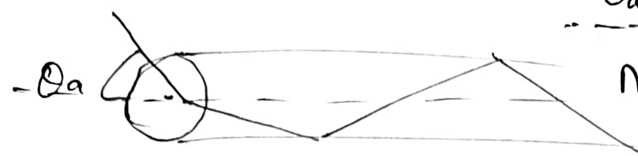
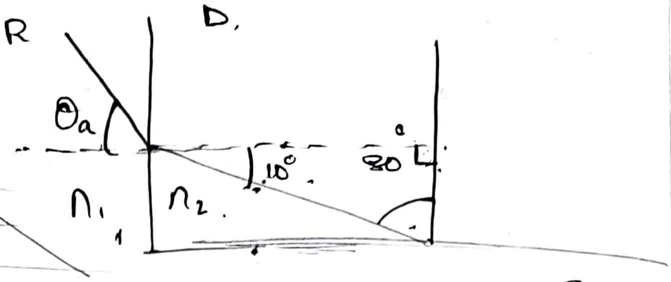
15/08/2021.

OFC.





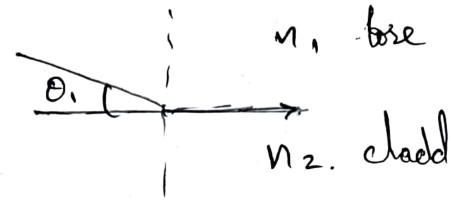
$\theta_a = \sin^{-1}\sqrt{n_1^2 - n_2^2}$

$n_1 \sin\theta_a = n_2 \sin 10^\circ$

$\theta_a = \sin^{-1}(n_2 \sin 10^\circ)$

Q1 Consider a multimode fiber with core RI of 1.48.
& a cladding with RI of 1.46.

Cal: (1) Critical angle,
(2) NA.
(3) Acceptance angle.



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

$\theta_2 = 90^\circ$.

$\sin\theta_1 = \frac{n_2}{n_1}$

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

Solution:

Critical angle θ_c =

$\theta = \sin^{-1}\left(\frac{1.46}{1.48}\right)$

$\theta_c = \cancel{67.668^\circ}\ 80^\circ$.

$\theta_a = \sin^{-1}\sqrt{n_1^2 - n_2^2}$.

$\cancel{\sin^{-1}}\sqrt{\quad}$

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

$\theta_a = 14.89^\circ$

$\longrightarrow V = \frac{2\pi a \cdot NA}{\lambda}$.

Q2 A step index fiber with normalised freq.

$V = 26.6$ @ 1300 nm λ

Radius of core: 25 μm. Cal: $Na = ?$

Core RI $= n_1$

Cladding RI. $= n_2 = 1.47.$

$$V = \frac{2\pi a\, Na}{\lambda}$$

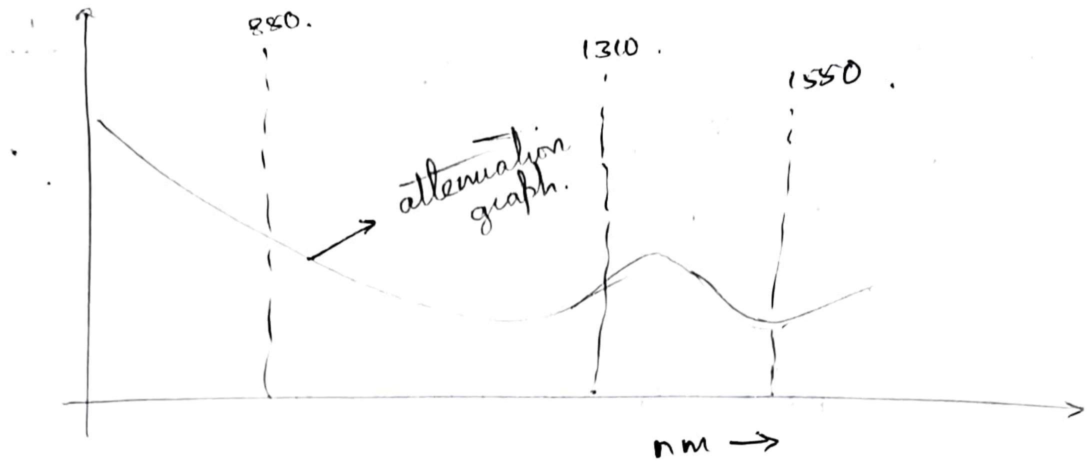
$$Na = \frac{V\lambda}{2\pi a} = 0.2201.$$

