1. A light ray enters a diamond \((n_1 = 2.42)\) from the air \((n_2 = 1.00)\) above and is being totally internally reflected near the bottom.

(a) Find the critical angle \(\theta_1\), which is the smallest angle at which total internal reflection occurs. [2 points]

\[
\sin \theta_4 = \frac{n_2}{n_1} \sin \theta_2
\]

\[
\sin \theta_4 = \frac{1}{2.42}
\]

\[
\theta_4 = 24.9^\circ
\]

(b) Find the incoming angle \(\theta_2\) which corresponds to this critical angle. If you could not do part a), assume \(\theta_1 = 28^\circ\). [2 points]

\[
90^\circ - \theta_4 + 90^\circ + 45^\circ = 360^\circ
\]

\[
\theta_3 = 45^\circ - \theta_1
\]

\[
\theta_3 = 20.6^\circ
\]

\[
\frac{n_2 \sin \theta_2}{n_4 \sin \theta_3} = \frac{n_4 \sin \theta_3}{n_2 \sin \theta_2}
\]

\[
\sin \theta_2 = \frac{2.42 \sin 20.6^\circ}{n_4}
\]

\[
\theta_2 = 58.1^\circ
\]

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REWRITE AND SIGN THE HONOR PLEDGE: “I pledge my honor that I have not violated the Honor Code during this examination”

______________________________
Signature
2. A photographic camera has a focal length \( f = 5 \text{cm} \).

(a) What is the distance between the lens and the film when the object is placed at infinity? [2 points]

\[
\begin{align*}
\frac{1}{f} &= \frac{1}{d_o} + \frac{1}{d_i} \\
\frac{1}{d_i} &= \frac{1}{f} - \frac{1}{d_o} = \frac{1}{f} \\
d_i &= \frac{f d_o}{d_o - f} = \frac{5 \text{cm} \times 100 \text{cm}}{95 \text{cm}} = 5.26 \text{cm}
\end{align*}
\]

(b) The object moves to distance 100cm away from the lens. By how much must the lens move to focus the image on the film? In which direction? If you could not do part a) compute the image distance instead. [2 points]

\[
\begin{align*}
\frac{1}{f} &= \frac{1}{d_o} + \frac{1}{d_i} \\
\frac{1}{d_i} &= \frac{1}{f} - \frac{1}{d_o} = \frac{1}{f} \\
d_i &= \frac{f d_o}{d_o - f} = \frac{5 \text{cm} \times 100 \text{cm}}{95 \text{cm}} = 5.26 \text{cm}
\end{align*}
\]

The lens has moved 0.26cm away from the film.

(c) Draw the ray diagram (not necessarily to scale) corresponding to the situation in part b). Is the image real or virtual, upright or inverted? [2 points]

The image is real and inverted.