Phys 531 Assignment 4 Due October 5

1. Determine the difference in phase shift introduced to TE and TM waves when they totally internally reflect off the boundary between SF11 glass ($n = 1.7$) and air ($n = 1$). The angle of incidence θ_i is 10° larger than the critical angle θ_c.

2. At a wavelength of 560 nm, nickel has a complex index of refraction $\tilde{n} = 1.8 + 3.3i$. Numerically compute and plot $R_\perp$ and $R_\parallel$ as a function of θ_i. Turn in your plot and a printout of the commands used to generate it.

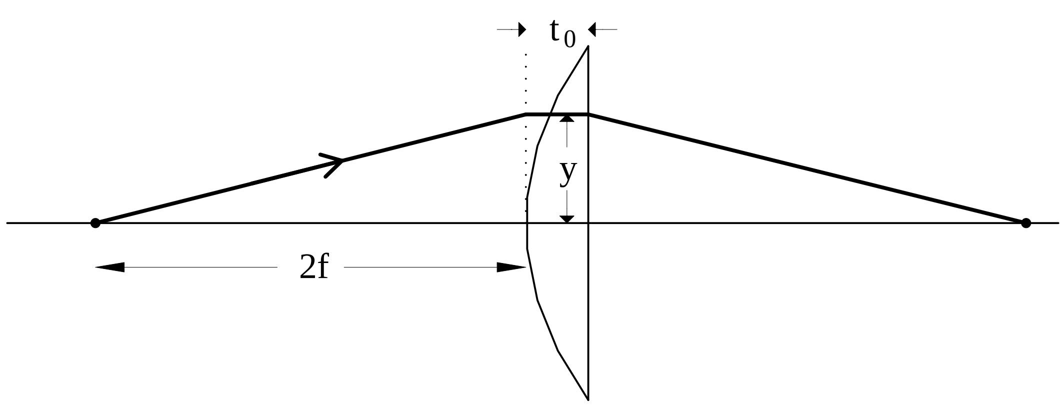
3. A plano-convex (PCX) lens is one in which one surface is convex with radius of curvature R, and the other is flat. A bi-convex (BCX) lens is one in which both surfaces are convex with radius R. Given R and the index of refraction n, find expressions for the focal length of a thin lens for both types. Does the orientation (which surface comes first) matter for a PCX lens?

4. Consider a thin PCX lens with radius of curvature R and refractive index n.

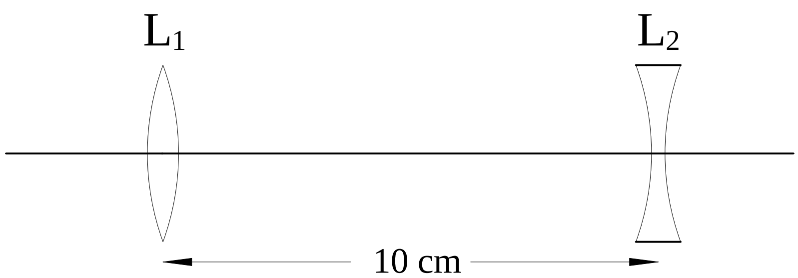
(a) If the thickness of the lens at the center ($y = 0$) is t_0, calculate its thickness t as a function of the ray height y. Use the Taylor expansion to approximate your answer to second order in y (that is, keep terms up to y^2).

(b) From problem 3, you know the focal length of this lens. Suppose it is used to image an object a distance $2f$ in front of the first surface. Use the thin lens equation to find the location of the image.

(c) Calculate the optical path length from the object to the image for a ray passing through the lens at height y. Approximate that the ray passes horizontally through the lens, as shown. Expand your answer to second order in y. Is your result consistent with Fermat's principle?



5. Consider the optical system shown, where L_1 is a thin lens of focal length $f_1 = 10$ cm and L_2 is a thin lens with focal length $f_2 = -20$ cm. If the lenses are separated by 10 cm and the object plane is located 15 cm in front of L_1, where is the image plane?



6. Suppose a thin lens with focal length $f = 30$ cm is used to image a real object located 20 cm away. Determine the location of the image and the magnification, and draw an accurate ray diagram showing all three simple rays.