

Vectors

$$\vec{A} = A_x \hat{x} + A_y \hat{y} \quad A = \sqrt{A_x^2 + A_y^2}$$

$$\sin \theta = \frac{opp}{hyp}, \quad \cos \theta = \frac{adj}{hyp}, \quad \tan \theta = \frac{opp}{adj}$$

Vector Addition

$$\vec{A} + \vec{B} = (A_x + B_x)\hat{x} + (A_y + B_y)\hat{y}$$

$$\vec{v}_{AC} = \vec{v}_{AB} + \vec{v}_{BC} \text{ (Relative Motion)}$$

General Definitions for Linear Motion

$$\text{Ave. speed} = \frac{\text{distance}}{\text{time}}$$

$$v_{x,avg} = \frac{\Delta x}{\Delta t} \quad (\text{motion along x-direction})$$

$$a_{x,avg} = \frac{\Delta v_x}{\Delta t} \quad (\text{motion along x-direction})$$

$$\vec{v} = \lim_{\Delta t \rightarrow 0} \frac{\Delta \vec{r}}{\Delta t}, \quad \vec{a} = \lim_{\Delta t \rightarrow 0} \frac{\Delta \vec{v}}{\Delta t}$$

$$g = 9.8 \text{ m/s}^2 \quad (\text{on Earth's surface})$$

Linear Motion at Constant Acceleration

$$v_x = v_{ox} + a_x t$$

$$v_x^2 = v_{ox}^2 + 2a_x(x - x_o)$$

$$x = x_o + v_{ox}t + \frac{1}{2}a_x t^2$$

$$x = x_o + \frac{1}{2}(v_x + v_{ox})t$$

Quadratic Equation Solver

$$x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A} \quad (\text{A,B,C coefficients})$$

Equations Associated with Newton's Laws

$$\sum \vec{F} = m\vec{a}, \quad w = mg,$$

$$0 \leq f_s \leq \mu_s N, \quad f_k = \mu_k N$$

$$f_{drag} = \frac{1}{2}C\rho A v^2$$

$$F_{spring} = -k_{spring}x \text{ (deformation along x-direction)}$$

Work, Energy, and Power Equations

$$W = F d \cos\theta \quad (\text{for constant force})$$

$$KE = \frac{1}{2}mv^2 \quad (\text{for linear motion})$$

$$W_{tot} = \sum W, \quad W_{tot} = \Delta K, \quad W_{cons} = -\Delta U$$

$$PE_{gravity} = mgy \quad (\text{for constant } g\text{-acceleration})$$

$$PE_{spring} = \frac{1}{2}k_{spring}x^2 \quad (\text{for ideal spring along x-axis})$$

$$E_{mech} = PE + KE, \quad W_{non\ cons} = \Delta E_{mech}$$

$$P_{avg} = \frac{W}{\Delta t}, \quad P = F v \cos\phi \quad (\text{for constant force})$$

Universal Gravitation

$$F = G \frac{m_1 m_2}{r^2}, \quad g = G \frac{M}{r^2}$$

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

$$M_{Earth} = 5.97 \times 10^{24} \text{ kg}, \quad R_{Earth} = 6.38 \times 10^3 \text{ km}$$

$$M_{Sun} = 1.99 \times 10^{30} \text{ kg}$$

Uniform Rotational Motion

$$\omega_{avg} = \frac{\Delta\theta}{\Delta t}, \quad \omega = \lim_{\Delta t \rightarrow 0} \frac{\Delta\theta}{\Delta t}$$

