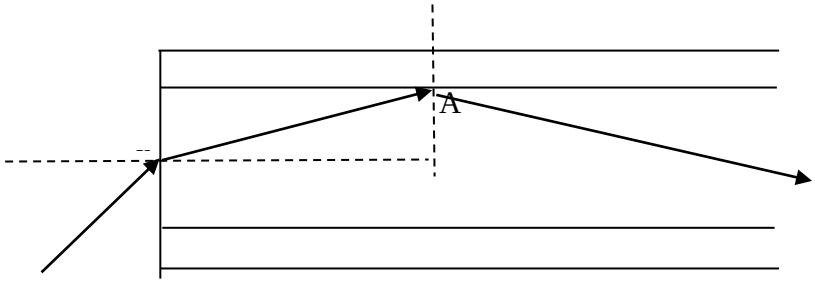
Q- The diagram shows the end of a fibre optic cable with core refractive index 1.5 and cladding refractive index 1.4



The critical angle is the angle of incidence in denser medium for which angle of refraction in rarer medium is just 90^0, and thus refractive index of the rarer medium with respect to denser medium is given by when light is incident from denser medium to the lower medium.

$$\mu_r/\mu_d = \sin i_c / \sin 90^0$$

(a) calculate the critical angle at which light in the core is just totally internally reflected at X

If the light is incident from the inside of the core at X, then the critical angle will be

$$\mu_{air}/\mu_{core} = \sin i_c / \sin 90^0$$

gives $1.0/1.5 = \sin i_c = 0.6$

hence $i_{cX} = \sin^{-1} 0.6 = 41.8^0$

(b) calculate the angle of incidence at A for light which is just internally reflected in the cable

At 'A' light is going from core to the cladding and thus for total internal reflection is given as

$$\mu_{cladding}/\mu_{core} = \sin i_c / \sin 90^0$$

gives $1.4/1.5 = \sin i_c = 0.93$

hence $i_{cA} = \sin^{-1} 0.93 = 69^0$

(c) calculate the speed of light in the core

Speed of light in the material = speed of light in vacuum/ refractive index of the material

Gives, $v = 3 \times 10^8 / 1.5 = 2.0 \times 10^8$ m/s

(d) calculate the time taken for light to travel 1.0 km directly down the centre of the core

Time taken is the ratio of the distance to the velocity hence

$t = 1000/(2.0 \times 10^8) = 5.0 \times 10^{-6}$ second

(e) calculate the longest time taken for light to traverse 1.0 km of cable by internal reflections.

The longest time is taken when the reflection at the side of the fibre is just at critical angle. The ratio of the distance travel to the direct distance will be

$t' = (l/x)\ t = \text{cosec}\ i_{cA} \times t$

or $t' = 1.075 \times 5.0 \times 10^{-6} = 5.38 \times 10^{-6}$ sec.