Optical FIbres - Numericals

(1) Data: $n_1 = 1.5$, $n_2 = 1.48$

to find: i_0, θ_c

$$i_0 = \sin^{-1}\left(\frac{n_2}{n_1}\right) = \sin^{-1}\left(\frac{1.48}{1.5}\right)$$

$$= 80.63^\circ$$

$$\theta_c = \sin^{-1}\left(\sqrt{n_1^2 - n_2^2}\right) = \sin^{-1}\left(\sqrt{1.5^2 - 1.48^2}\right)$$

$$= 14.13^\circ$$

② Data: $\theta_c = 25°$, $n_1 = 1.52$

to find: n_2

$$NA = \sin\theta_c = \sqrt{n_1^2 - n_2^2}$$

$$\Rightarrow n_2 = \sqrt{n_1^2 - \sin^2\theta_c}$$

$$= \sqrt{1.52^2 - \sin^2(25)}$$

$$= 1.46$$

(3) Data : $\Delta = 0.0025$, $n_1 = 1.45$

to find : NA, θ_c

$$NA = n_1 \sqrt{2\Delta}$$

$$= 1.45 \sqrt{2 \times 0.0025}$$

$$= 0.1$$

$$\theta_c = \sin^{-1}(NA) = \sin^{-1}(0.1)$$

$$= 5.88^\circ$$

(4) Data : $\theta_c = 25°$, $i_0 = 70°$

to find : n_1, n_2

$\sin i_0 = \frac{n_2}{n_1}$, $\sin\theta_c = \sqrt{n_1^2 - n_2^2} \Rightarrow \sqrt{n_1^2 - n_1^2 \sin^2 i_0}$

$\therefore \sin\theta_c = n_1 \sqrt{1 - \sin^2 i_0}$

$$\Rightarrow n_1 = \frac{\sin\theta_c}{\sqrt{1-\sin^2 i_0}} = \frac{\sin(25)}{\sqrt{1-\sin^2(70)}} = 1{\cdot}23$$

$$n_2 = n_1 \sin i_0 = 1{\cdot}23 \times \sin(70) = 1{\cdot}16$$

(5) Data: $n_1 = 1.46$, $n_2 = 1.42$, $\lambda = 1.3\ \mu m$, $a = 0.05\ mm$

to find V, N_m (SI fibre)

$$V = \frac{2\pi a}{\lambda} NA = \frac{2\pi a}{\lambda} \times \sqrt{n_1^2 - n_2^2}$$

$$= \frac{2 \times 3.14 \times 0.05 \times 10^{-3}}{1.3 \times 10^{-6}} \times \sqrt{1.46^2 - 1.42^2}$$

$$= 81.98$$

$$N_m = \frac{V^2}{2} \text{ (SI fibre)} = \frac{81.98^2}{2} \simeq 3360 \text{ mode}$$

(6) Data: $a = 0.15$ mm, $\lambda_1 = 1550$ nm, $\lambda_2 = 850$ nm, $i_0 = 80°$, $n_1 = 1.48$

to find: N_m for λ_1 and λ_2 (Graded index fibre)

$$n_2 = n_1 \sin i_0 = 1.48 \times \sin(80°) = 1.46$$

$$V = \frac{2\pi a}{\lambda} \times \sqrt{n_1^2 - n_2^2} = \frac{2 \times 3.14 \times 0.15 \times 10^{-3}}{1550 \times 10^{-9}} \times \sqrt{1.48^2 - 1.46^2}$$

(λ_1)

$$\therefore V(\lambda_1) = 147.37 \Rightarrow N_m(\lambda_1) = \frac{V^2}{4} = \frac{147.37^2}{4} \simeq 5429$$

$$2\pi a \sqrt{n_1^2 - n_2^2} = 2.28 \times 10^{-4} \text{ m}$$

$$V(\lambda_2) = \frac{2.28 \times 10^{-4}}{850 \times 10^{-9}} = 268.23 \Rightarrow N_m(\lambda_2) = \frac{V^2}{4}$$

$$= \frac{268.23^2}{4} \simeq 17987$$

(7) Data: $\lambda = 8500$ Å. $NA = 0.025$

to find; a (for SM operation)

for SM, $V < 2.405$ i.e $\frac{2\pi a}{\lambda} \times NA < 2.405$

i.e. $a < \frac{2.405 \times \lambda}{2\pi \times NA}$ i.e $a < \frac{2.405 \times 8500 \times 10^{-10}}{2 \times 3.14 \times 0.025}$

$a < 1.3 \times 10^{-6}$ m or 1.3 μm

limiting radius of core for SM operation

is 1.3 μm

(8) Data: $a = 5\,\mu m$, $\lambda = 850\,nm$, $n_1 = 1.4$, $n_2 = 1.399$

to check: if it works as SM fibre

$$V = \frac{2\pi a}{\lambda} \times NA = \frac{2\pi a}{\lambda} \times \sqrt{n_1^2 - n_2^2}$$

$$= \frac{2 \times 3.14 \times 5 \times 10^{-6}}{850 \times 10^{-9}} \times \sqrt{1.4^2 - 1.399^2}$$

$$= 1.95 < 2.405$$

since $V < 2.405$,

Fibre will work as SM fibre