8.19 A parallel-polarized plane wave is incident from air at an angle $\theta_i = 30^\circ$ onto a pair of dielectric layers as shown in Fig. P8.19.

(a) Determine the angles of transmission θ_2, θ_3, and θ_4.

(b) Determine the lateral distance d.

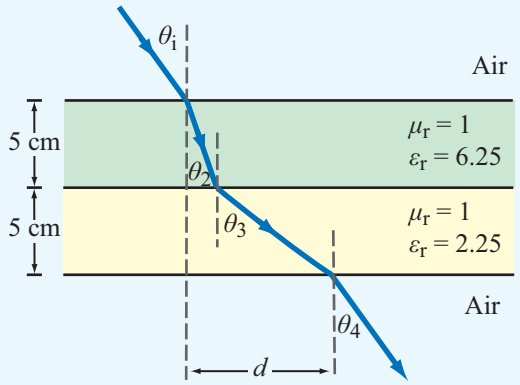

Figure P8.19 Problem P8.19.

Solution:

(a) Application of Snell's law of refraction given by (8.31) leads to:

$$\sin\theta_2 = \sin\theta_1\sqrt{\frac{\varepsilon_{r1}}{\varepsilon_{r2}}} = \sin 30^\circ\sqrt{\frac{1}{6.25}} = 0.2$$

$$\theta_2 = 11.54^\circ.$$

Similarly,

$$\sin\theta_3 = \sin\theta_2\sqrt{\frac{\varepsilon_{r2}}{\varepsilon_{r3}}} = \sin 11.54^\circ\sqrt{\frac{6.25}{2.25}} = 0.33$$

$$\theta_3 = 19.48^\circ.$$

And,

$$\sin\theta_4 = \sin\theta_3\sqrt{\frac{\varepsilon_{r3}}{\varepsilon_{r4}}} = \sin 19.48^\circ\sqrt{\frac{2.25}{1}} = 0.5$$

$$\theta_4 = 30^\circ.$$

As expected, the exit ray back into air will be at the same angle as θ_i.

(b)

$$\begin{aligned} d &= (5\text{ cm})\tan\theta_2 + (5\text{ cm})\tan\theta_3 \\ &= 5\tan 11.54^\circ + 5\tan 19.48^\circ = 2.79\text{ cm}. \end{aligned}$$