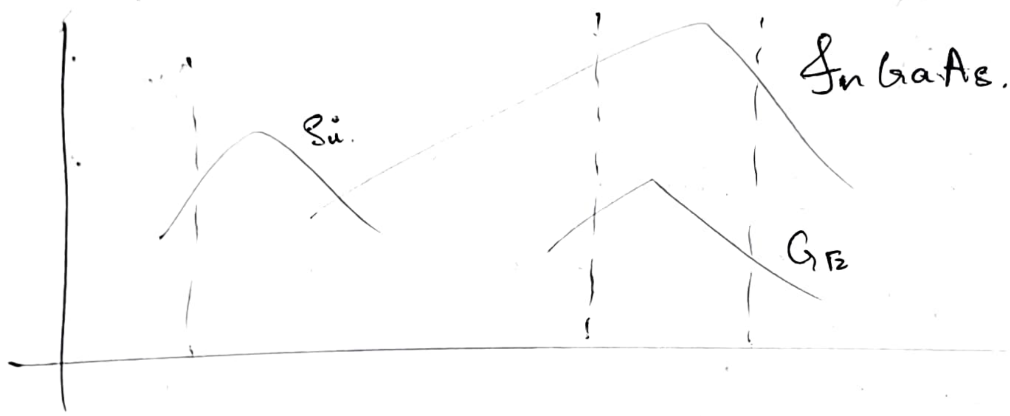
$$Na = \sqrt{n_1^2 - n_2^2}$$

$n_1 = 1.486.$

16/03/2021

OFC





(Q1) A typical relation RI difference for an OFC designed for long distance Tx is $\underline{1\%}$. Estimate the (1) NA. (2) θ_a in air for the fiber when $n_1 = 1.46$. Also calculate the $\boxed{\theta_c}$ at core cladding interface.

$n_1 = 1.46$,

$n_2 = ?$

$NA = ?$

$\theta_a =$

$\theta_c =$

$\Delta n = 1\% = \frac{1}{100}$.

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

$NA = 1.46\sqrt{2 \times 0.01} = \underline{0.206}$.

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

$\frac{n_1 - n_2}{n_1} = \frac{1}{100}$

$n_2 = \underline{1.4454}$

$\theta_c = \underline{81.89^\circ}$.

Core & cladding loss.

$P \rightarrow$ Power.

$$\alpha_{vm} = \frac{\alpha_1 P_{core}}{P} + \frac{\alpha_2 P_{clad}}{P}$$

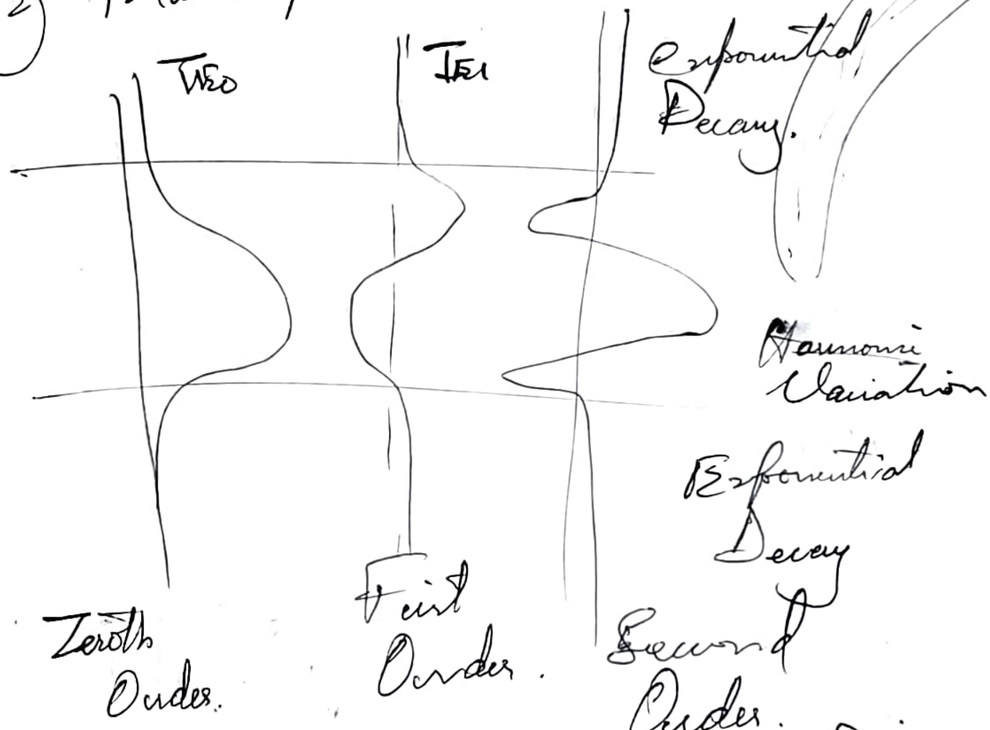
$$\alpha_{vm} = \alpha_1 + (\alpha_2 - \alpha_1)\frac{P_{clad}}{P}.$$

