, gravitational constant $G = 6.67 \times 10^{-11}\ \text{Nm}^2/\text{kg}^2$, Coulomb force constant $k_e = 8.99 \times 10^9\ \text{Nm}^2/\text{C}^2$, permeability of free space $\mu_o = 4\pi \times 10^{-7}\ Tm/A$, 1 mile = 5280 feet, 1 cal = 4.2 J, 1 km = 5/8 mile, gravitational acceleration on the surface of the Earth g = 9.81 m/s^2 = 32 ft/s^2, speed of sound v = 340 m/s, speed of light in vacuum $c = 3 \times 10^8\ \text{m/s}$.

Mathematical Relationships

$$\frac{d}{dz} z^n = n z^{n-1} \qquad \frac{d}{dz}\cos z = -\sin z \qquad \frac{d}{dz}\sin z = \cos z \qquad \frac{d}{dt} f(z) = \frac{d}{dz} f(z) \frac{d}{dt} z$$

$$\int z^n dz = \frac{z^{n+1}}{n+1} \text{ for } (n \neq -1) \qquad \frac{d}{dz}\int w dz = w \qquad \int \frac{dw}{dz} dz = w$$

For a circle $C = 2\pi R$ and $A = \pi R^2$, For a sphere $A = 4\pi R^2$ and $V = \frac{4}{3}\pi R^3$

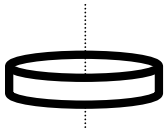
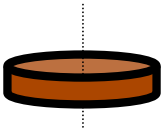
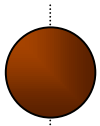
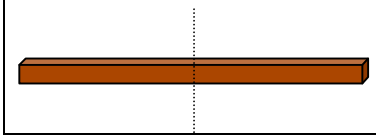
Reminder the GOAL of problem solving:

Gather Information: What do you know? What do you want? Draw coordinate frame. Draw a picture with labels.

Organize: Type of problem (Kinematics, Energy Conservation, Momentum Conservation, Rotation), Pick approach.

Analyze: List mathematical relationships, Simplify and solve, Plug in numbers.

Learn: Check your answer – Is it reasonable? Are units correct?

	Ring (thin)	$I = mr^2$
	Disk (solid)	$I = \frac{1}{2}mr^2$
	Sphere (solid)	$I = \frac{2}{5}mr^2$
	Sphere (hollow)	$I = \frac{2}{3}mr^2$
	Rod	$I = \frac{1}{12}ml^2$