Directions: Complete the following problems with your group. Be sure to clearly show all your work!

1. In searching the bottom of a pool at night, a watchman shines a narrow beam of light from his flashlight, 1.3 m above the water level, onto the surface of the water at a point 2.7 m from the edge of the pool. Where does the spot of light hit the bottom of the pool, measured from the wall beneath his foot, if the pool is 2.1 m deep.

\[ \tan \theta = \frac{1.3}{2.7} \quad \phi = 25.7^\circ \quad \theta_1 = 90 - \phi = 64.3^\circ \]

\[ \sin \theta_1 = \sin \theta_2 \]

\[ \theta_2 = \sin^{-1}\left(\frac{n_1}{1.3} \sin 44.3^\circ\right) \]

\[ \theta_2 = 42.6^\circ \]

\[ \tan \theta_2 = \frac{x}{2.1} \]

\[ x = 2.1 \tan 42.6^\circ \]

\[ x = 1.9 \text{ m} \]

\[ x' = 2.7 + 1.9 = 4.6 \text{ m} \]

2. Light is incident on an equilateral glass prism at 45 degrees to one face. Calculate the angle at which light emerges from the opposite face. Assume \( n = 1.58 \).

\[ n_1 \sin \theta_1 = n_2 \sin \theta_2 \]

\[ \theta_2 = \sin^{-1}\left(\frac{1}{1.58} \sin 45^\circ\right) \]

\[ \theta_2 = 26.6^\circ \]

\[ \theta_3 = 90 - \theta_2 = 63.4^\circ \]

\[ \theta_4 = 180 - 60 - \theta_3 = 54.6^\circ \]

\[ \theta_5 = 90 - \theta_4 = 33.4^\circ \]

\[ n_2 \sin \theta_5 = n_1 \sin \theta_6 \]

\[ \theta_6 = \sin^{-1}\left(\frac{n_2}{n_1} \sin \theta_5\right) \]

\[ \theta_6 = \sin^{-1}\left(1.58 \sin 33.4^\circ\right) \]

\[ \theta_6 = 60.4^\circ \]
1. A sharp image is located 10.0 mm behind a 5.0-mm focal-length converging lens. Find the object distance and magnification (a) using a ray diagram.

\[ \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \]

\[ \frac{1}{10} + \frac{1}{d_i} = \frac{1}{5} \]

(b) by calculation.

\[ d_i = 10 \text{ mm} \]

\[ m = \frac{d_i}{d_o} = -\frac{10}{10} = -1 \]

4. An object is located 3.0 mm behind a 5.0-mm focal-length converging lens. Find the image distance and magnification (a) using a ray diagram.

\[ \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \]

\[ \frac{1}{3} + \frac{1}{d_i} = \frac{1}{5} \]

(b) by calculation.

\[ d_i = \frac{15}{2} = 7.5 \text{ mm} \]

\[ m = \frac{d_i}{d_o} = -\frac{7.5}{3} \]

\[ m = 2.5 \]
5. An object is located 5.0 mm behind a 5.0-mm focal-length converging lens. Find the image distance (a) using a ray diagram. 

(b) by calculation.

\[ \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \]

\[ \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{5} - \frac{1}{5} = 0 \]

\[ d_i = \infty \]

6. A certain lens focuses light from an object 2.75 m away as an image 48.3 cm on the other side of the lens. What type of lens is it and what is its focal length? Is the image real or virtual?

\[ \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \]

\[ \frac{1}{2.75} + \frac{1}{0.483} = \frac{1}{f} \]

\[ f = \frac{1.233}{13.2} = 0.093 \text{ m} \]

7. (a) How far from a converging lens with a 50.0-mm-focal-length lens must an object be placed if its image is to be magnified 2.00 times and be real?

\[ \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \]

\[ \frac{1}{d_o} = \frac{1}{f} - \frac{1}{d_i} = \frac{1}{25} - \frac{1}{75} \]

\[ d_o = \frac{1}{m} = \frac{75}{2} = 37.5 \text{ mm} \]

(b) What if the image is to be virtual and magnified 2.00 times?

\[ \frac{1}{d_o} - \frac{1}{2d_o} = \frac{1}{f} \]

\[ \frac{1}{d_o} = \frac{1}{2} - \frac{1}{d_o} = \frac{1}{2} + \frac{1}{2d_o} \]

\[ m = -\frac{d_i}{d_o} = 2 \]

\[ d_i = \frac{d_o}{2} \]

\[ d_i = -2d_o \]