Solution Sheet - Tutorial 5 Physics-2 2019-2020 L14-L18

(Q1) $n_1 = 1,\ n_2 = \sqrt{3},\ \theta_i = 60^\circ \Rightarrow n_1 \sin\theta_i = n_2 \sin\theta_t$

$$\theta_t = \sin^{-1}\left[\frac{1}{2}\right] = 30^\circ$$

$$r_\perp = \frac{n_1 \cos\theta_i - n_2 \cos\theta_t}{n_2 \cos\theta_t + n_1 \cos\theta_i} = \frac{\cos 60 - \sqrt{3} \times \cos 30}{\cos 60 + \sqrt{3} \cos 30}$$

$$= \frac{\frac{1}{2} - \frac{3}{2}}{\frac{1}{2} + \frac{3}{2}} = -\frac{1}{2} \quad \text{Ans.}$$

(Q2) $\theta_i = 30^\circ,\ n_1 = 1,\ n_2 = 1.5 \Rightarrow \theta_t = \sin^{-1}\left[\frac{1}{1.5}\sin 30^\circ\right] = 19.47^\circ$

$$r_\perp = \frac{n_1 \cos\theta_i - n_2 \cos\theta_t}{n_1 \cos\theta_i + n_2 \cos\theta_t} = 0.2404 \Rightarrow R_\perp = |r_\perp|^2 = 0.0578$$

$$t_\perp = \frac{2 n_1 \cos\theta_i}{n_1 \cos\theta_i + n_2 \cos\theta_t} = 0.7596 \Rightarrow T_\perp = \frac{4 n_1 n_2 \cos\theta_i \cos\theta_t}{(n_1 \cos\theta_i + n_2 \cos\theta_t)^2}$$

$$= 0.9422$$

$$\Rightarrow \boxed{R_\perp + T_\perp = 1}$$

(Q3) $n_1 = 1.5,\ n_2 = 1.45 \Rightarrow NA = \sqrt{n_1^2 - n_2^2} = 0.384,\ \theta_A = \sin^{-1}[0.384] = 22.58^\circ$

$$\theta_c = \sin^{-1}\left[\frac{n_2}{n_1}\right] = 75.2^\circ$$

(Q4) $\Delta = 0.005 = \frac{n_1 - n_2}{n_1}$
$n_1 = 1.5 \Rightarrow$ (a) $n_2 = 1.4925$

(b) $\theta_c = \sin^{-1}\left[\frac{n_2}{n_1}\right] = 84.26^\circ$ (c) $NA = n_1\sqrt{2\Delta} = 0.15$

(Q5) $V = \frac{2\pi a}{\lambda}\sqrt{n_1^2 - n_2^2}$

$$= \frac{2 \times 3.1416 \times 25 \times 10^{-6}}{1300 \times 10^{-9}}\sqrt{1.54^2 - 1.50^2}$$

$$= 42.15$$

No. of modes $\Rightarrow M \approx \frac{V^2}{2} = 888$

(Q6) $L = 15$ km, Connector Loss $= 0.8$ dB
Fiber loss $= 1.5$ dB/km

Total loss for whole length $\Rightarrow \alpha L \approx (1.5 \times 15 + 0.8 \times 14)$
$= 33.7$ dB

$\alpha L = 10 \log\left(\frac{P_i}{P_o}\right) \Rightarrow P_i = 0.703\ \mu W$

*Assume 14 connectors.

(Q7) $n_1 = 1.5$, $n_2 = 1.48$ $\Big\}$ $\phi_c = 80.63^\circ = \sin^{-1}\left(\frac{n_2}{n_1}\right)$

$\theta_m = 90 - 80.63^\circ = 9.37^\circ$

$\tan\theta_m = \frac{a}{L} \Rightarrow L = \frac{a}{\tan\theta_m} = \frac{50 \times 10^{-6}\,m}{\tan(9.37^\circ)} = 3.03 \times 10^{-4}\,m$

$\Rightarrow$ Max. reflections per meter $= \frac{1}{2L} = 1650$ /m

Min reflection $\Rightarrow$ for $\theta_i = 0 \Rightarrow$ reflections are zero.