

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

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

- b) In this case, the total distance is the sum of the air thickness and the reduced thickness:

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

- 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:

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

- For part b), the total equivalent distance is

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

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 durvatures of each surface, an incoming collimated ray will outputs collimated by scaled. Therefore, the problem reduces to find R_1 and R_2 of the rod to accomplish both conditions: remains collimated, and perform magnification.

- a) For a magnification of -0.5 , we want to only scale the height but to have a net zero power of the optical system, which means that

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

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

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

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

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

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

$$\Phi_2 = 30 \rightarrow R_2 = -0.016 \text{ mm.}$$

Then, R_1 is

$$\Phi_1 = 0.5(30) = 15 \rightarrow R_1 = 0.033 \text{ mm.}$$

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

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

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

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

The value of the radii of curvature 1 is

$$\Phi_1 = 5 \rightarrow R_1 = 0.10 \text{ mm.}$$

The same for R_2 is

$$\Phi_2 = -2(5) = -10 \rightarrow R_2 = 0.050 \text{ mm.}$$