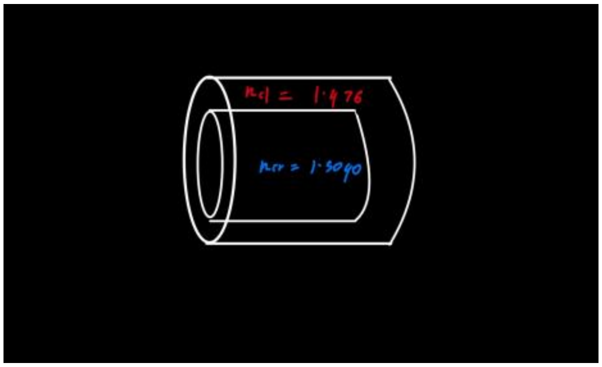

a. Critical angle for core cladding interface

$$\sin(\theta_c) = \frac{n_{cl}}{n_{cr}} = \frac{1.476}{1.5040}$$

$$= 0.9814 \Rightarrow \theta_c = \sin^{-1}(0.9814) \approx 78.94^\circ$$

b. Refractive index difference (Δ)

$$\Delta = \frac{n_{cr}^2 - n_{cl}^2}{2n_{cr}^2}$$

$$= \frac{(1.5040)^2 - (1.476)^2}{2\cdot(1.5040)^2} = \frac{2.2620 - 2.1786}{2\cdot 2.2620}$$

$$= \frac{0.0834}{4.524} \approx 0.01844 \text{ or } 1.844\%$$

c. Numerical aperture (NA)

$$NA = \sqrt{n_{cr}^2 - n_{cl}^2} = \sqrt{2.2620 - 2.1786}$$

$$= \sqrt{0.0834} \approx 0.2888$$

d. Maximum radius of the core for single mode operation for 1555nm light

$$V = \frac{2\pi a}{\lambda} NA < 2.405$$

$$a = \frac{2.405 \cdot \lambda}{2\pi \cdot NA} = \frac{2.405 \cdot 1555 \times 10^{-9}}{2\pi \cdot 0.2888}$$

$$a \approx \frac{3.740 \times 10^{-6}}{1.814} \approx 2.061 \times 10^{-6} m = 2.06 \mu m$$

2. Why has telecom industry converted from copper cables to optical fibre for long and short distance transmission?

① Higher Bandwith

optical fibres can carry much more data than copper cables making them ideal for today high-speed internet and hig data demand Application

② faster transmission speed

fiber optics trasmite data as light witch travel faster than electrical signals in copper

③ Better security

It is much harder to tap into a fiber optic cable without being detected which makes it more secure against data theft

3. A ray of light travels from air into water then into glass (n = 1.50) as shown in the diagram. Find the angle of refraction in the glass.

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

form air to water

$n_{air} = 1$

$\theta_{air} = 50^\circ$

$n_{water} = 1.33$

form water to glass

$n_{water} = 1.33$

$n_{glass} = 1.50$

find angle in water

$$1 \times \sin(50^\circ) = 1.33 \times \sin(\theta_{water})$$

$$\sin(\theta_{water}) = \frac{\sin(50^\circ)}{1.33} \approx \frac{0.7660}{1.33} \approx 0.5767$$

$$\theta_{water} = \sin^{-1}(0.5767) \approx 35.2^\circ //$$

find angle in glass

$$1.33 \times \sin(35.2^\circ) = 1.50 \times \sin(\theta_{glass})$$

$$\sin(\theta_{glass}) = \frac{1.33 \times \sin(35.2^\circ)}{1.50} \approx \frac{1.33 \cdot 0.5766}{1.50} \approx \frac{0.7679}{1.50} \approx 0.5119$$

$$\theta_{glass} = \sin^{-1}(0.5119) \approx 30.8^\circ //$$

4. An optic fiber of RI 1.50 is to be clad to ensure TIR that will contain light travelling with in **50** of the fiber axis. What minimum RI is allowed for the cladding?

Minimum RI for cladding to cladding TIR with 5 Agle to axis

Angle of incident at the Interface is $\theta i = 90^\circ - 5 = 85^\circ$

$$n_{cl} = n_{cr} = \sin(85^\circ)$$

$$= 1.50 \times 0.9962$$

$$= 1.494$$

5. The angle of acceptance of an optical fiber is **300** when kept in air. Find the acceptance angle when the same fiber is immersed in water of RI 1.33

Acceptance angle in Water (RI = 1.33) originally 30° in air

In Air

$$NA = \sin(30^\circ) = 0.5$$

In Water

$$\sin \theta_w = \frac{NA}{n_{water}} = \frac{0.5}{1.33} = 0.3759$$

$$\theta_w = 22.06^\circ$$

6. Calculate the V- number for a fiber of core diameter 40µm & RI of 1.55 and 1.50 respectively for its core & cladding when a light of wavelength 1400nm is propagating. Also calculate the number of modes that the fiber can support for the propagation.

V– Number and number of modes

Cr diameter $= 40 \cdot \mu m$ $\quad a = 20 \times 10^{-6}$

$n_{cr} = 1.55$, $n_{cl} = 1.50$ $\quad \lambda = 1400nm$

$$NA = \sqrt{1.55^2 - 1.50^2} = \sqrt{0.1525} = 0.3905$$

$$V = \frac{2\pi a}{\lambda} \times NA = \frac{2\pi \times 2 \times 10^{-6}}{1400 \times 10^{-9}} \times 0.3905 = 35.05$$

$$\text{Number of modes} = \frac{V^2}{2} = \frac{(35.05)^2}{2} = 614.25$$