PHY385H1F – "Introductory Optics"
Problem Set 1
Due: **September 20**, 2012 in class by 1:10pm

Instructions: Please complete the following problems on separate paper. SHOW ALL YOUR WORK. You will be graded more on correct method than correct answer. If you take an equation from the Hecht text, please give the equation number and page number.

Based on Chapter 2 of Optics (4th Edition) by Eugene Hecht, ©2002 by Addison-Wesley:

1. A wavepulse travels 15 m along the length of a string in 2.5 s. A harmonic disturbance of wavelength 0.50 m is then generated on the same string. What is the frequency of this harmonic wave?

2. The wave-function of a transverse wave on a string is:

$$\psi(x,t) = (20.0\text{cm})\cos\left[(4.35\text{rad/m})x - (15.0\text{rad/s})t\right].$$

   Find the:

   a. Frequency
   b. Wavelength
   c. Period
   d. Amplitude
   e. Phase velocity
   f. Direction of motion

3. A sound wave with frequency 1.50 kHz propagates with a speed of 334 m/s. Determine the phase difference, in radians, between any two points on the wave separated by 15.0 cm, as measured along the direction of wave motion.

4. Two harmonic plane waves of the same amplitude, speed and frequency travel in opposite directions in the same region of space. The resultant standing wave may be written as a sum of the individual waves: $\phi(y,t) = A\sin(ky+\omega t) + A\sin(ky-\omega t+\pi)$. With the help of complex exponentials, show that $\phi(y,t) = 2A\cos(ky)\sin(\omega t)$.

5. Two harmonic electromagnetic plane waves are travelling along the *z*-direction with the same frequency. **Wave A** has an $\vec{E}$-field amplitude of 0.3 V/M in the *x*-direction, and **Wave B** has an $\vec{E}$-field amplitude of 0.4 V/m, also in the *x*-direction. Wave A has an initial phase (at $z = 0$ and $t = 0$) of 0.2 radians and **Wave B** has an initial phase of 1.5 radians. Determine the $\vec{E}$-field amplitude and phase of the resultant superposition of **Wave A** and **Wave B**.

Based on Chapter 3 of Optics (4th Edition) by Eugene Hecht, ©2002 by Addison-Wesley:

6. An electromagnetic wave propagates along the *x*-axis with its $\vec{E}$ -field oscillating in the *y*-direction. Show that Eq.3.27 from page 46:

$$\frac{\partial E}{\partial x} = -\frac{\partial B}{\partial t}$$

applied to the harmonic wave given by:

$$\vec{E} = \vec{E}_0 \cos(kx - \omega t) \qquad \vec{B} = \vec{B}_0 \cos(kx - \omega t)$$

yields the fact that $E_0 = cB_0$, in agreement with Eq. 3.30 on page 47.

7. A 656 nm harmonic electromagnetic wave whose electric field oscillates in the *z*-direction is travelling in the *y*-direction in a vacuum.
   a. What is the frequency of the wave?
   b. What is ω for this wave?
   c. What is *k* for this wave?
   d. If the electric field amplitude is 600 V/m, what is the amplitude of the magnetic field?
   e. Write an expression for both $E(t)$ and $B(t)$ given that each is zero at $x = 0$ and $t = 0$. Put in all the appropriate units.