PHY385H1F – "Introductory Optics"
Problem Set 4
Due: **November 1**, 2012 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 5 of Optics (4th Edition) by Eugene Hecht, ©2002 by Addison-Wesley:

1. Consider a step-index single clad optical fibre, whose core has an index of $n_f = 1.62$ and cladding has an index of $n_c = 1.52$.
    a. Determine the numerical aperture of the fibre.
    b. When immersed in air, what is its maximum acceptance angle?
    c. What would happen to a ray that was incident on the flat end of the fibre at an incidence angle of 45°?
2. A step-index, multimode communications fibre is 1200 m long and has a core with an index of $n_f = 1.500$ and cladding with an index of $n_c = 1.485$. What is the minimum duration upon output of a short optical pulse which travels through the length of this fibre?
3. An optometrist finds that a farsighted person has a near point at 125 cm. What power will be required for contact lenses that will allow the person to read a book at a comfortable distance of 25 cm?
4. A 2.4 m diameter telescope on Earth can be used to look at distant stars. Due to "seeing", or thermal distortions in wave-fronts caused by the Earth's atmosphere, an effective resolution lower-limit of 1 arc-second is typical, when not using adaptive optics or other wave-front correcting techniques. [1 arc-second is $1/60^{th}$ of 1 arc-minute, or $1/3600^{th}$ of 1°.] Consider a 2.4 m diameter telescope like the Hubble, but one that is pointing down, back toward the earth. What is the minimum resolution, in distance, of objects seen on the surface of the Earth as viewed with this telescope? Assume the telescope orbits at a height of 315 km above the surface.

Based on Chapter 7 of Optics (4th Edition) by Eugene Hecht, ©2002 by Addison-Wesley:

5. Show in a phasor diagram the following two harmonic waves, and determine the mathematical expression for the resultant wave [ie, in the form $E_{tot} = E_0 \sin(\omega t + \alpha)$, with numerical values given for E_0 and α.]

$$E_1 = 2 \sin \omega t \qquad \text{and} \qquad E_2 = 7 \sin(\omega t - \pi/4)$$

Based on Section 13.1 of Optics (4th Edition) by Eugene Hecht, ©2002 by Addison-Wesley:

6. Consider an assembly of atoms in a gas that have two energy levels separated by an energy corresponding to a wavelength of 632.8 nm, as in a He-Ne laser. If the gas is at room temperature, what is the ratio of the population densities of the two energy levels?