P35.2 $\Delta x = ct$; $c = \frac{\Delta x}{t} = \frac{2(1.50 \times 10^8 \text{ km})(1\,000 \text{ m/km})}{(22.0 \text{ min})(60.0 \text{ s/min})} = 2.27 \times 10^8 \text{ m/s} = \boxed{227 \text{ Mm/s}}$

P35.15 (a) $n_1 \sin\theta_1 = n_2 \sin\theta_2$

$1.00 \sin 30.0° = n \sin 19.24°$

$n = \boxed{1.52}$

(c) $f = \frac{c}{\lambda} = \frac{3.00 \times 10^8 \text{ m/s}}{6.328 \times 10^{-7} \text{ m}} = \boxed{4.74 \times 10^{14} \text{ Hz}}$ in air and in syrup.

(d) $v = \frac{c}{n} = \frac{3.00 \times 10^8 \text{ m/s}}{1.52} = 1.98 \times 10^8 \text{ m/s} = \boxed{198 \text{ Mm/s}}$

(b) $\lambda = \frac{v}{f} = \frac{1.98 \times 10^8 \text{ m/s}}{4.74 \times 10^{14}\text{/s}} = \boxed{417 \text{ nm}}$

P35.18 $\sin\theta_1 = n_w \sin\theta_2$

$\sin\theta_2 = \frac{1}{1.333}\sin\theta_1 = \frac{1}{1.333}\sin(90.0° - 28.0°) = 0.662$

$\theta_2 = \sin^{-1}(0.662) = 41.5°$

$h = \frac{d}{\tan\theta_2} = \frac{3.00 \text{ m}}{\tan 41.5°} = \boxed{3.39 \text{ m}}$

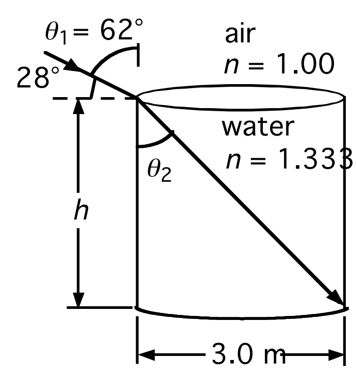

FIG. P35.18

P35.29 From Fig 35.21 $n_v = 1.470$ at 400 nm and $n_r = 1.458$ at 700 nm.

Then $1.00 \sin\theta = 1.470 \sin\theta_v$ and $1.00 \sin\theta = 1.458 \sin\theta_r$

$$\delta_r - \delta_v = \theta_r - \theta_v = \sin^{-1}\left(\frac{\sin\theta}{1.458}\right) - \sin^{-1}\left(\frac{\sin\theta}{1.470}\right)$$

$$\Delta\delta = \sin^{-1}\left(\frac{\sin 30.0°}{1.458}\right) - \sin^{-1}\left(\frac{\sin 30.0°}{1.470}\right) = \boxed{0.171°}$$

P35.30 $n(700\text{ nm}) = 1.458$

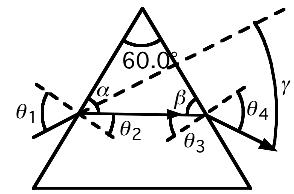

FIG. P35.30

(a) $(1.00)\sin 75.0° = 1.458\sin\theta_2$; $\theta_2 = \boxed{41.5°}$

(b) Let $\theta_3 + \beta = 90.0°$, $\theta_2 + \alpha = 90.0°$ then $\alpha + \beta + 60.0° = 180°$.
So $60.0° - \theta_2 - \theta_3 = 0 \Rightarrow 60.0° - 41.5° = \theta_3 = \boxed{18.5°}$.

(c) $1.458\sin 18.5° = 1.00\sin\theta_4$ $\qquad \theta_4 = \boxed{27.6°}$

(d) $\gamma = (\theta_1 - \theta_2) + [\beta - (90.0° - \theta_4)]$
$\gamma = 75.0° - 41.5° + (90.0° - 18.5°) - (90.0° - 27.6°) = \boxed{42.6°}$

***P35.40** (a) A ray along the inner edge will escape if any ray escapes. Its angle of incidence is described by $\sin\theta = \dfrac{R-d}{R}$ and by $n\sin\theta > 1\sin 90°$. Then

$$\frac{n(R-d)}{R} > 1 \qquad nR - nd > R \qquad nR - R > nd \qquad R > \boxed{\frac{nd}{n-1}}.$$

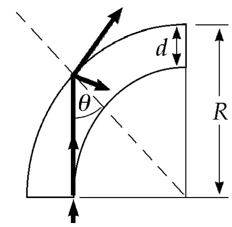

FIG. P35.40

(b) As $d \to 0$, $R_{\min} \to 0$. This is reasonable.
As n increases, $R_{\min}$ decreases. This is reasonable.
As n decreases toward 1, $R_{\min}$ increases. This is reasonable.

(c) $$R_{\min} = \frac{1.40(100\times 10^{-6}\text{ m})}{0.40} = \boxed{350\times 10^{-6}\text{ m}}$$

P35.41 From Snell's law, $n_1\sin\theta_1 = n_2\sin\theta_2$.
At the extreme angle of viewing, $\theta_2 = 90.0°$

$(1.59)(\sin\theta_1) = (1.00)\sin 90.0°$.
So $\theta_1 = 39.0°$.

Therefore, the depth of the air bubble is

$$\frac{r_d}{\tan\theta_1} < d < \frac{r_p}{\tan\theta_1}$$

or $\boxed{1.08\text{ cm} < d < 1.17\text{ cm}}$.

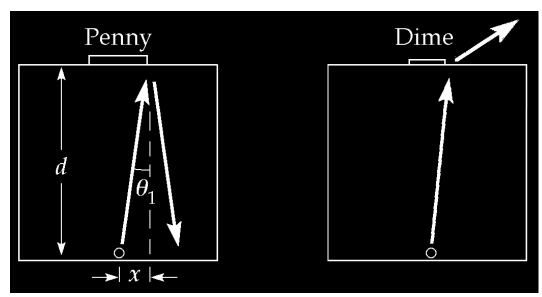

FIG. P35.41