$$s = r\theta, \quad v = r\omega$$

$$a_{cp} = \frac{v^2}{r}, \quad T = \frac{2\pi}{\omega}$$

Equations Associated with Linear Momentum

$$\vec{p} = m\vec{v}, \quad \vec{p}_{system} = \sum \vec{p}$$

$$\text{Impulse: } \vec{I} = \Delta\vec{p} = \vec{F}_{avg} \cdot \Delta t$$

Rotational Motion and Torque

$$\tau = r F_{tan} = r_{\perp} F = r F \sin\theta$$

$$\sum \vec{\tau} = I\vec{\alpha}, \quad I = \sum_i m_i r_i^2$$

Rotational Motion at Constant Acceleration

$$\alpha_{avg} = \frac{\Delta\omega}{\Delta t}, \quad \alpha = \lim_{\Delta t \rightarrow 0} \frac{\Delta\omega}{\Delta t}$$

$$\omega = \omega_o + \alpha t$$

$$\omega^2 = \omega_o^2 + 2\alpha(\theta - \theta_o)$$

$$\theta = \theta_o + \omega_o t + \frac{1}{2}\alpha t^2$$

$$\theta = \theta_o + \frac{1}{2}(\omega + \omega_o)t$$

$$a_{tan} = r\alpha, \quad a = \sqrt{a_{cp}^2 + a_{tan}^2}$$

Angular Momentum and Energy

$$L = r m v_{tan}$$

$$\vec{L} = I\vec{\omega}, \quad \Delta\vec{L} = \vec{\tau}_{net}\Delta t$$

$$I_{particle} = mR^2, \quad I_{hoop} = mR^2$$

$$I_{sphere} = \frac{2}{5}mR^2, \quad I_{disk} = \frac{1}{2}mR^2$$

$$KE = \frac{1}{2}I\omega^2 \quad (\text{for rotational motion})$$

$$KE_{total} = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

Fluids

$$p = \frac{F}{A} \quad (\text{uniformly distributed perpendicular force})$$

$$p = p_{top} + \rho gh$$

$$\rho_{air} = 1.29 \text{ kg/m}^3, \quad \rho_{water} = 1000 \text{ kg/m}^3$$

$$p_{atm} = 1.01 \times 10^5 \text{ Pa}, \quad p_{gauge} = p - p_{atm}$$

$$F_B = \rho_{fluid} V_{body} g$$

Simple Harmonic Oscillations

$$f = \frac{1}{T}, \quad \omega = 2\pi f = \frac{2\pi}{T}$$

$$x = A\cos(\omega t + \varphi), \quad v = -A\omega\sin(\omega t + \varphi)$$

$$a = -A\omega^2\cos(\omega t + \varphi)$$

$$\omega = \sqrt{\frac{k_{spring}}{m}}, \quad T = 2\pi\sqrt{\frac{m}{k_{spring}}} \quad (\text{ideal spring})$$

$$T = 2\pi\sqrt{\frac{l}{g}} \quad (\text{simple pendulum})$$

$$E_{SHO} = \frac{1}{2}k_{spring}A^2$$

Traveling Waves and Sound

$$v = \lambda f$$

$$v_{sound} = 343 \text{ m/s} \quad (\text{in calm air at } 20^\circ\text{C})$$

$$v_{sound} = (331 \text{ m/s}) \sqrt{\frac{T}{273 \text{ K}}}$$

$$f_{perceived} = f \frac{v \pm v_{observer}}{v \mp v_{source}}$$

$$v_{transverse} = \sqrt{\frac{F}{\mu}}, \quad \mu = \frac{m}{l} \quad (\text{taut string})$$

Wave Intensity

$$I = \frac{P}{\Delta A}$$

$$I = \frac{P}{4\pi r^2} \quad (\text{at distance } r \text{ from a point source})$$

$$\beta(\text{dB}) = (10 \text{ dB}) \log\left(\frac{I}{I_0}\right)$$

Standing Waves

$$\text{String:} \quad f_n = \frac{n}{2l}\sqrt{\frac{F}{\mu}}, \quad n=1,2,3,\dots$$

$$\text{Open pipe:} \quad f_n = \frac{nv}{2l}, \quad n=1,2,3,\dots$$

$$\text{Closed pipe:} \quad f_n = \frac{nv}{4l}, \quad n=1,3,5,\dots$$