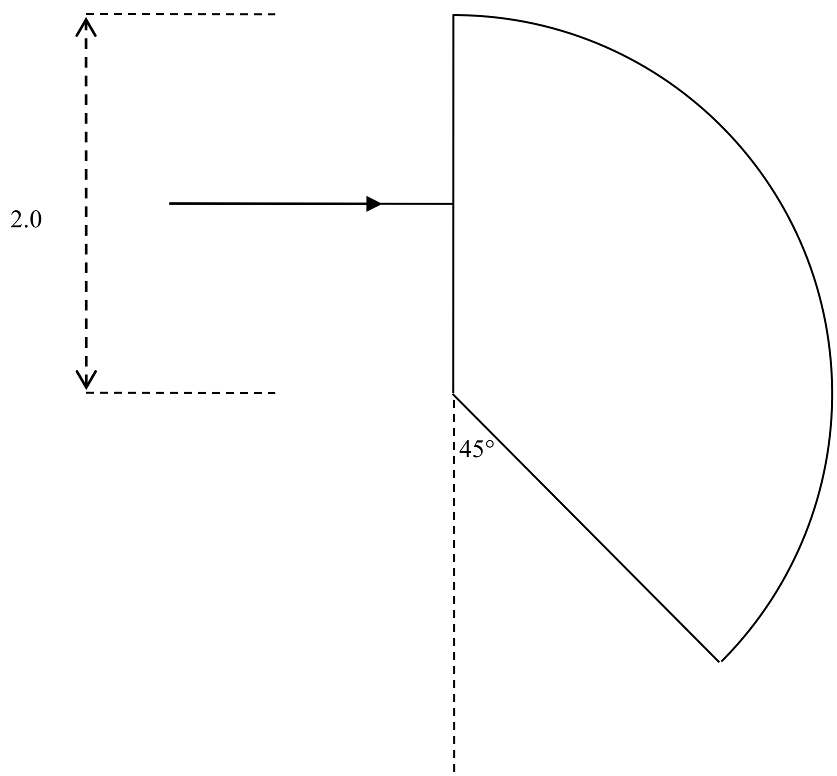
Disclaimer: Also practice single slit, double slit, diffraction grating, and polarizers (and anything else I forgot). Just putting this much together has fried my brain…

1) A crystal with index of refraction 2.3 is cut into the unusual shape shown in the figure. The shape is essentially a semi-circle with a 45° slice removed. The radius is 2.0 cm. Light is normally incident on the vertical face at the midpoint of that face.

a) Sketch any reflected and refracted rays for the first time light reaches the curved surface. Clearly label the figure with all angles labeled in a clearly legible fashion. Show all work for credit.

b) Sketch any reflected and refracted rays for the first time the light reaches the slanted surface.

c) Lastly, would things differ significantly for the curved surface if the crystal was submerged in water with index 1.33?



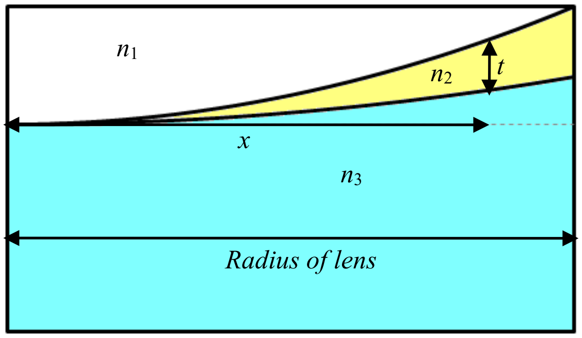
2) Know the answers to all the conceptual questions in the workbook. For example, what happens to erg, wavelength, speed, frequency of a photon upon changing medium? Or, which has more energy per photon: blue versus red light? Another example: is it possible for light to be refracted but not reflected at a particular interface of two materials? What about the other way around (reflection but not refraction)? Explain why or why not and support your answer with words and pictures. Last example, how do double slit or single slit patterns change

3) A reflective, hemispherical bowl has an unknown radius of curvature. When looking at one side of the bowl, an object that is distance p from the bowl forms a real image with a distance of 0.8 m from the bowl. Turning the bowl around, the same object with distance p from the bowl now forms a virtual image with distance 0.4 m from the bowl.

a) Assuming each side of the bowl acts as a spherical mirror, determine the object distance p and curvature of the bowl R. Don't forget that one side of the bowl is concave while the other side is convex. You should be able to determine which side is concave or convex by considering the types of images formed.

b) Draw a ray diagram for each of the above cases.

c) Lastly, plot q vs p for both sides of the bowl.



4) A cross-sectional view (right half only) of an unusual camera lens is shown. The lens is designed such that the surface between materials 1 and 2 is described by the equation $y=ax^2$ where y is the height above the horizontal axis shown. The surface between materials 2 and 3 is the top of a plano-concave lens with radius of curvature 2.00 m. The radius of the lens is 30.0 cm.

a) Determine the units of a.

b) Assume n_1=1.3, n_2=1.6, and n_3=1.5. What will be that phase shift (if any) at the two interfaces of interest? Answer in terms of wavelengths of phase shift…$\lambda/2$, $\lambda/4$, λ, $2\lambda/3$, etc)

c) What is the thickness of the film (the one with index n_2) at an arbitrary position from the center x in terms of a & x? Specifically note values of a for which this problem is actually valid. Hint: expand your function for t for small values of x and simplify the equation.

d) Determine the minimum horizontal position form the center of the lens for which blue light with wavelength 450 nm and red light with wavelength 750 nm will both experience strong reflection. Think: if white light was incident upon the film at this location what color would the reflection (at this point be). What color would the light transmitted at this location be?

e) Where would you expect fringes to be more closely spaced in the figure (the right side or the left side)? Explain why. Sketch what a top view of the interference pattern should look like (remember that I have only shown the right half of the lens, the left half would look symmetric to the right half. Also, it is reasonable to assume the lens has cylindrical symmetry.

f) Strictly speaking, the lens has two thin films (one has index n_1 while the other is the one with index n_2). If you are really insane, one could calculate similar information for the other film as well. Rather than do all that, just practice getting the film thickness as a function of x and determine the appropriate bright and dark conditions based on the number of phase reversals.

g) Bonus(I thought about this as I was writing the problem): Suppose the coating was formed by applying a liquid which then dried out to form the parabolic shape. What would be the easiest way to apply a coating of this material and ensure it formed a parabolic shape? How could one adjust the parameter a? Why would anyone do this to a lens? I seriously have no idea, but it made for fun practice…

BONUS PUZZLE: The bouncing laser beam (AKA "Don't jostle the tank or Angus will cry…")

The laser beam in this tank appears to bounce as it travels through the water. It is difficult to set up this experiment. First, the tank is filled with warm water. Then, sugar cubes are dropped into the bottom of the tank (covering about 1/3 of the floor of the tank). The sugar slowly dissolves over time (a day or two) but remains predominately in the bottom of the tank (if it is left undisturbed).

Explain why the laser follows a curved path then appears to bounce off the bottom.

Hint: consider a laser beam traveling at an angle upward from the floor of the tank. As it travels into a region with less sugar, what property of the fluid might be affected (and how would that property be affected)?

Can you make a Snell's law problem for that arbitrary point in the light ray's travel at some angle upward from the floor? Think about what is the appropriate plane of the interface and the commensurate normal to the surface.

If the light ray curves back downwards, is there an analogy with TIR? I don't know if this makes sense…I'm pretty tired right now.