Balika Vidyapith, Lakhisarai

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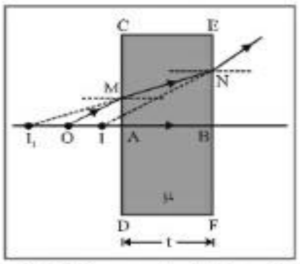
Continued ………….

5.4 Shift due to a Glass Slab (Double Refraction from Plane Surfaces)

(i) Normal Shift : Here, again two cases are possible.



An object is placed at O. Plane surface CD forms its image (virtual) at I_1. This image acts as object for EF which finally forms the image (virtual) at I. Distance OI is called the normal shift and its value is,

$$OI = \left(1 - \frac{1}{\mu}\right)t$$

This can be proved as under :

Let $OA = x$ then $AI_1 = \mu x$ (Refraction from CD)

$BI_1 = \mu x + t$

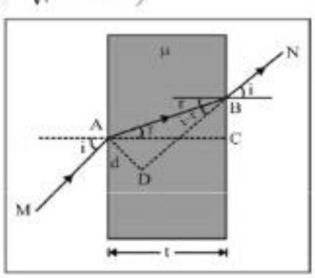
$$BI = \frac{BI_1}{\mu} = x + \frac{t}{\mu} \quad \text{(Refraction from EF)}$$

$$\therefore \quad OI = (AB + OA) - BI = (t + x) - \left(x + \frac{t}{\mu}\right)$$

$$= \left(1 - \frac{1}{\mu}\right)t \quad \text{Hence Proved.}$$

(ii) Lateral Shift : We have already discussed that ray MA is parallel to ray BN. But the emergent ray is displaced laterally by a distance d, which depends on μ, t and i and its value is given by the relation,

$$d = t\left(1 - \frac{\cos i}{\sqrt{\mu^2 - \sin^2 i}}\right)\sin i$$



Proof : $AB = \frac{AC}{\cos r} = \frac{t}{\cos r}$

(as AC = t)

Now, $d = AB \sin(i - r) = \frac{t}{\cos r}[\sin i \cos r - \cos i \sin r]$

or $d = t[\sin i - \cos i \tan r]$ ...(i)

Further $\mu = \frac{\sin i}{\sin r}$ or $\sin r = \frac{\sin i}{\mu}$

$$\therefore \quad \tan r = \frac{\sin i}{\sqrt{\mu^2 - \sin^2 i}}$$

Substituting in eq. (i), we get,

$$d = \left[1 - \frac{\cos i}{\sqrt{\mu^2 - \sin^2 i}}\right] t \sin i$$

Hence Proved.

Exercise : Show that for small angles of incidence,

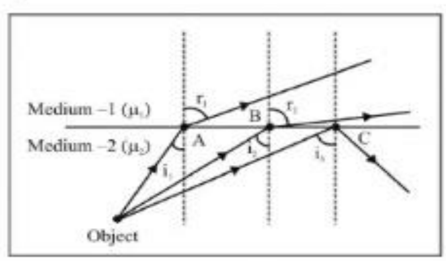
$$d = ti\left(\frac{\mu - 1}{\mu}\right).$$

Apparent distance from observer

$$= \mu_{obser}\left(\frac{h_1}{\mu_1} + \frac{h_2}{\mu_2} + \ldots\ldots \frac{h_n}{\mu_n}\right)$$

5.5 Total Internal Reflection

Consider an object placed in a denser medium 2 (having refractive index μ_2) being seen from a rarer medium 1 (having refractive index μ_1)



Different rays from the object are shown. As we move from A towards C, angle of incidence goes on increasing. Therefore, the angle of refraction goes on increasing. At B, angle of refraction approaches 90°. This is called critical condition. After B, angle of