47. The law of refraction states

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

We take medium 1 to be the vacuum, with $n_1 = 1$ and $\theta_1 = 32.0°$. Medium 2 is the glass, with $\theta_2 = 21.0°$. We solve for n_2:

$$n_2 = n_1 \frac{\sin\theta_1}{\sin\theta_2} = (1.00)\left(\frac{\sin 32.0°}{\sin 21.0°}\right) = 1.48.$$

51. (a) Approximating $n = 1$ for air, we have

$$n_1 \sin\theta_1 = (1)\sin\theta_5 \quad \Rightarrow \quad 56.9° = \theta_5$$

and with the more accurate value for n_{air} in Table 33-1, we obtain 56.8°.

(b) Eq. 33-44 leads to

$$n_1 \sin\theta_1 = n_2 \sin\theta_2 = n_3 \sin\theta_3 = n_4 \sin\theta_4$$

so that

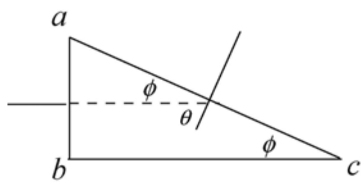
$$\theta_4 = \sin^{-1}\left(\frac{n_1}{n_4}\sin\theta_1\right) = 35.3°.$$

54. (a) Snell's law gives $n_{air}\sin(50^o) = n_{2b}\sin\theta_{2b}$ and $n_{air}\sin(50^o) = n_{2r}\sin\theta_{2r}$ where we use subscripts b and r for the blue and red light rays. Using the common approximation for air's index ($n_{air} = 1.0$) we find the two angles of refraction to be 30.176° and 30.507°. Therefore, $\Delta\theta = 0.33°$.

(b) Both of the refracted rays emerges from the other side with the same angle (50°) with which they were incident on the first side (generally speaking, light comes into a block at the same angle that it emerges with from the opposite parallel side). There is thus no difference (the difference is 0°) and thus there is no dispersion in this case.

58. The critical angle is $\theta_c = \sin^{-1}\left(\frac{1}{n}\right) = \sin^{-1}\left(\frac{1}{1.8}\right) = 34°.$

59. (a) No refraction occurs at the surface ab, so the angle of incidence at surface ac is $90° - \phi$, as shown in the figure below.



For total internal reflection at the second surface, n_g sin (90° – ϕ) must be greater than n_a. Here n_g is the index of refraction for the glass and n_a is the index of refraction for air. Since sin (90° – ϕ) = cos ϕ, we want the largest value of ϕ for which $n_g \cos \phi \geq n_a$. Recall that cos ϕ decreases as ϕ increases from zero. When ϕ has the largest value for which total internal reflection occurs, then $n_g \cos \phi = n_a$, or

$$\phi = \cos^{-1}\left(\frac{n_a}{n_g}\right) = \cos^{-1}\left(\frac{1}{1.52}\right) = 48.9°.$$

The index of refraction for air is taken to be unity.

(b) We now replace the air with water. If $n_w = 1.33$ is the index of refraction for water, then the largest value of ϕ for which total internal reflection occurs is

$$\phi = \cos^{-1}\left(\frac{n_w}{n_g}\right) = \cos^{-1}\left(\frac{1.33}{1.52}\right) = 29.0°.$$

68. (a) We use Eq. 33-49: $\theta_B = \tan^{-1} n_w = \tan^{-1}(1.33) = 53.1°$.

(b) Yes, since n_w depends on the wavelength of the light.