Fundamental Concepts and Principles

$$\vec{p} = m\vec{v} \qquad \sum \vec{F} = \frac{d}{dt}\vec{p}(t) = m\vec{a} \qquad \vec{a} = \frac{d}{dt}\vec{v}(t) \qquad \vec{v} = \frac{d}{dt}\vec{r}(t) \qquad \vec{a}_c = -\frac{v^2}{r}\hat{r} \qquad \omega = 2\pi f \qquad \frac{1}{T} = f$$

$$\vec{L} = \vec{r} \times \vec{p} = I\omega \qquad \sum \vec{\tau} = \frac{d}{dt}\vec{L}(t) = I\alpha \qquad \vec{\tau} = \vec{r} \times \vec{F} \qquad \alpha = \frac{d\omega}{dt} \qquad \omega = \frac{d\theta}{dt} \qquad I = \sum_i m_i r_i^2 = \int_{object} r^2 dm$$

$$\vec{p}_f - \vec{p}_i = \int \vec{F}dt \qquad \vec{L}_f - \vec{L}_i = \int \vec{\tau}dt \qquad r_{cm} = \frac{\sum_i m_i r_i}{\sum_i m_i} = \frac{\int_{object} r\,dm}{\int_{object} dm} \qquad KE = \tfrac{1}{2}mv^2 \qquad E_f - E_i = \Delta E_{transfer}$$

$$\vec{F}_e = q\vec{E} \qquad C = \frac{Q}{\Delta V} \qquad P = I\Delta V \qquad I = \frac{d}{dt}q(t) \qquad k_e = \frac{1}{4\pi\varepsilon_o} \qquad K = \frac{\varepsilon}{\varepsilon_o} \qquad \oiint \vec{E}\cdot d\vec{A} = \frac{\Sigma q}{\varepsilon_o} \qquad \oiint \vec{B}\cdot d\vec{A} = 0$$

$$\iint_{surface} \vec{E}\cdot d\vec{A} = \Phi_E \qquad \iint_{surface} \vec{B}\cdot d\vec{A} = \Phi_B \qquad \Delta V = -\int_{s_i}^{s_f} \vec{E}\cdot d\vec{s} \qquad N\Phi_B = LI$$

Under Certain Conditions

$$x = x_o + v_{xo}t + \tfrac{1}{2}a_x t^2 \qquad \vec{F} = \mu_k \vec{F}_N \qquad \vec{F} \le \mu_s \vec{F}_N \qquad PE_G = mgy \qquad v = r\omega \qquad a = r\alpha$$

$$\theta = \theta_o + \omega_o t + \tfrac{1}{2}(\alpha)t^2 \qquad I = I_{cm} + md^2 \qquad \mathrm{n}_1\sin\theta_1 = \mathrm{n}_2\sin\theta_2 \qquad \left(\frac{1}{R_1} - \frac{1}{R_2}\right)(n_l - 1) = \frac{1}{f} \qquad \frac{1}{i} + \frac{1}{o} = \frac{1}{f}$$

$$E_{transfer} = \int \vec{F}\cdot d\vec{r} \qquad KE = \frac{1}{2}I\omega^2 \qquad PE_G = -\frac{Gm_1m_2}{r} \qquad \vec{F} = \frac{d(PE_G)}{dr} \qquad PE_s = \tfrac{1}{2}kx^2 \qquad F = -kx$$

$$\omega^2 = A \text{ if } \frac{d^2}{dt^2}[\vec{x}(t)] = -A[\vec{x}(t)] \qquad v = \sqrt{\frac{F_T}{\mu}} \qquad v = \lambda f \qquad R = \rho\frac{L}{A} \qquad \Delta V = IR \qquad PE_{cap} = \tfrac{1}{2}C(\Delta V)^2$$

$$\vec{F}_e = \frac{k_e q_1 q_2}{r^2}\hat{r} \qquad \vec{E} = \frac{k_e q}{r^2}\hat{r} \qquad V = \frac{k_e q}{r} \qquad PE_e = \frac{k_e q_1 q_2}{r} \qquad \Delta PE_e = q\Delta V \qquad \vec{F} = q\vec{v} \times \vec{B}$$

$$\oint \vec{B}\cdot d\vec{s} = \mu_o I \qquad \vec{\tau} = \vec{\mu} \times \vec{B} \qquad V_{emf} = -\frac{d}{dt}(\Phi_B) \qquad N\frac{d}{dt}(\Phi_B) = -L\frac{d}{dt}I(t) \qquad m = \frac{y_i}{y_o} = \frac{-i}{o}$$

