PHY2048 Exam 3 Formula Sheet

Law of Gravitation

Magnitude of Force: $F_{grav} = G\frac{m_1 m_2}{r^2}$ $G = 6.67\times10^{-11} Nm^2/kg^2$

Potential Energy: $U_{grav} = -G\frac{m_1 m_2}{r}$ Escape Speed: $v_{escape} = \sqrt{\frac{2GM}{R}}$

Tension & Compression (Y = Young's Modulus, B = Bulk Modulus)

Linear: $\frac{F}{A} = Y\frac{\Delta L}{L}$ Volume: $P = \frac{F}{A} = B\frac{\Delta V}{V}$

Ideal Fluids

Pressure (variable force): $P = \frac{dF}{dA}$ Pressure (constant force): $P = \frac{F}{A}$ Units: 1 Pa = 1 N/m^2

Equation of Continuity: $R_V = Av =$ constant (volume flow rate) $R_m = \rho Av =$ constant (mass flow rate)

Bernoulli's Equation (y-axis up): $P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2 =$ constant

Fluids at rest (y-axis up): $P_2 = P_1 + \rho g(y_1 - y_2)$ Buoyancy Force: $F_{Buoy} = M_{fluid}\, g$

Simple Harmonic Motion (SHM) (angular frequency ω = 2πf =2π/T)

$x(t) = x_{\max}\cos(\omega t + \phi)$ $v_{\max} = \omega x_{\max}$

$v(t) = -\omega x_{\max}\sin(\omega t + \phi)$ $a_{\max} = \omega^2 x_{\max}$

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

Ideal Spring (k = spring constant)): $F_x = -kx$ $\omega = \sqrt{\frac{k}{m}}$ $E = \frac{1}{2}mv^2(t) + \frac{1}{2}kx^2(t) =$ constant

Sinusoidal Traveling Waves (frequency f = 1/T = ω/2π, wave number k = 2π/λ)

$y(x,t) = y_{\max}\sin(\Phi) = y_{\max}\sin(kx \pm \omega t + \phi)$ (- = right moving, + = left moving)

Phase: $\Phi = kx \pm \omega t$ Wave Speed: $v_{wave} = \frac{\omega}{k} = \frac{\lambda}{T} = \lambda f$ Wave Speed (tight string): $v_{wave} = \sqrt{\frac{\tau}{\mu}}$

Interference (Max Constructive): $\Delta\Phi = 2\pi n$ $n = 0,\pm1,\pm2,\cdots$ $\Delta d = n\lambda$ $n = 0,\pm1,\pm2,\cdots$

Interference (Max Destructive): $\Delta\Phi = \pi + 2\pi n$ $n = 0,\pm1,\pm2,\cdots$ $\Delta d = (n + \frac{1}{2})\lambda$ $n = 0,\pm1,\pm2,\cdots$

Standing Waves (L = length, n = harmonic number)

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

Sound Waves (P = Power)

Intensity (W/m^2): $I = \frac{P}{A}$ Isotropic Point Source: $I(r) = \frac{P_{source}}{4\pi r^2}$ Speed of Sound: $v_{sound} = \sqrt{\frac{B}{\rho}}$

Speed of Sound in Air (temperature T in Kelvin): $v_{sound}(T) = v_0\sqrt{\frac{T}{T_0}}$ v_0 = 331 m/s T_0 = 273.15 ^{o}K

Temperature (Kelvin, Centegrade, Fahrenheit): T(in ^{o}K) = T(in ^{o}C) + 273.15 T(in ^{o}F) = 1.8×T(in ^{o}C) + 32

Doppler Shift: $f_{obs} = f_S\frac{v_{sound} - v_D}{v_{sound} - v_S}$ (f_S = frequency of source, v_S, v_D = 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.