Optics

Warm-Up questions

Optics

i. The sun has a radius of $r_s = 700000$km and a distance to the earth of $R_s = 150$ million km whereas the moon has a radius of $r_m = 1700$km and a distance of $R_m = 0.38$ million km. At a total eclipse of the sun, the moon covers the sun completely. At a lunar eclipse, the moon is in the shadow of the earth (radius of earth is $r_e = 6400$km). Why is a lunar eclipse always visible when the earth is in between sun and moon, whereas we connot always see the total sun eclipse when the moon is in between the sun and the earth?

ii. Two mirrors which are touching each other along one edge are standing next to each other with an angle of 60°. You are standing in between them. How many time do you see yourself in front of you? And for which angle do you see yourself an integer number of times?

iii. What is the minimal mirror size such that you can see yourself entirely in the mirror when standing in front of it?

iv. A thermometer is made from a cylindrical glass pipe, whose inner radius is $r = 0.5$mm and outer radius is $R = 1.5$mm. The refraction index of glass is $n_1 = 1.5$ and the refraction index of air is $n_2 = 1$. How thick does the inner radius r' appears to you when you look at the thermometer from the side? Hint: Assume for simplicity that the rays propagate parallel though the thermometer (see figure 1)

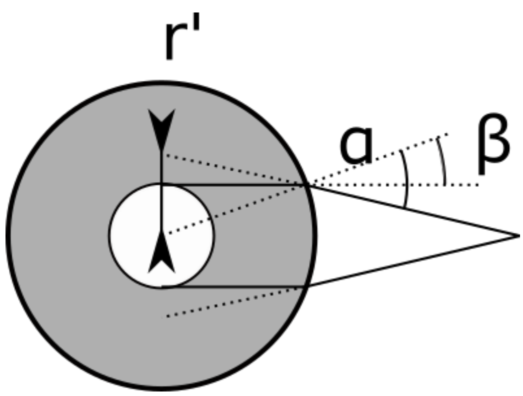

Figure 1:

v. A prism is a triangular piece of glass ($n = 1.3$), see figure 2. Assume the apex angle to be $90°$ and the incident ray has an angle of $\alpha = 60°$ with respect to the surface normal.

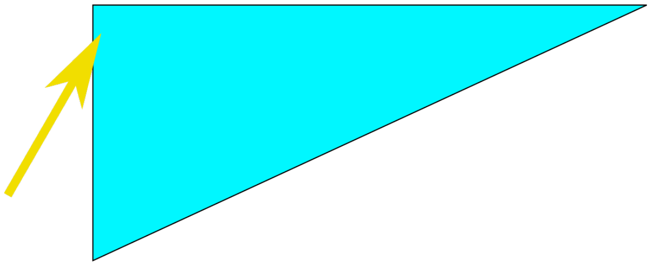

Figure 2:

a) Draw qualitatively the light path in the prism

b) How big is the angle β with respect to the surface normal for the ray after being refracted at the surface?

c) What is the distance the ray propagates though the crystal when it hits the crystal at a distance $d = 5$mm from the $90°$ apex?

d) How long does the light need to travel this distance in the crystal?

e) When reaching the other surface, which angle does it enclose with respect to that surface normal?

f) How big is the outgoing angle (in air) with respect to the second surface normal?

g) What is the minimal incident angle α where the light can leave the prism at that side before getting totally reflected?

vi. We take a lens with focal length $f = 10$cm. There is an object at a distance $u = 15$cm in front of the lens.

a) Find the position of the object's image.

b) We place a planar mirror at a distance $d = 10cm$ behind the lens. Make a suitable drawing and construct the image. At which position is the image now?

c) Can you think of an experimental method to measure the focal length of a convex lens, using this optical setup? (Hint: change u to a suitable value)

vii. You want to image a red apple (700nm wavelength) with diameter 5cm onto a screen such that the apple appears twice as big. The distance between the apple and the screen is 1.5m. To image it, you take a single (thin) lens.

a) where do you place the lens, i.e. what is the distance between the apple and the lens?

b) what is the focal length of the lens do you need to create this image?

c) A worm is watching out of that apple and smiling at you. You have a lens with smaller diameter and one with bigger diameter at hand. Which one do you take to get a better resolution of the worm?

d) Assuming the worm has a diameter of 0.1mm, what diameter do you need at most/at minimal to resolve it?