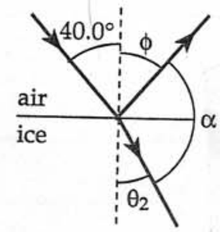
PHYSICS 122 PROB. SET 8. SOLUTIONS

6. The spectrum of the light sent back to you from a drop at the top of the rainbow arrives such that the red light (deviated by an angle of 42°) strikes the eye while the violet light (deviated by 40°) passes over your head. Thus, the top of the rainbow looks red. At the bottom of the bow, violet light arrives at your eye and red light is deviated toward the ground. Thus, the bottom part of the bow appears violet.

22.13 From Snell's law,



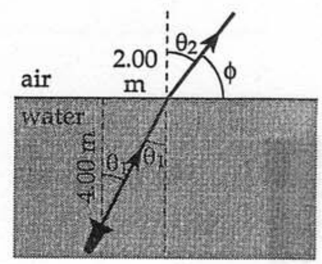
$$\theta_2 = \sin^{-1}\left[\frac{n_1 \sin\theta_1}{n_2}\right] = \sin^{-1}\left[\frac{(1.00)\sin 40.0°}{1.309}\right] = 29.4°,$$

and from the law of reflection, $\phi = \theta_1 = 40.0°$.

Hence, the angle between the reflected and refracted rays is

$$\alpha = 180° - \theta_2 - \phi = 180° - 29.4° - 40.0° = \boxed{111°}$$

22.16 The angle of incidence is



$$\theta_1 = \tan^{-1}\left[\frac{2.00\text{ m}}{4.00\text{ m}}\right] = 26.6°$$

Therefore, Snell's law gives

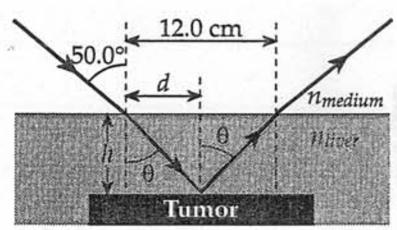
$$\theta_2 = \sin^{-1}\left[\frac{n_1 \sin\theta_1}{n_2}\right]$$

$$= \sin^{-1}\left[\frac{(1.333)\sin 26.6°}{1.00}\right] = 36.6°$$

and the angle the refracted ray makes with the surface is

$$\phi = 90.0° - \theta_2 = 90.0° - 36.6° = \boxed{53.4°}$$

22.24 From Snell's law, $\sin\theta = \left(\frac{n_{medium}}{n_{liver}}\right)\sin 50.0°$.



But, $\frac{n_{medium}}{n_{liver}} = \frac{c/v_{medium}}{c/v_{liver}} = \frac{v_{liver}}{v_{medium}} = 0.900$,

so, $\theta = \sin^{-1}\left[(0.900)\sin 50.0°\right] = 43.6°$.

From the law of reflection,

$$d = \frac{12.0\text{ cm}}{2} = 6.00\text{ cm}, \text{ and } h = \frac{d}{\tan\theta} = \frac{6.00\text{ cm}}{\tan(43.6°)} = \boxed{6.30\text{ cm}}$$

22.36 Using Snell's law, the index of refraction of the liquid is found to be

$$n_{liquid} = \frac{n_{air}\sin\theta_i}{\sin\theta_r} = \frac{(1.00)\sin 30.0°}{\sin 22.0°} = 1.33$$

Thus, $\theta_c = \sin^{-1}\left(\frac{n_{air}}{n_{liquid}}\right) = \sin^{-1}\left(\frac{1.00}{1.33}\right) = \boxed{48.5°}$

8. A flat mirror does not reverse left and right. The image of the left hand forms on the left side and the image of the right hand forms on the right side.

23.11 The *magnified, virtual* images formed by a concave mirror are upright, so $M > 0$.

Thus, $M = -\frac{q}{p} = \frac{h'}{h} = \frac{5.00\text{ cm}}{2.00\text{ cm}} = +2.50$, giving

$$q = -2.50p = -2.50(+3.00\text{ cm}) = -7.50\text{ cm}$$

The mirror equation then gives,

$$\frac{1}{f} = \frac{2}{R} = \frac{1}{p} + \frac{1}{q} = \frac{1}{3.00\text{ cm}} - \frac{1}{7.50\text{ cm}} = \frac{2.50-1}{7.50\text{ cm}},$$

or $$f = \frac{7.50\text{ cm}}{1.50} = \boxed{5.00\text{ cm}}$$

23.15 The focal length of the mirror may be found from the given object and image distances as $1/f = 1/p + 1/q$, or

$$f = \frac{pq}{p+q} = \frac{(152\text{ cm})(18.0\text{ cm})}{152\text{ cm} + 18.0\text{ cm}} = +16.1\text{ cm}$$

For an upright image twice the size of the object, the magnification is

$$M = -\frac{q}{p} = +2.00 \text{ giving } q = -2.00p$$

Then, using the mirror equation again, $1/p + 1/q = 1/f$ becomes

$$\frac{1}{p}+\frac{1}{q}=\frac{1}{p}-\frac{1}{2.00p}=\frac{2-1}{2.00p}=\frac{1}{f},$$

or $$p=\frac{f}{2.00}=\frac{16.1\text{ cm}}{2.00}=\boxed{8.05\text{ cm}}$$

23.31 From the thin lens equation, $\frac{1}{p}+\frac{1}{q}=\frac{1}{f}$, the image distance is found to be

$$q=\frac{fp}{p-f}=\frac{(-20.0\text{ cm})p}{p-(-20.0\text{ cm})}=-\frac{(20.0\text{ cm})p}{p+20.0\text{ cm}}$$

(a) If $p=40.0\text{ cm}$, then $q=-13.3\text{ cm}$ and $M=-\frac{q}{p}=-\frac{(-13.3\text{ cm})}{40.0\text{ cm}}=\boxed{+1/3}$

The image is $\boxed{\text{virtual, upright, and 13.3 cm in front of the lens}}$

(b) If $p=20.0\text{ cm}$, then $q=-10.0\text{ cm}$ and

$$M=-\frac{q}{p}=-\frac{(-10.0\text{ cm})}{20.0\text{ cm}}=\boxed{+1/2}$$

The image is $\boxed{\text{virtual, upright, and 10.0 cm in front of the lens}}$

(c) When $p=10.0\text{ cm}$, $q=-6.67\text{ cm}$ and $M=-\frac{q}{p}=-\frac{(-6.67\text{ cm})}{10.0\text{ cm}}=+2/3$

The image is $\boxed{\text{virtual, upright, and 6.67 cm in front of the lens}}$