Assignment 4

OPTI 502 Optical Design and Instrumentation I

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Exercise 1

The reduced thickness in this case, help us to obtain the equivalent air space of the medium of refractive index n. The greater n the shorter the equivalent distance, that because the wave propagates slower.

a) In this case, we have

$$\tau = \frac{500\ mm}{1.33} = 375.94\ mm.$$

b) The total distance is the sum of the air thickness and the reduced thickness of the water:

$$\tau_{\text{total}} = 500\ mm + 375.94\ mm = 875.94\ mm.$$

c) In this case, we assume that the thick layer of ice has **replaced** 100 m of the air distance while the distance from of the water remains the same.

- For the part a), the distance would be:

$$\tau_{\text{total}} = \frac{100\ mm}{1.31} + \frac{500\ mm}{1.33} = 452.27\ mm.$$

- For part b), the total equivalent distance is

$$\tau_{\text{total}} = 400\ mm + \frac{100\ mm}{1.31} + \frac{500\ mm}{1.33} = 852.27\ mm.$$

  Because 100 mm of aire has now been replaced by the ice.

Exercise 2

I will assume that the glass rod is intended to perform the action of the two lenses in each case so that depending on the raddi of curvatures of each surface, an incoming collimated ray will outputs collimated but scaled. Therefore, the problem reduces to find R_1 and R_2 of the rod to accomplish both conditions: remains collimated (zero total optical power), and perform magnification.

a) For a magnification of -0.5, we have

$$\Phi_{\text{total}} = \Phi_1 + \Phi_2 - \frac{t}{n}\Phi_1\Phi_2 = 0.$$

Using the magnification formula for afocal systems $m = -f_2/f_1$ and the definition of the optical power $\Phi_i = (n' - n)/R_i = 1/f_i$ allow us to related the optical power of each surface as $m = -\Phi_1/\Phi_2$. Equating the magnification if the previous formula

$$m = -\Phi_1/\Phi_2 = -0.5 \longrightarrow \Phi_1 = 0.5\Phi_2.$$

If we replace this rsult in the total power and solve for Φ_2 yields

$$(0.5\Phi_2) + \Phi_2 - \frac{t}{n}(0.5\Phi_2)\Phi_2 = 0 \longrightarrow \Phi_2 = \frac{3n}{t} = -\frac{(n-1)}{R_2}.$$

We can now substitute the refactive index and the length for then solve for R_2:

$$\Phi_2 = 30\ mm^{-1} \longrightarrow R_2 = -0.016\ mm.$$

Then, R_1 is

$$\Phi_1 = 0.5(30) = 15\ mm^{-1} \longrightarrow R_1 = \frac{n-1}{\Phi_1} = 0.033\ mm.$$

b) To achieve a magnification of $+0.5$ we do the same procedure. First, the magnification tells us

$$m = -\frac{\Phi_1}{\Phi_2} = 0.5 \longrightarrow \Phi_2 = -2\Phi_1.$$

Then, substituting in the total power and solving for Φ_1 yields

$$\Phi_1 + (-2\Phi_1) - \frac{t}{n}\Phi_1(-2\Phi_1) = 0 \longrightarrow \Phi_1 = \frac{n}{2t} = \frac{(n-1)}{R_1}.$$

The value of the raddii of curvature 1 is

$$\Phi_1 = 5\ mm^{-1} \longrightarrow R_1 = 0.10\ mm.$$

The same for R_2 is

$$\Phi_2 = -2(5) = -10\ mm^{-1} \longrightarrow R_2 = 0.050\ mm.$$