Chapter 36 Solutions

*36.5*  
(1) The first image in the left mirror is 5.00 ft behind the mirror, or \textbf{10.0 ft} from the position of the person.

(2) The first image in the right mirror is located 10.0 ft behind the right mirror, but this location is 25.0 ft from the left mirror. Thus, the second image in the left mirror is 25.0 ft behind the mirror, or \textbf{30.0 ft} from the person.

(3) The first image in the left mirror forms an image in the right mirror. This first image is 20.0 ft from the right mirror, and, thus, an image 20.0 ft behind the right mirror is formed. This image in the right mirror also forms an image in the left mirror. The distance from this image in the right mirror to the left mirror is 35.0 ft. The third image in the left mirror is, thus, 35.0 ft behind the mirror, or \textbf{40.0 ft} from the person.

36.12  
For a concave mirror, \( R \) and \( f \) are positive. Also, for an erect image, \( M \) is positive. Therefore, \( M = -\frac{q}{p} = 4 \) and \( q = -4p \).

\[
\frac{1}{f} = \frac{1}{p} + \frac{1}{q} \quad \text{becomes} \quad \frac{1}{40.0 \text{ cm}} = \frac{1}{p} - \frac{1}{4p} = \frac{3}{4p};
\]

from which, \( p = 30.0 \text{ cm} \)

36.15  
Assume that the object distance is the same in both cases (i.e., her face is the same distance from the hubcap regardless of which way it is turned). Also realize that the near image \((q = -10.0 \text{ cm})\) occurs when using the convex side of the hubcap. Applying the mirror equation to both cases gives:

(concave side: \( R = |R|, \quad q = -30.0 \text{ cm} \)) \[
\frac{1}{p} - \frac{1}{30.0} = \frac{2}{|R|},
\]

or

\[
\frac{2}{|R|} = \frac{30.0 \text{ cm} - p}{(30.0 \text{ cm})p}
\]

[1]
(convex side: $R = -|R|, \ q = -10.0 \text{ cm}$)

$$\frac{1}{p} - \frac{1}{10.0} = -\frac{2}{|R|}, \ \text{or} \ \frac{2}{|R|} = \frac{p - 10.0 \text{ cm}}{(10.0 \text{ cm})p}$$

(a) Equating Equations (1) and (2) gives:

$$\frac{30.0 \text{ cm} - p}{3.00} = p - 10.0 \text{ cm} \ \text{or} \ \ p = 15.0 \text{ cm}$$

Thus, her face is 15.0 cm from the hubcap.

(b) Using the above result ($p = 15.0 \text{ cm}$) in Equation [1] gives:

$$\frac{2}{|R|} = \frac{30.0 \text{ cm} - 15.0 \text{ cm}}{(30.0 \text{ cm})(15.0 \text{ cm})} \ \text{or} \ \frac{2}{|R|} = \frac{1}{30.0 \text{ cm}}, \ \text{and} \ |R| = 60.0 \text{ cm}$$

The radius of the hubcap is 60.0 cm.

36.24 For a plane surface,

$$\frac{n_1}{p} + \frac{n_2}{q} = \frac{n_2 - n_1}{R} \ \text{becomes} \ q = -\frac{n_2 p}{n_1}.$$

Thus, the magnitudes of the rate of change in the image and object positions are related by

$$\left| \frac{dq}{dt} \right| = \frac{n_2}{n_1} \left| \frac{dp}{dt} \right|$$

If the fish swims toward the wall with a speed of 2.00 cm/s, the speed of the image is given by

$$v_{\text{image}} = \left| \frac{dq}{dt} \right| = \frac{1.00}{1.33} (2.00 \text{ cm/s}) = 1.50 \text{ cm/s}$$
The image is inverted: \[ M = \frac{h'}{h} = \frac{-1.80 \text{ m}}{0.0240 \text{ m}} = -75.0 = \frac{-q}{p} \]

\[ q = 75.0p \]

(b) \[ q + p = 3.00 \text{ m} = 75.0p + p \]

\[ p = 39.5 \text{ mm} \]

(a) \[ q = 2.96 \text{ m} \]

\[ \frac{1}{f} = \frac{1}{p} + \frac{1}{q} = \frac{1}{0.0395 \text{ m}} \]

\[ f = 39.0 \text{ mm} \]