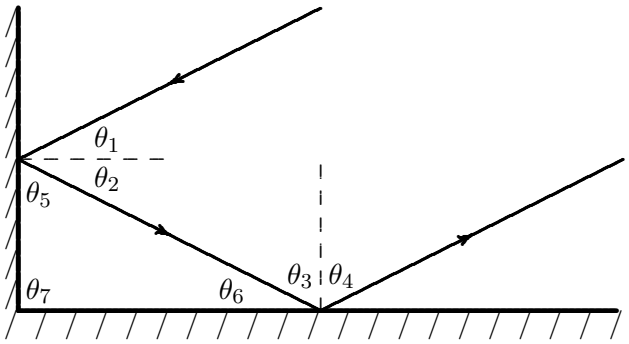
Solutions
Chapter 12

Problem 1



If the incident ray is parallel to the final reflected ray

$$\theta_1 + \theta_2 + \theta_3 + \theta_4 = 180^\circ$$

The laws of reflection give

$$\theta_1 = \theta_2, \quad \theta_3 = \theta_4.$$

Hence, from the first equation

$$2\theta_2 + 2\theta_3 = 180^\circ$$

or

$$\theta_2 + \theta_3 = 90^\circ$$

But

$$\theta_2 + \theta_5 = 90^\circ$$

Hence,

$$\theta_5 = \theta_3$$

Similarly,

$$\theta_6 = \theta_2$$

This means

$$\theta_5 + \theta_6 = 90^\circ$$

As the total angle in a triangle is 180°, this gives

$$\theta_7 = 90^\circ$$

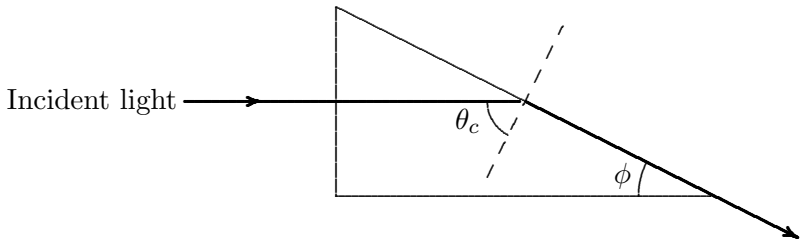
Problem 2

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

If n_1 is the refractive index of air, then $n_1 = 1.00$. Hence, for the glass

$$n_2 = \frac{n_1 \sin\theta_1}{\sin\theta_2} = \frac{1.00 \times \sin 35.0^\circ}{\sin 22.0^\circ} = 1.53$$

Problem 3



From geometry it is seen that the critical angle is

$$\theta_c = 90^\circ - \phi = 60.0^\circ.$$

If the refractive index of the liquid is n_l and that of the glass is n_g, then

$$\sin(60.0^\circ) = \sin\theta_c = \frac{n_l}{n_g} = \frac{n_l}{1.52}.$$

Hence,

$$n_l = 1.52 \times \sin(60.0^\circ) = 1.32.$$