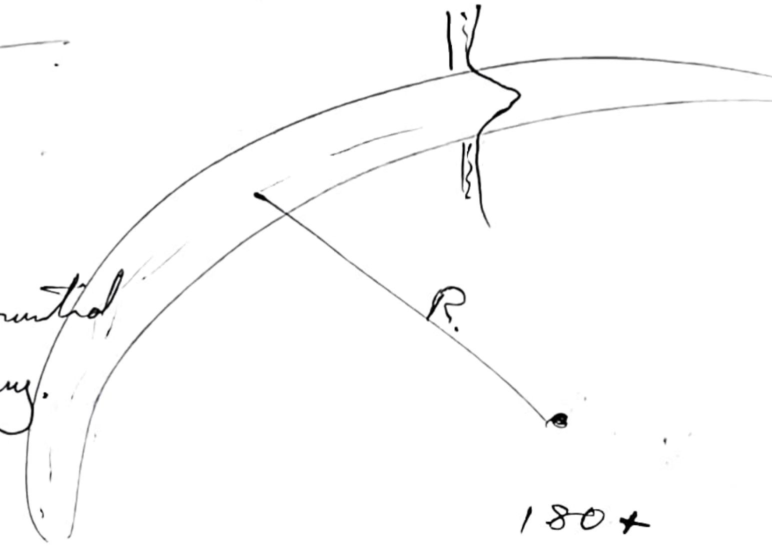
$$\alpha(r) = \alpha_1 + (\alpha_2 - \alpha_1)\frac{n^2(0) - n^2(r)}{n^2(0) - n_2^2}.$$

Losses.

Bending Loss.

1. Macroscopic Bending Loss.
2. Microscopic — " —





$$N_{eff} = N_A \left\{ 1 - \frac{\alpha+2}{2\alpha\Delta} \left[\frac{2a}{R} + \left(\frac{3}{2n_2 K R} \right)^{2/3} \right] \right\}$$

$$N_\infty = \frac{\alpha}{\alpha+2} (n_1 K a)^2 \Delta$$

$$F(\alpha_m) = \left[1 + \pi \Delta^2 \left(\frac{b}{a} \right)^4 \frac{E_f}{E_j} \right]^2$$

$E_f \rightarrow$ Young's Modulus fiber.

$E_j \rightarrow$ — " — Jacket.

(i) Mean optical power launched into a 8 km line length of OFC is 12 μW & op power is 3 μW.

Find over all signal attenuation dB. & in Nepers

For a 10 km link same fiber, compare attenuation loss if there are slices located at 1 km intervals each having an attenuation loss of 1 dB.

Sol:

$Z = 8Km$

$P_{in} = 12 \mu w$

$P_{out} = 3 \mu w$,

$$\alpha = \frac{1}{Z} \ln\left(\frac{P(in)}{P(out)}\right)$$

$$= \frac{1}{\cancel{0.00}8000} \ln\left(\frac{12}{3}\right)$$

$$\frac{1}{\cancel{0.00}8000} \ln(4) = 173 \times 10^{-6} \text{ neper}$$

$$10 \log_{10}(x) = 173 \times 10^{-6}$$

$$x = 1 \text{ Nepers}.$$

$$\alpha_p = \frac{10}{Z} \log_{10}\left[\frac{P_{in}}{P_{out}}\right] \ dB/km$$

$$= \frac{10}{8} \log_{10}(4) = 0.752 \ dB/Km$$

For 10 km line:

$10 \times 0.752 + 9$.

$7.52 + 9$

16.52 dB

$$\alpha_{uv} = \frac{154.2\,x}{46.6\,x + 60}\, 10^{2}\, \exp\left(\frac{4.63}{\lambda}\right)$$

x - mole fraction.

$$\alpha_{scattering} = \frac{8\pi^3}{3\lambda^4}\left(n^2 - 1\right)^2 K_B T_f \beta_T.$$

Nepers.

(Q3) ~~A multimode~~ SI Fiber Find numbers of ~~modes for single~~ ~~mode~~ if the fiber is replaced with single mode. Cal core dia of the single mode Fiber.

