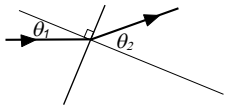
Chapter 1 Problem 57 [†]



Given
$\theta_1 = 30.0°$
$\lambda_y = 580\ nm = 5.80 \times 10^{-7}\ m$
$\lambda_g = 550\ nm = 5.50 \times 10^{-7}\ m$
$n_{air} = 1.000$
$n_y = 1.492$
$n_g = 1.493$

Solution
a) What is the angle between the green and yellow light as it leaves the polystyrene?

Begin with Snell's law and solve for the exit angle.

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

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

Solving for the exiting angle for yellow light gives

$$\theta_y = \sin^{-1}\left(\frac{1.492 \sin(30.0°)}{1.000}\right) = 48.245°$$

Solving for the exiting angle for green light gives

$$\theta_g = \sin^{-1}\left(\frac{1.493 \sin(30.0°)}{1.000}\right) = 48.288°$$

The different in the angle is

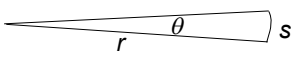
$$\Delta\theta = \theta_g - \theta_y = 48.288 - 48.245 = 0.043°$$

Converting to radians gives

$$\Delta\theta = \frac{\pi}{180}(0.043°) = 7.5 \times 10^{-4}\ rad$$

b) At what distance is are the two colors 1.00 mm apart?

Using our definition of radians



[†]Problem from Univesity Physics by Ling, Sanny and Moebs (OpenStax)

the relationship between arc length and distance is

$$s = r \cdot \theta$$

Solving for 'r' gives

$$r = \frac{s}{\Delta\theta}$$

The angle must be in radians

$$r = \frac{1.00 \times 10^{-3}\ m}{7.5 \times 10^{-4}\ rad} = 1.33\ m$$