PHY2048 Exam 3 Formula Sheet

Law of Gravitation

Magnitude of Force: \[ F_{\text{grav}} = G \frac{m_1 m_2}{r^2} \quad G = 6.67 \times 10^{-11} \text{Nm}^2/\text{kg}^2 \]

Potential Energy: \[ U_{\text{grav}} = -G \frac{m_1 m_2}{r} \]

Escape Speed: \[ v_{\text{escape}} = \sqrt{\frac{2GM}{R}} \]

Tension & Compression (\(Y = \text{Young’s Modulus}, B = \text{Bulk Modulus}\))

Linear: \[ F = \frac{A}{L} \Delta L \]

Volume: \[ P = \frac{F}{A} = \frac{B}{V} \Delta V \]

Ideal Fluids

Pressure (variable force): \[ p = \frac{dF}{dA} \]

Pressure (constant force): \[ p = \frac{F}{A} \]

Units: \(1 \text{ Pa} = 1 \text{ N/m}^2\)

Equation of Continuity: \( R_{\text{in}} A_{\text{in}} = R_{\text{out}} A_{\text{out}} \)

Bernoulli’s Equation (y-axis up): \[ \frac{1}{2} \rho v_1^2 + \rho g y_1 = \frac{1}{2} \rho v_2^2 + \rho g y_2 + \rho g y_0 \]

Pressure (variable force): \[ \frac{dA}{dF} = \frac{p}{\rho} \]

Pressure (constant force): \[ \frac{F}{A} = \frac{p}{\rho} \]

Equation of Continuity: \( \frac{1}{2} \rho v_1^2 + \rho g y_1 = \frac{1}{2} \rho v_2^2 + \rho g y_2 + \rho g y_0 \)

Simple Harmonic Motion (SHM) (angular frequency \(\omega = 2\pi f = \frac{2\pi}{T}\))

\[ x(t) = x_{\text{max}} \cos(\omega t + \phi) \]

\[ v(t) = -\omega x_{\text{max}} \sin(\omega t + \phi) \]

\[ a(t) = -\omega^2 x_{\text{max}} \cos(\omega t + \phi) = -\omega^2 x(t) \]

Ideal Spring (k = spring constant): \[ F = -kx \quad \omega = \sqrt{\frac{k}{m}} \quad E = \frac{1}{2}mv^2(t) + \frac{1}{2}kx^2(t) = \text{constant} \]

Sinusoidal Traveling Waves (frequency \(f = 1/T = \omega/2\pi\), wave number \(k = 2\pi/\lambda\))

\[ y(x, t) = y_{\text{max}} \sin(\Phi) = y_{\text{max}} \sin(kx \pm \omega t + \phi) \quad (\_ = \text{right moving}, + = \text{left moving}) \]

Phase: \(\Phi = kx \pm \omega t\)

Wave Speed: \(v_{\text{wave}} = \frac{\omega}{k} = \frac{\lambda}{T} = \frac{\lambda f}{\mu}\)

Wave Speed (tight string): \(v_{\text{wave}} = \sqrt{\frac{T}{\mu}}\)

Interference (Max Constructive): \(\Delta \Phi = 2\pi n, n = 0, \pm 1, \pm 2, \cdots\)

Interference (Max Destructive): \(\Delta \Phi = \pi + 2\pi n, n = 0, \pm 1, \pm 2, \cdots\)

Standing Waves (L = length, \(n = \text{harmonic number}\))

Allowed Wavelengths & Frequencies: \(\lambda_n = 2L/n \quad f_n = \frac{v_{\text{wave}}}{\lambda_n} = \frac{nv_{\text{wave}}}{2L} \quad n = 1, 2, 3, \cdots\)

Sound Waves (\(P = \text{Power}\))

Intensity (W/m²): \(I = \frac{P}{A}\)

Isotropic Point Source: \(I(r) = \frac{P_{\text{source}}}{4\pi r^2}\)

Speed of Sound: \(v_{\text{sound}} = \sqrt{\frac{B}{\rho}}\)

Doppler Shift: \(f_{\text{obs}} = f_s \frac{v_{\text{sound}} - v_D}{v_{\text{sound}} - v_s}\)

(\(f_s = \text{frequency of source}, v_s, v_D = \text{speed of source, detector}\))

Change \(-v_D\) to \(+v_D\) if the detector is moving opposite the direction of the propagation of the sound wave.

Change \(-v_s\) to \(+v_s\) if the source is moving opposite the direction of the propagation of the sound wave.\]