Problems: Week 13

Note: All solutions must have ray diagrams

13-1. A penny lies at the bottom of a swimming pool which is 4m deep. What is the apparent depth of the penny as viewed straight down if the refractive index of water is 1.33?

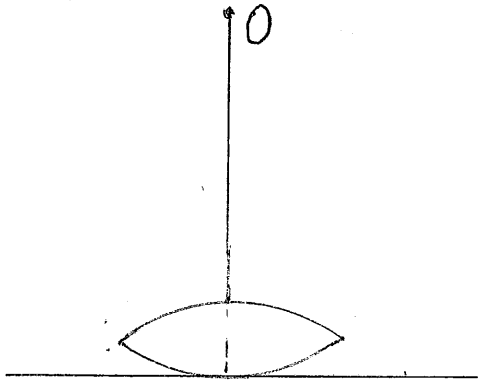
13-2. The lens maker's formula for a thin lens made of a material of refractive index n and having two spherical surfaces of radii R_F and R_B is written as

$$\frac{1}{f} = (n-1)\left[\frac{1}{R_F} - \frac{1}{R_B}\right]$$

How do you distinguish between a convergent lens and a divergent lens? [Hint: Use the sign convention that distances measured along the path of light are positive and those against the path of light are negative]

13-3. Can you use a divergent lens to produce an image which is the same size as the object? Justify your answer.

13-4. A thin convergent lens ($f = 20\,\text{cm}$) is placed on a plane mirror as shown. Where would you place the object O so that the image coincides with itself?



13-5. An object is placed a distance of 5cm from a thin convergent lens whose focal length is 10cm. Locate the image. (i) Is the image real or virtual? (ii) What is the magnification?

13-6. A double convex lens is made of glass ($n = 1.5$). The surfaces have radii in the ratio 1:2. If $f = 6$ cm, what are the radii? [Hint: Look at problem 13-2 again.]

13-7. Newton had an unusual method for writing the lens equation

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

He measured the object and image distances from the focal point and wrote

$$x = p - f \text{ and } x' = q - f$$

Show that this will lead to the lens equation

$$xx' = f^2$$

13-8. The picture shows the paths of two rays used to locate the image of a point object O. The rays are paraxial (in the picture angles are slightly exaggerated), $\alpha << 1, \beta << 1$. Show that $\delta = h/f$.

13-9. Considering that the emission of light involves the transition of one electron in one atom, explain why the phase of the light wave emitted by a simple lamp (not a laser) varies randomly in time?

13-10. When would you regard two sources of light to be incoherent?

13-11. If light waves from two identical but incoherent sources are superposed we observe twice the intensity due to one source. Why? [Hint: $(\sin A + \sin B) = 2\cos\left(\frac{A-B}{2}\right)\sin\left(\frac{A+B}{2}\right)$]

13-12. What minimum path difference is needed to produce a phase shift of π radians in light of wavelength 600nm? What would be the phase shift of 700nm light over this distance?

13-13. Green light of wavelength 436nm is incident on a 580nm thick sheet of glass with refractive index 1.5. What will be the phase difference between the wave reflected from the top surface and that reflected from the bottom surface?

13-14. Two coherent sources of 340Hz sound are 5m apart. (i) You are standing in the middle (at 2.5m) and hear nothing (this is not a comment on your aural acuity). What does this tell you about the phase difference of the two waves at their starting points? (ii) If the speed of sound is 340m/s how many such "quiet spots" (minima) will you encounter as you walk from one source to the other?