1. PSE6 35.P.006. [317879] The two mirrors illustrated in Figure P35.6 meet at a right angle with \( L = 1.40 \text{ m} \) and \( \theta = 41.0^\circ \). The beam of light in the vertical plane \( P \) strikes mirror 1 as shown.

![Figure P35.6](image)

(a) Determine the distance the reflected light beam travels before striking mirror 2.

(b) In what direction does the light beam travel after being reflected from mirror 2? (counterclockwise from the horizontal is positive)

\[
\text{incident angle} = \text{reflected angle} \\
\theta_{\text{in}} = \theta_{\text{ref}} \\
\theta_{\text{c}} = \theta_{\text{ref}} \text{ because of the right triangle.} \\
\therefore d = \frac{L}{\sin \theta_{\text{in}}} = \frac{1.40 \text{ m}}{\sin 41.0^\circ} \\
\therefore d = 2.13 \text{ m} \\
\]

b.) \( \theta_{\text{ref}} = 90^\circ \Rightarrow \theta_{\text{ref}} = 90^\circ - 41^\circ = 49.0^\circ \)
2. A narrow beam of sodium yellow light with wavelength 589 nm in vacuum, is incident from air onto a smooth water surface at an angle of incidence of $\theta_1 = 23.0^\circ$. Determine the angle of refraction, $\theta_2$.

a) $n_1 \sin \theta_1 = n_2 \sin \theta_2$

\[ n_1 = 1; \quad n_2 = 1.333 \]

\[ \theta_1 = 23^\circ \]

\[ \sin \theta_2 = \frac{n_1}{n_2} \sin \theta_1 \]

\[ \theta_2 = \sin^{-1} \left( \frac{n_1}{n_2} \sin \theta_1 \right) \]

\[ \theta_2 = \sin^{-1} \left( \frac{1}{1.333} \sin(23^\circ) \right) \]

\[ \theta_2 = 17.04^\circ \]

b) The frequency does not change so $\lambda t = c$, $\lambda w t = \nu = \text{velocity of light in water}$.

Also $\nu = \frac{c}{\lambda_w}$

Use $\lambda w \cdot t = \nu$

\[ \lambda_w \left( \frac{c}{\lambda_w} \right) = \frac{c}{n_2} \]

\[ \lambda_w = \frac{\lambda}{n_2} \]

\[ \lambda_w = \frac{589 \text{ nm}}{1.333} \]

\[ \lambda_w = 441.8 \text{ nm} \]
An underwater scuba diver sees the Sun at an apparent angle of $46.0^\circ$ above the horizon. What is the actual elevation angle of the Sun above the horizon?

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

\[ n_1 = 1.333, \quad n_2 = 1 \]

\[ \theta_\rho = 46.0^\circ, \quad \theta_i = 90^\circ - \theta_\rho = 44.0^\circ \]

\[ \theta_2 = \sin^{-1} \left( \frac{n_1}{n_2} \sin \theta_i \right) \]

\[ \theta_2 = \sin^{-1} \left( \frac{1.333}{1} \sin 44.0^\circ \right) \]

\[ \theta_2 = 67.8^\circ \]

\[ \theta_{elev} = 90^\circ - 67.8^\circ = 22.2^\circ \]
A laser beam is incident at an angle of 31.0° from the vertical onto a solution of corn syrup in water.

(a) If the beam is refracted to 23.84° from the vertical, what is the index of refraction of the syrup solution?

(b) Suppose the light is red, with vacuum wavelength 632.8 nm. Find its wavelength in the solution.

(c) What is its frequency in the solution?

(d) What is its speed in the solution?

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

\[ n_1 = 1.0, \theta_1 = 31.0^\circ, \theta_2 = 23.84^\circ \]

\[ n_2 = \frac{n_1 \sin \theta_1}{\sin \theta_2} \]

\[ n_2 = \frac{1.0 \sin (31.0^\circ)}{\sin (23.84^\circ)} \]

\[ n_2 = 1.27 \]

\[ \lambda' = \frac{\lambda}{n_2} \]

\[ \lambda' = \frac{632.8 \text{ nm}}{1.27} \]

\[ \lambda' = 498.3 \text{ nm} \]

(c) Frequency doesn't change

\[ f = \frac{c}{\lambda'} = \frac{3 \times 10^8 \text{ m/s}}{632.8 \text{ nm}} = 4.74 \times 10^{14} \text{ Hz} \]

(d) \[ v = f \lambda' = (4.74 \times 10^{14} \text{ Hz}) \times 498.3 \text{ nm} \]

\[ v = 2.36 \times 10^8 \text{ m/s} \] (can also use \( v = \frac{c}{n_2} \) )