PHY 431 Homework Set #3

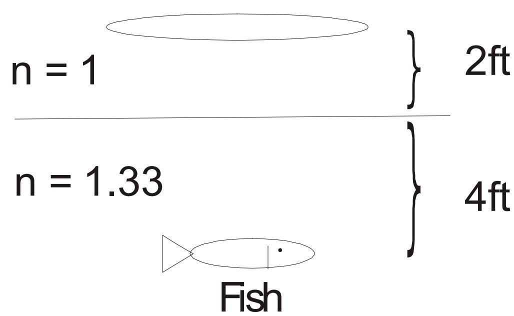
Due October 6 at the start of class

1) ***Ray Tracing (10%)***

An object of vertical height L is located an axial distance 2f from a thin glass lens. Sketch the rays **to scale** for each of two lenses of equal focal length but opposite sign, i.e., a bi-convex and a bi-concave lens. Draw three rays for each lens that define the image.

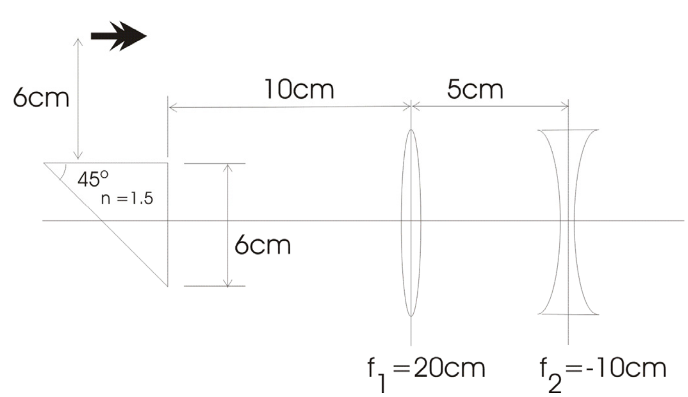
2) ***Imaging - Thin lens (20%)***

A small fish, four feet below the surface of Lake Lansing is viewed through a simple thin converging lens with focal length 30 feet. If the lens is 2 feet above the water surface, where is the image of the fish seen by the observer? Assume the fish lies on the optical axis of the lens and that $n_{air}=1$, $n_{water}=1.33$.



3) ***Imaging - Prism/Thin lens (20%)***

For the combination of one prism and 2 lenses shown (Fig. 1), find the location and size of the final image when the object, length 1 cm, is located as shown in the figure. [Hint: Treat the prism as a mirror, but you have to take into account the image shift caused by the prism (equivalent to a glass plate of thickness 6 cm)]



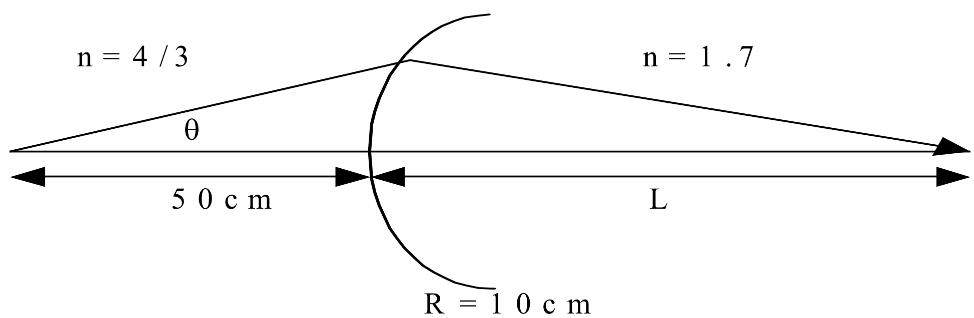
4) ***Compound lens (25%)***

   a. [Hecht 6.14] A compound lens is composed of two thin lenses separated by 10 cm. The first of these has a focal length of +20cm, and the second a focal length of –20cm. Determine the focal length of the combination and locate the corresponding principal points. Draw a diagram of the system.

   b. Three identical positive lenses, of focal length *f*, are aligned and separated by a distance *f* from each other. An object is located *f/2* in front of the leftmost lens. Find the position and the magnification power of the resultant image.

5) ***Paraxial approximation*** (25%)

   You will explore some of the differences between real and paraxial rays in this problem. For each part below, trace the specified ray and determine where it crosses the optical axis. Show all calculations and include a diagram. Report your answers to 4 decimal places. Use the same analysis we discussed in class.



a) Find L when $\theta = 5°$ with real ray (no paraxial approximation).
b) Find L when $\theta = 0.5°$ with real ray (no paraxial approximation).
c) Repeat part (a) with the paraxial ray (paraxial approximation)
d) Repeat part (b) with the paraxial ray (paraxial approximation)
e) Is there a difference between your answers in (a) and (b)? Is there any difference between your answers in (c) and (d)?
f) Now compare your answers in (b) and either (c) or (d). Why are they so similar?