Physics
Theory Part 6

Topics: Fibre Optics/ Electrodynamics
Course: B.Sc/ Physics

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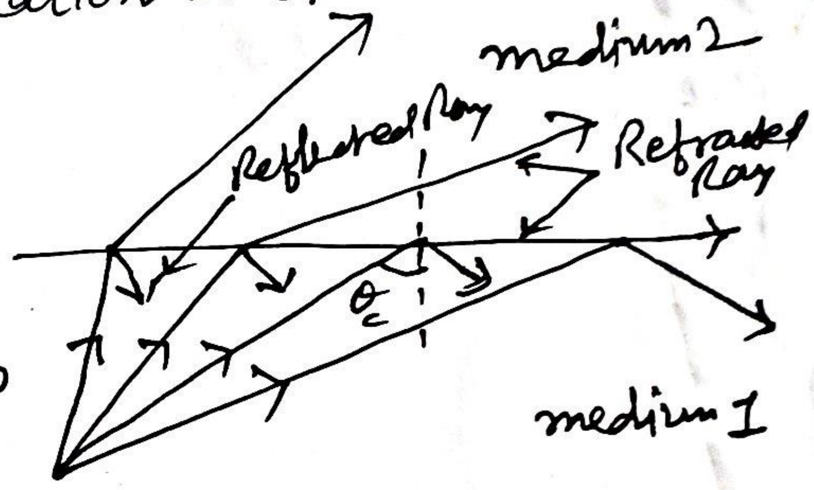
Total Internal Reflection (TIR) and its application in Optical Fibre

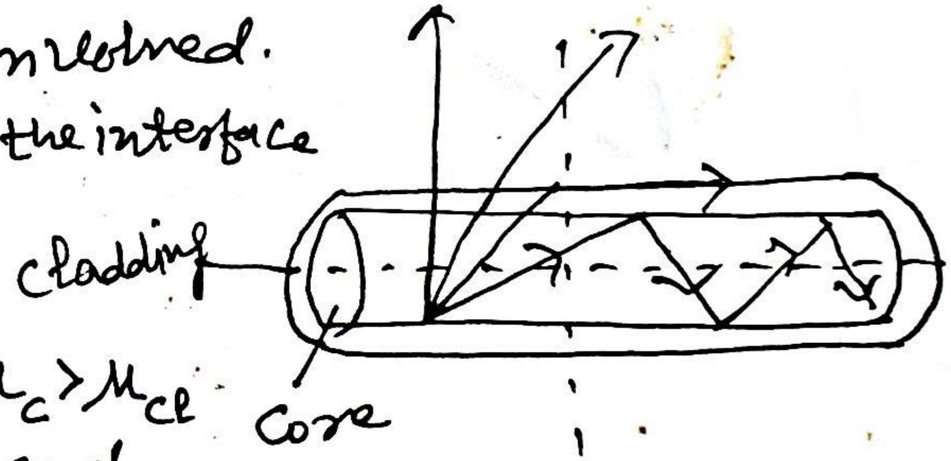


It is the phenonomenon in which reflection of all the incident light off the boundary/Interface of two different mediums. Conditions for TIR are:

(a) light travels from denser medium to rarer medium.

(b) the angle of incidence is greater than the critical angle for the mediums involved.

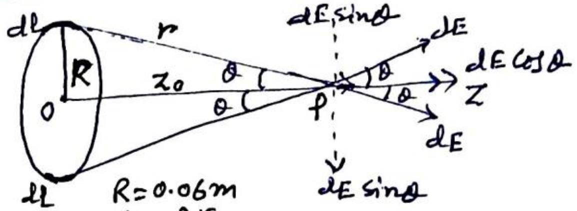
when $\theta = \theta_c$ refracted ray grazes the interface & when $\theta > \theta_c$, TIR will occur.



In optical fibre core & cladding materials are chosen such that $\mu_c > \mu_{cl}$ so when light enters inside the core and incident at $\theta > \theta_c$ (of the fibre) then light will undergo TIR and it will be transported over large distance without any appreciable losses.

Given a conducting ring of linear charge density, $\lambda = \frac{q}{2\pi r} = 120\times10^{-9}$ c/m

Find Axial Electric field.



$R = 0.06m$

$z_0 = 1.75m$

$r = \sqrt{R^2+z_0^2} = 1.75$ m

Consider length element dl on diametrically opposite side as shown with charge, $dq = \lambda dl$

(a) Calculate the E.F (E) due to both at point P ($z_0 = 1.75$m). vertical component cancel out only horizontal component contributes to total field.

$$\therefore dE = \underset{(K)}{\frac{1}{4\pi\epsilon_0}}\frac{dq}{r^2} \quad \& \quad dE' = dE\cos\theta = K\frac{dq}{r^2}\times\frac{z_0}{r} = \frac{Kz_0}{r^3}dq$$

If we take contribution from the whole circle then final E.F is

$$E = \int\frac{Kz_0}{r^3}dq = \frac{Kz_0}{r^3}\int dq = \frac{Kz_0}{r^3}\int\lambda dl = \frac{Kz_0\lambda}{r^3}\times 2\pi R = \frac{2\pi K z_0\lambda R}{r^3} \quad \text{—(1)}$$

$$= \frac{9\times10^9\times2\times3.14\times\cancel{1.75}\times12\times10^{-8}\times0.06}{1.75^{\cancel{3}\,2}} = 387.56\times10 = \boxed{\cancel{3875.6\ N/C}}\ \boxed{232.53}\ \text{N/C}$$

(b) when $z_0 \gg R$ (i,e at a point, very far from the plane of the ring).

from eqn. (1) $E = 2\pi K\lambda\frac{z_0 R}{(R^2+z_0^2)^{3/2}}$ Now $z_0 \gg R$ so we can neglect R $\because \frac{z_0}{R}\gg1$

$$= 2\pi K\lambda\frac{z_0 R}{z_0^3} = \frac{2\pi\lambda KR}{z_0^2} \therefore E \propto \frac{1}{z_0^2}$$ (similar to that of a point charge)

(c) when $z_0 \ll R$ (i,e at a point very close to ring) $\therefore \frac{z_0}{R} \ll 1$

$$E = (2\pi\lambda R)\frac{z_0}{(R^2+z_0^2)^{3/2}} = (2\pi\lambda R)\frac{z_0}{[R^2(1+(\frac{z_0}{R})^2)]^{3/2}}$$

$$= (2\pi\lambda R)\frac{z_0}{R^3} = (2\pi\lambda R)\times\frac{1}{R^2}\times\left(\frac{z_0}{R}\right) \ll 1$$ i,e if $z_0 = 0$ i,e at the

$(\therefore E \propto z_0)$

centre of the ring $E = 0$.

$$F = K'\frac{q_1q_2}{r^2} = Kr$$

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