PHYS 1301 Equation Sheet

Vectors

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

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

Vector Addition

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

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

General Definitions for Linear Motion

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

$$\mathrm{v}_{x,avg} = \frac{\Delta x}{\Delta t} \qquad \text{(motion along x-direction)}$$

$$a_{x,avg} = \frac{\Delta \mathrm{v}_x}{\Delta t} \qquad \text{(motion along x-direction)}$$

$$\vec{\mathbf{v}} = \lim_{\Delta t \to 0} \frac{\Delta\vec{\boldsymbol{r}}}{\Delta t}, \qquad \vec{\boldsymbol{a}} = \lim_{\Delta t \to 0} \frac{\Delta\vec{\mathbf{v}}}{\Delta t}$$

$$g = 9.80 \text{ m/s}^2 \qquad \text{(on Earth's surface)}$$

Linear Motion at Constant Acceleration

$$\mathrm{v}_x = \mathrm{v}_{ox} + a_x t$$

$${\mathrm{v}_x}^2 = {\mathrm{v}_{ox}}^2 + 2a_x(x - \mathrm{x}_o)$$

$$x = \mathrm{x}_o + \mathrm{v}_{ox}t + \frac{1}{2}a_x t^2$$

$$x = \mathrm{x}_o + \frac{1}{2}(\mathrm{v}_x + \mathrm{v}_{ox})t$$

Quadratic Equation Solver

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

Equations Associated with Newton's Laws

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

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

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

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

Work, Energy, and Power Equations

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

$$KE = \frac{1}{2}m\mathrm{v}^2 \qquad \text{(for linear motion)}$$

$$W_{tot} = \sum W, \quad W_{tot} = \Delta KE, \quad W_{cons} = -\Delta PE$$

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

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

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

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

Universal Gravitation

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

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

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

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

Uniform Rotational Motion

$$\omega_{avg} = \frac{\Delta\theta}{\Delta t}, \qquad \omega = \lim_{\Delta t \to 0}\frac{\Delta\theta}{\Delta t}$$

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

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

Equations Associated with Linear Momentum

$$\vec{\boldsymbol{p}} = m\vec{\mathbf{v}}, \qquad \vec{\boldsymbol{p}}_{system} = \sum\vec{\boldsymbol{p}}$$

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

Elastic & $\mathrm{v}_{2,i} = 0$: $v_{1,f} = \frac{m_1 - m_2}{m_1 + m_2} v_{1,i}$, $v_{2,f} = \frac{2m_1}{m_1 + m_2} v_{1,i}$

Rotational Motion and Torque

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

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

Rotational Motion at Constant Acceleration

$$\alpha_{avg} = \frac{\Delta\omega}{\Delta t}, \qquad \alpha = \lim_{\Delta t \to 0} \frac{\Delta\omega}{\Delta t}$$

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

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

$$\theta = \theta_o + \omega_0 t + \frac{1}{2}\alpha t^2$$

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

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

Angular Momentum and Energy

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

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

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

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

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

$$KE_{total} = \frac{1}{2}m\mathrm{v}^2 + \frac{1}{2}I\omega^2$$

Fluids

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

$$p = p_{top} + \rho g h$$

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

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

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

Simple Harmonic Oscillations

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

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

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

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

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

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

Traveling Waves and Sound

$$v = \lambda f$$

$\mathrm{v}_{sound} = 343\ m/s$ (in calm air at 20C)

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

$$f_{perceived} = f\,\frac{\mathrm{v} \pm \mathrm{v}_{observer}}{\mathrm{v} \mp \mathrm{v}_{source}}$$

$\mathrm{v}_{transverse} = \sqrt{\frac{F}{\mu}}, \quad \mu = \frac{m}{l}$ (taut string)

Wave Intensity

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

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

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

Standing Waves

String: $f_n = \frac{n}{2l}\sqrt{\frac{F}{\mu}}$, *n=1,2,3,…*

Open pipe: $f_n = \frac{n\mathrm{v}}{2l}$, *n=1,2,3,…*

Closed pipe: $f_n = \frac{n\mathrm{v}}{4l}$, *n=1,3,5,…*