List of useful formulae for Phys 123, Midterm 2

Density = Mass/Volume (kg/m^3) ; Linear Density = Mass/Length (kg/m)

Ch. 14

Hooke's law for spring: $F = -kx$, k is spring constant

For a horizontal mass-spring system: $E = mv^2/2 + kx^2/2$, E is total energy

Simple Harmonic Motion: $x(t) = A \cos(\omega t + \delta)$

$f = 1/T$; $\omega = 2\pi f$; $v_{max} = \omega A$; $a_{max} = \omega^2 A$

For a mass-spring system: $\omega = (k/m)^{1/2}$; for a simple pendulum: $\omega = (g/L)^{1/2}$

Energy of an under-damped oscillator: $E(t) = (½)\, m\, \omega^2 A^2(t) = E_o \exp[-t/\tau]$
where τ is the time constant

Quality Factor $Q = \omega_o \tau \approx 2\pi / (|\Delta E|/E)_{cycle}$

Ch. 15

Speed of a string wave: $v_{string} = (Tension/\mu)^{1/2}$, μ is linear density

Harmonic Wave Function: $y(x,t) = A \sin(kx \pm \omega t + \delta)$ with $k = 2\pi/\lambda$

Speed of a harmonic wave: $v = f\lambda = \omega/k$

Doppler Effect for Sound: $f_r = f_s\, (v \pm u_r) / (v \pm u_s)$
where: u_r = velocity of receiver , u_s = velocity of source , v = speed of sound

Ch. 16

$\sin\theta_1 + \sin\theta_2 = 2 \cos[(\theta_1 - \theta_2)/2] \sin[(\theta_1 + \theta_2)/2]$

Beat frequency: $\Delta f = f_1 - f_2$

Phase difference due to path difference: $\delta = 2\pi\, (\Delta x / \lambda)$

For standing waves on a string fixed at both ends: $f_n = nf_1$
with $f_1 = v/2L$ and $n = 1,2,3, \ldots$

For standing waves on a string fixed at one end, free at the other: $f_n = nf_1$
with $f_1 = v/4L$ and $n = 1,3,5, \ldots$

Ch. 30

For a plane EM wave moving to the right along +x axis:

$E_y = E_0 \sin(kx - \omega t)$; $B_z = B_0 \sin(kx - \omega t)$; $B_0 = E_0 / c$

$c^2 = 1 / (\mu_0 \varepsilon_0)$ $c = 3 \text{ X } 10^8$ m/s

Ch. 31

Index of Refraction: $n = c/v$ with $n_{air} = 1.0$

Law of Reflection: $\theta_1' = \theta_1$

Snell's Law of Refraction: $n_1 \sin \theta_1 = n_2 \sin \theta_2$

Total Internal Reflection: $\sin \theta_C = n_2 / n_1$ with $n_1 > n_2$

Polarization by Absorption (Law of Malus): $I = I_0 \cos^2(\theta)$

Polarization by Reflection: $n_1 \sin\theta_P = n_2 \sin\theta_2$ with $\theta_2 = 90^o - \theta_P$

Ch. 32

Mirror equation: $1/s + 1/s' = 1/f$ where $f = r/2$

Lateral magnification by mirror: $m = y'/y = - s'/s$

Image formed by refraction: $n_1/s + n_2/s' = (n_2 - n_1) / r$

Magnification due to refraction: $m = y'/y = - (n_1 s') / (n_2 s)$

Lens-maker's equation: $1/f = (n_1/n_2 - 1) (1/r_1 - 1/r_2)$

Thin-Lens equation: $1/s + 1/s' = 1/f$

Power of a lens: $P = 1/f$ (in Diopters = m^{-1})

Lateral magnification by lens: $m = y'/y = - s'/s$

Angular magnification of a Simple Magnifier: $M = \theta / \theta_o = x_{np} / f$

Magnifying power of a Microscope: $M = m_o M_e$ w/ $m_o = - L/f_o$ and $M_e = x_{np}/f_e$

Magnifying Power of a Telescope: $M = \theta_e/\theta_o$ w/ $\tan\theta_o = y/s = -y'/f_o$ and $\tan\theta_e = y'/f_e$

Ch. 33

Phase difference due to path-length difference: $\delta = 2\pi\,(\Delta r/\lambda)$

Two-slit Interference maxima: $d \sin\theta_m = m\,\lambda$ where $m = 0,1,2,3,\ldots$

Two-slit Interference minima: $d \sin\theta_m = (m - \tfrac{1}{2})\,\lambda$ where $m = 1,2,3,\ldots$

Distance of m^{th} fringe from the central point of the screen: $y_m = L \tan\theta_m$

Intensity of light from interference: $I = 4I_0 \cos^2(\delta/2)$

Single-slit Diffraction minima: $\alpha \sin\theta_n = n\,\lambda$ where $n = 1,2,3,\ldots$

Rayleigh's criterion for resolution for a circular aperture of diameter D: $\theta_c = 1.22\,\lambda / D$

Resolving power of a grating: $R = \lambda / |\Delta\lambda| = mN$, m = order number, N = # of slits