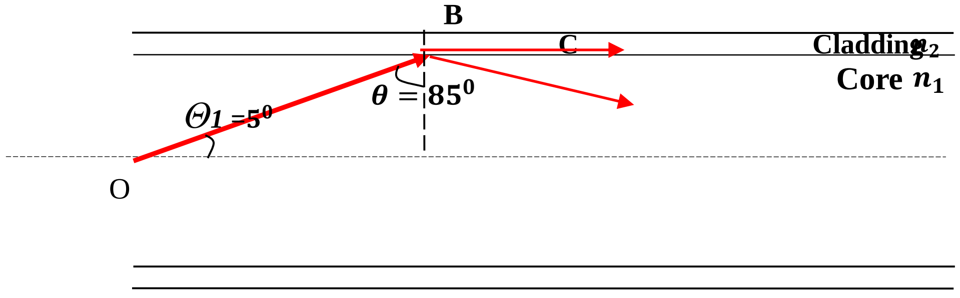
Numerical examples

1. An optic fiber of RI 1.50 is to be clad to ensure TIR that will contain light travelling with in 5^0 of the fiber axis. What minimum RI is allowed for the cladding?

Given: RI of Core n_1= 1.5

The light rays are travelling with in 5^0 wrt fiber axis $\theta_1 = 5^0$

RI OF cladding n_2= ?



The ray travelling at 5^0 will have min angle of incidence and those with lesser angle, have still greater angle of incidence. To calculate minimum RI allowed for cladding, one has to apply Snell's Law.

Let us assume this ray, travelling at 5^0wrt fiber axis, grazes the core – clad interface

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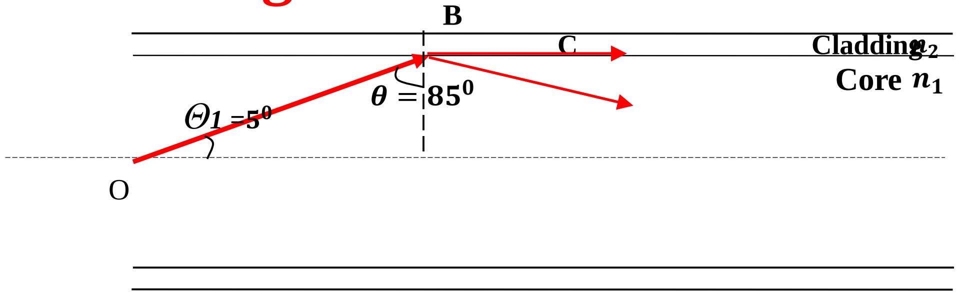

Appling Snell's law at B, we have

$$n_1 \sin 85 = n_2 \sin 90$$

Or $n_2 = 1.5 \times 0.996 = 1.494$

Ie. If Cladding have a RI 1.494, the ray travelling at 5^0 wrt axis f the fiber grazes the interface.

Thus, minimum RI is allowed for the cladding such that the light travelling with in 5^0ensure TIR should be less than 1.494

Numerical examples

2. The angle of acceptance of an optical fiber is 30^0 when kept in air. Find the acceptance angle when the same fiber is immersed in water of RI 1.33

Given: RI of air $n_0 = 1$, Acceptance angle $\theta_a = 30^0$
RI of water $n_0 = 1.33$ Acceptance angle ϕ_a=?

When the fiber is in air, NA $=\sin\theta_a = \mathbf{Sin30^0}$
When the fiber is in water,

$$\text{NA} = \sin\phi_a = \frac{\sin\theta_a}{n_0} = \frac{\sin 30^0}{1.33} = \frac{\mathbf{0.5}}{1.33} = 0.376$$

$$\therefore\ \boldsymbol{\phi_a} = \sin^{-1}(\mathbf{0.376}) = \mathbf{22^0 4'}$$

When the same fiber is immersed in water, the acceptance angle reduces to 22^0.

Numerical examples

3. 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.

Given: RI of Core $n_1 = 1.55$, RI of cladding $n_2 = 1.50$
Core diameter d = 40µm, wavelength of light λ =1400nm.
V=? & N =?

The V – Number is given by $V = \frac{\pi d}{\lambda}(NA)$

$$= \frac{\pi \times 40 \times 10^{-6}}{1400 \times 10^{-9}}\left(\sqrt{n_1^2 - n_2^2}\right) = 89.76 \times \sqrt{(1.55)^2 - (1.50)^2}$$

V = 35.05

No of Modes $N = \frac{V^2}{2} = \frac{35.05^2}{2} = 612.5$

V parameter is 35 & the no of modes that fiber can support is 312

Numerical examples

4. The attenuation in optical fiber is 3.6dB/Km. What fraction of its initial intensity remain after 1.5Km

Given: Attenuation coefficient α = 3.6dB/Km.

Length of fiber L = 1.5K

Fractional intensity at the receiving end $\left(\frac{P_o}{P_i}\right)$**=?**

Attenuation coefficient $\alpha = -\frac{10}{L}\log_{10}\left(\frac{P_0}{P_i}\right) \Rightarrow -\frac{\alpha L}{10} = \log_{10}\left(\frac{P_0}{P_i}\right)$

Or $\left(\frac{P_o}{P_i}\right) = 10^{\left(-\frac{\alpha L}{10}\right)} = 10^{\left(-\frac{3.6\times1.5}{10}\right)} = 10^{(-0.54)} = 0.29$

At the receiving end 29% of its initial intensity is received.