PHY385H1F – "Introductory Optics"
Problem Set 2
Due: **October 6**, 2011

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

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

1. Consider a linearly polarized plane electromagnetic wave travelling in the $+x$-direction in free space having as its plane of vibration the xy-plane. Given that its frequency is 102.1 MHz and its amplitude is $E_0 = 0.085$ V/m,
    a. Find the period and wavelength of the wave.
    b. Write and expression for $E(t)$ and $B(t)$
    c. Find the flux density, $\langle S \rangle$, of the wave.

2. The net average electromagnetic power radiated by the Sun is called its luminosity, which is $L_\odot = 3.839 \times 10^{26}$ W. Determine the mean amplitude of the electric field due to all the radiant energy arriving at the top of the Earth's atmosphere (which is 1.496×10^{11} m from the Sun).

3. Given that the wavelength of a green laser in a vacuum is 532 nm, what will its wavelength be in water, where $n = 1.33$? Will it still be green?

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

4. The Sun is setting, and it shines white light through a very large volume across the surface of the Earth, which contains air: a tenuous molecular gas mixture of mostly nitrogen and oxygen. Compare the relative amount of scattering of sunlight occurring for the yellow (580 nm) component with that of the violet (400 nm) component. In other words, if the amount of scattered irradiance at a wavelength, λ, is S_λ, find the ratio: S_{580}/S_{400}.

5. A beam of light in water (n=1.33) is incident upon a flat piece of glass (n=1.50) with an angle of incidence of 45°. Compute the refraction angle into the glass. If the transmitted beam in the glass is reversed, so that it impinges on the interface at the angle you just computed, show that its angle of refraction into the water is 45°.

6. A very narrow beam of white light is incident at 60.0° on a sheet of glass 10.0 cm thick in air. The index of refraction of the glass for red light is 1.505 and for violet light it's 1.545. Determine the approximate thickness of the emerging beam.

7. Derive the Law of Reflection, $\theta_i = \theta_r$, by minimizing the transit time, as required by Fermat's Principle.