

PHY 2130 Homework solutions Assignment 14

22.14 From Snell's law, $\theta_2 = \sin^{-1} \left[\frac{n_1 \sin \theta_1}{n_2} \right] = \sin^{-1} \left[\frac{(1.00) \sin 35.0^\circ}{1.333} \right] = \boxed{25.5^\circ}$

The wavelength in water is $\lambda_{\text{water}} = \frac{\lambda_0}{n_{\text{water}}} = \frac{589 \text{ nm}}{1.333} = \boxed{442 \text{ nm}}$

22.16 The angle of incidence is

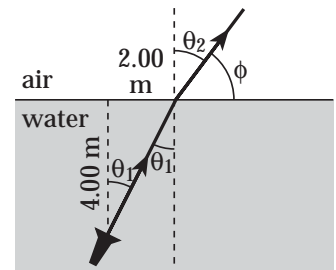
$$\theta_1 = \tan^{-1} \left[\frac{2.00 \text{ m}}{4.00 \text{ m}} \right] = 26.6^\circ$$

Therefore, Snell's law gives

$$\begin{aligned} \theta_2 &= \sin^{-1} \left[\frac{n_1 \sin \theta_1}{n_2} \right] \\ &= \sin^{-1} \left[\frac{(1.333) \sin 26.6^\circ}{1.00} \right] = 36.6^\circ \end{aligned}$$

and the angle the refracted ray makes with the surface is

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



22.18 At the first surface, the angle of incidence is $\theta_1 = \boxed{30.0^\circ}$, and Snell's law gives

$$\theta_2 = \sin^{-1} \left[\frac{n_{\text{air}} \sin \theta_1}{n_{\text{glass}}} \right] = \sin^{-1} \left[\frac{(1.00) \sin 30.0^\circ}{1.50} \right] = \boxed{19.5^\circ}$$

Since the second surface is parallel to the first, the angle of incidence at the second surface is $\theta_1 = 19.5^\circ$ and the angle of refraction is

$$\theta_2 = \sin^{-1} \left[\frac{n_{\text{glass}} \sin \theta_{\text{glass}}}{n_{\text{air}}} \right] = \sin^{-1} \left[\frac{(1.50) \sin 19.5^\circ}{1.00} \right] = \boxed{30.0^\circ}$$

Thus, the light emerges traveling parallel to the incident beam.

22.30 The angles of refraction for the two wavelengths are

$$\theta_{red} = \sin^{-1}\left(\frac{n_{air} \sin \theta_i}{n_{red}}\right) = \sin^{-1}\left(\frac{(1.000) \sin 30.00^\circ}{1.615}\right) = 18.04^\circ,$$

and $\theta_{blue} = \sin^{-1}\left(\frac{n_{air} \sin \theta_i}{n_{blue}}\right) = \sin^{-1}\left(\frac{(1.000) \sin 30.00^\circ}{1.650}\right) = 17.64^\circ$

Thus, the angle between the two refracted rays is

$$\Delta\theta = \theta_{red} - \theta_{blue} = 18.04^\circ - 17.64^\circ = \boxed{0.40^\circ}$$

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

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

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