Useful Constants

Radius of the Earth R_E = 6370 km, mass of the Earth $M_E = 5.98\text{x}10^{24}$ kg, speed of sound (STP) v=340 m/s, charge on an electron e = $-1.6\text{x}10^{-19}$ C, 1 mile = 5280 feet, 1 cal = 4.2 J, 1 lb = 4.45 N, gravitational constant $G = 6.67\times10^{-11}\ \mathrm{Nm^2/kg^2}$, speed of light in vacuum $c = 3\times10^8$ m/s, Coulomb force constant $k_e = 8.99\times10^9\ \mathrm{Nm^2/C^2}$, permeability of free space $\mu_o = 4\pi\times10^{-7}\ Tm/A$, 1 km = 5/8 mile, gravitational acceleration on the surface of the Earth g = 9.81 m/s^2 = 32 ft/s^2,

Mathematical Relationships

$$\frac{d(z^n)}{dz} = nz^{n-1} \qquad \frac{d(\cos z)}{dz} = -\sin z \qquad \frac{d(\sin z)}{dz} = \cos z \qquad \frac{df(z)}{dt} = \frac{df(z)}{dz}\frac{d(z)}{dt} \qquad \text{For circle } C = 2\pi R \quad A = \pi R^2$$

$$\int (z^n)dz = \frac{z^{n+1}}{n+1} \text{ for } (n \ne -1) \qquad \frac{d}{dz}\int w\,dz = w \qquad \int \frac{dw}{dz}dz = w \qquad \text{For Sphere } A = 4\pi R^2 \quad V = \tfrac{4}{3}\pi R^3$$

Volume Elements for: cartesian $dV = dxdydz$; cylindrical $dV = rdrd\theta dz$; spherical $dV = r^2\sin\theta drd\theta d\phi$

Reminder the GOAL of problem solving:

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

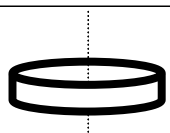
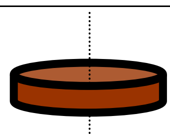
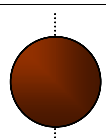
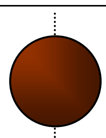
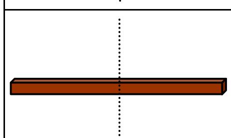
Organize: Type of problem (Kinematics, Energy Conservation, Momentum Conservation, Rotation), Pick approach.

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

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

It's all Greek to me!

The table to the right contains common symbols (both greek and latin) – Watch subscripts and context (units) to determine what the symbol represents.

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

x, y, z *i, j, k*	position – cartesian or rectilinear coordinates
r, θ, z	position – cylindrical coordinates
ρ, θ, φ	position – spherical coordinates
λ	wavelength; linear density (mass, charge etc.)
σ	standard deviation; surface area density (mass, charge etc.); cross section
ρ	resistivity; volume density (mass, charge, air, etc.)
ω	angular frequency, angular velocity
ν	frequency; phase velocity
f	frequency; focal distance
ε	permittivity, electromotive force (εmf)
V	voltage; volume
m	mass; magnification
q	charge
e	electron charge; exponential function
k	spring constant; coulomb force constant
K	dielectric constant
Ω	Ohm (resistance)
Σ	summation
α	angular acceleration; alpha particle (He nucleus)
β	beta particle (electron)
γ	gamma radiation (photon)
Ψ	wave function
Δ	a small quantity or "change of"
Φ	flux
i	unit direction ($\hat{x}$); $i^2 = -1$; small current; image distance
τ	torque, time constant
μ	permeability; coefficient of friction; mass density (eg string)
n	index of refraction; number
I	current; moment of inertia
L	angular momentum, inductance
X	reactance (inductive and capacitive)
Z	impedance
D	Diopter (1/*f*)