1.) Question
Answer: red

2.) textbook

3.) textbook

Problem 4:

$$\Delta x = ct; \qquad c = \frac{\Delta x}{t} = \frac{2\left(1.50\times 10^{8}\ \text{km}\right)\left(1\,000\ \text{m/km}\right)}{\left(22.0\ \text{min}\right)\left(60.0\ \text{s/min}\right)} = 2.27\times 10^{8}\ \text{m/s} = \boxed{227\ \text{Mm/s}}$$

Problem 5:

At entry, $n_1 \sin\theta_1 = n_2 \sin\theta_2$

or $1.00 \sin 30.0° = 1.50 \sin\theta_2$

$\theta_2 = 19.5°$.

The distance h the light travels in the medium is given by

$$\cos\theta_2 = \frac{2.00\ \text{cm}}{h}$$

or $h = \dfrac{2.00\ \text{cm}}{\cos 19.5°} = 2.12\ \text{cm}$.

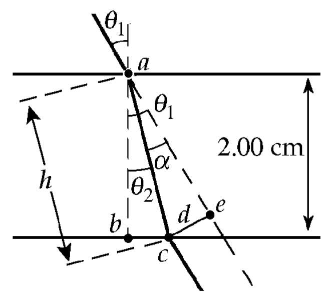

FIG. P35.21

The angle of deviation upon entry is

$\alpha = \theta_1 - \theta_2 = 30.0° - 19.5° = 10.5°$.

The offset distance comes from $\sin\alpha = \dfrac{d}{h}$: $d = \left(2.21\ \text{cm}\right)\sin 10.5° = \boxed{0.388\ \text{cm}}$.

Problem 6:

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

$\sin\theta_1 = 1.333 \sin 45°$

$\sin\theta_1 = \left(1.33\right)\left(0.707\right) = 0.943$

$\theta_1 = 70.5° \rightarrow \boxed{19.5°\ \text{above the horizon}}$

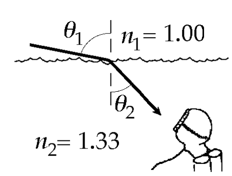

FIG. P35.13

Problem 7:

P35.44 Assume the lifeguard's initial path makes angle θ_1 with the north-south normal to the shoreline, and angle θ_2 with this normal in the water. By Fermat's principle, his path should follow the law of refraction:

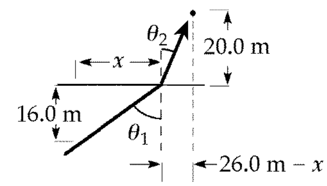

FIG. P35.44

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{7.00 \text{ m/s}}{1.40 \text{ m/s}} = 5.00 \text{ or } \theta_2 = \sin^{-1}\left(\frac{\sin\theta_1}{5}\right).$$

The lifeguard on land travels eastward a distance $x = (16.0 \text{ m})\tan\theta_1$. Then in the water, he travels $26.0 \text{ m} - x = (20.0 \text{ m})\tan\theta_2$ further east. Thus,

$$26.0 \text{ m} = (16.0 \text{ m})\tan\theta_1 + (20.0 \text{ m})\tan\theta_2$$

$$\text{or } 26.0 \text{ m} = (16.0 \text{ m})\tan\theta_1 + (20.0 \text{ m})\tan\left[\sin^{-1}\left(\frac{\sin\theta_1}{5}\right)\right].$$

There is no analytical solution to this problem. A computer program is the only way to solve this. A simple way is to use for example an Excel table. You put the degrees in one column and the above equation for the solution of the path length in the next column.

We home in on the solution as follows:

θ_1 (deg)	50.0	60.0	54.0	54.8	54.81
right-hand side	22.2 m	31.2 m	25.3 m	25.99 m	26.003 m

The lifeguard should start running at $\boxed{54.8° \text{ east of north}}$.

Problem 8:

$$\frac{1}{q} = \frac{1}{f} - \frac{1}{p} = -\frac{1}{0.275 \text{ m}} - \frac{1}{10.0 \text{ m}} \quad \text{gives} \quad \boxed{q = -0.267 \text{ m}}.$$

Thus, the image is $\boxed{\text{virtual}}$.

$$M = \frac{-q}{p} = -\frac{-0.267}{10.0 \text{ m}} = \boxed{0.026\,7}$$

Thus, the image is $\boxed{\text{upright}}$ $(+M)$ and $\boxed{\text{diminished}}$ $(|M| < 1)$.

Problem 9:

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

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q} \text{ becomes } \frac{1}{40.0\text{ cm}} = \frac{1}{p} - \frac{1}{4p} = \frac{3}{4p}\text{; from which, } p = \boxed{30.0\text{ cm}}.$$

Problem 10:

With

$$M = \frac{h'}{h} = \frac{+4.00\text{ cm}}{10.0\text{ cm}} = +0.400 = -\frac{q}{p}$$

$$q = -0.400p$$

the image must be virtual.

(a) It is a $\boxed{\text{convex}}$ mirror that produces a diminished upright virtual image.

(b) We must have

$$p + |q| = 42.0\text{ cm} = p - q$$

$$p = 42.0\text{ cm} + q$$

$$p = 42.0\text{ cm} - 0.400p$$

$$p = \frac{42.0\text{ cm}}{1.40} = 30.0\text{ cm}$$

The mirror is $\boxed{\text{at the 30.0 cm mark}}$.

(c) $\frac{1}{p} + \frac{1}{q} = \frac{1}{f} = \frac{1}{30\text{ cm}} + \frac{1}{-0.4(30\text{ cm})} = \frac{1}{f} = -0.050\,0/\text{cm}$ $\quad \boxed{f = -20.0\text{ cm}}$

The ray diagram looks like Figure 36.15(c) in the text.

Problem 11:

When $R \to \infty$, the equation describing image formation at a single refracting surface becomes $q = -p\left(\frac{n_2}{n_1}\right)$. We use this to locate the final images of the two surfaces of the glass plate. First, find the image the glass forms of the *bottom* of the plate.

$$q_{B1} = -\left(\frac{1.33}{1.66}\right)(8.00\text{ cm}) = -6.41\text{ cm}$$

This virtual image is 6.41 cm below the top surface of the glass of 18.41 cm below the water surface. Next, use this image as an object and locate the image the water forms of the bottom of the plate.

$$q_{I2} = -\left(\frac{1.00}{1.33}\right)(18.41 \text{ cm}) = -13.84 \text{ cm} \text{ or}$$

13.84 cm below the water surface.

Now find image the water forms of the *top* surface of the glass.

$$q_3 = -\left(\frac{1}{1.33}\right)(12.0 \text{ cm}) = -9.02 \text{ cm} \quad \text{or}$$

9.02 cm below the water surface.

Therefore, the apparent thickness of the glass is $\Delta t = 13.84 \text{ cm} - 9.02 \text{ cm} = \boxed{4.82 \text{ cm}}$.

Problem 12:

For a plane surface, $\frac{n_1}{p} + \frac{n_2}{q} = \frac{n_2 - n_1}{R}$ 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

$$v_{\text{image}} = \left|\frac{dq}{dt}\right| = \frac{1.00}{1.33}(2.00 \text{ cm/s}) = \boxed{1.50 \text{ cm/s}}.$$

Problem 13:

answer: r