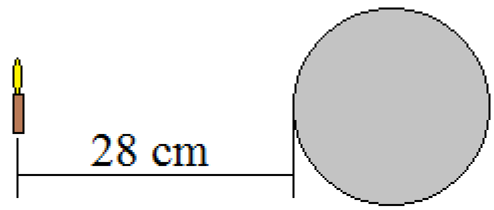
Optics

Thick lenses

Problem 1.- Find the position of the image of a candle located 28cm away from a transparent spherical crystal ball of radius 12cm and index of refraction n=1.54



Solution: First, we find the image produced by the first curvature

$$\frac{1}{28}+\frac{1.54}{d_i}=\frac{1.54-1}{12}\rightarrow d_i=165.8cm$$

This gives us the object distance for the second interface

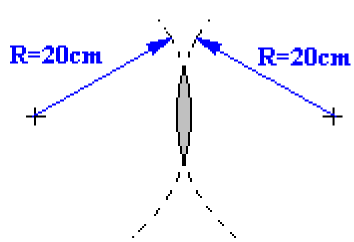
$$d_{oB}=-(d_i-24)=-(165.8-24)=-141.8cm$$

Finally, we calculate the image distance produced by the second curved glass

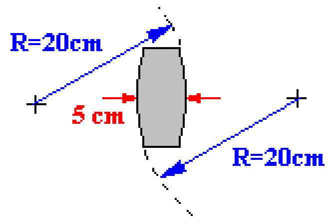
$$\frac{1.54}{-141.8}+\frac{1}{d_i}=\frac{1.54-1}{12}\rightarrow d_i=\mathbf{17.9\ cm}$$

This distance is going to be on the right side of the crystal ball.

Problem 2.- Consider a biconvex lens made of silica glass (n=1.52) with identical spherical surfaces of 20cm radius. Find the focal length of this lens assuming it is very thin.



Now assume the lens has an axial thickness of 5cm. Find the position of the image of an object located 12cm from the first vertex.



Solution: For a thin lens we can write: $\frac{1}{d_i}+\frac{1}{d_o}=\frac{n-1}{R_1}+\frac{n-1}{R_2}$ or: $f=\frac{1}{\frac{n-1}{R_1}+\frac{n-1}{R_2}}$

With the values of the problem:

$$f=\frac{1}{\frac{0.52}{20cm}+\frac{0.52}{20cm}}=\mathbf{19.2\ cm}$$

Now assuming the lens has an axial thickness of 5cm we need to be more careful. The position of the image created by the first interface can be found with the following equation:

$$\frac{1}{d_o}+\frac{n}{d_i}=\frac{n-1}{R_1}\rightarrow\frac{1}{12cm}+\frac{1.52}{d_i}=\frac{1.52-1}{20cm}\rightarrow d_i=\text{-26.5cm}$$

And then we should realize that the image created by the first interface is the object to the second interface. Including the distances between the two surfaces:

$$d_o'=-d_i+d_{12}=26.5+5=31.5cm$$

So for the second interface:

$$\frac{1.52}{31.5cm}+\frac{1}{d_i'}=\frac{1.52-1}{20cm}\rightarrow d_i'=\mathbf{-44.9cm}$$