No. of modes for single mode is $\frac{V^2}{4}$

$$V = \frac{2\pi a}{\lambda}(Na)$$

$$\frac{V^2}{4} = 1 \qquad V = \cancel{1.414} \; 2 \qquad \frac{V^2}{4} = 1$$

$$V^2 = 4 \qquad V^2 = \sqrt{4} = 2$$

$$2 \cancel{.1414} = \frac{2\pi a}{\lambda}(Na)$$

$$d = 2.113 \times 10^{-6} m = 2.113 \mu m$$

$$V = 2.405$$

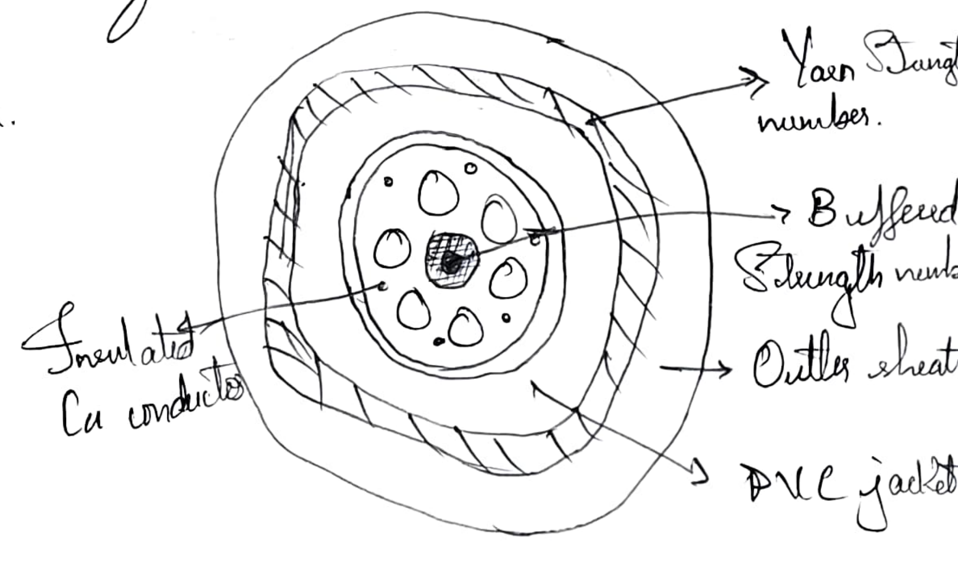
$$V = \frac{2\pi a}{\lambda}(Na) \qquad a = 1.27 \mu m$$

$$d = 2.55 \mu m$$

$$\boxed{\text{GRIN} \quad V = \frac{\pi a}{\lambda}(Na)}$$

Photonic Fiber. Faber Holey Fiber.

- Core & cladding are made of same material.

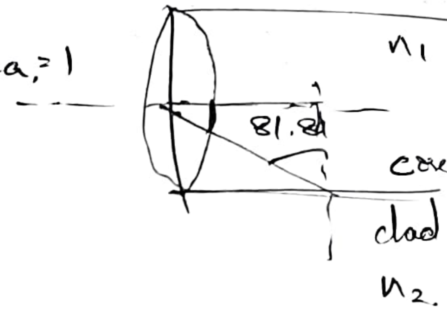


$\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$ ~~$\theta_a = \sin^{-1}\sqrt{1.46^2 - 1^2}$~~

$n_a = 1$

~~$n_1 \sin\theta_a = n_2 \sin\theta_2$~~

~~$\sin\theta_a = \frac{n_2}{n_1} \sin 81.89^\circ$~~



~~$\theta_a =$~~

$\sin\theta_a = 1.46 \sin(90 - 81.89^\circ)$

$\theta_a = 11.886^\circ$

$\varepsilon = \pi\theta_a^2 = \pi \sin^2\theta_a$ → Solid acceptance angle.

$\varepsilon =$ ~~37.3409~~. ~~443.83~~. 0.13327

17/03/2021.

Q2. A multimode step index fiber with a core dia of 80 μm & relative index diff of 1.5% is operating at a λ = 0.85 μm. If $n_1 = 1.48$, estimate the "V" for fiber & no of guided modes.

Sol: Given: $a = 80\,\mu m$

$\Delta n = 1.5\% = 0.015$

$\lambda = 0.85\,\mu m$

$n_1 = 1.48$

$V = ?$

$V = \frac{2\pi a \, NA}{\lambda}$

$\frac{n_1 - n_2}{n_1} = 0.015$

$n_2 = 1.4578$

$NA = \sqrt{n_1^2 - n_2^2} = 0.255$

$V = \frac{151.02}{2}$ Hz $= 75.51$

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

$\frac{V^2}{2} = 2850.88$