CHAPTER 16

REFRACTION THROUGH PRISMS:-

Date | 1
Page |

Prism:-

↳ Prism is a wedge shaped transparent refracting medium bounded by two plane surfaces inclined to each other at some angle. The angle between refracting faces of prism is called angle of prism. It is denoted by 'A'.

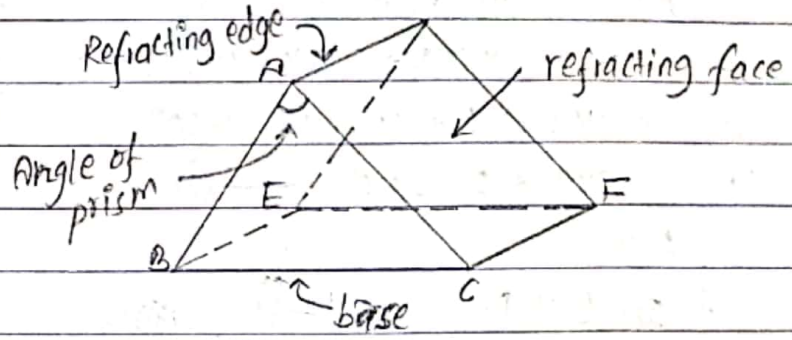

Fig: A glass prism

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Refraction through prism:-

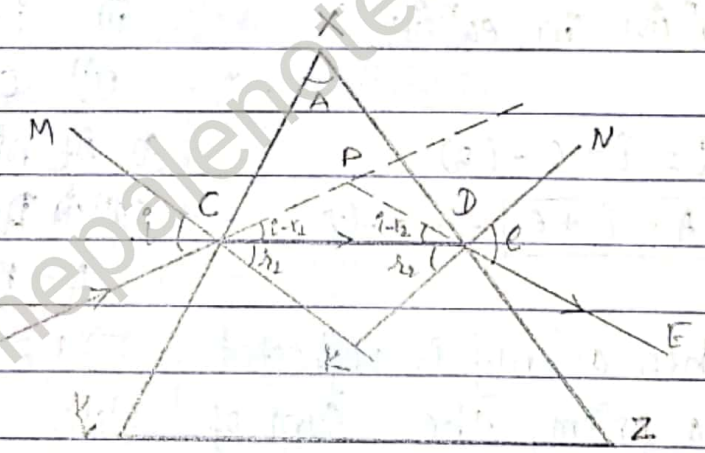

Fig:- Refraction through prism

↳ Let us Consider a glass prism having angle of prism 'A'. Suppose a ray of light 'BC' incident on face 'XY' of the prism at an angle of incident 'i' and get refrated inside the glass along CD at angle 'r1' and incident on other face XZ at angle 'r2' which finally emerged out along DE at angle of emergence 'e'. Also Let 'δ' be the angle of deviation.

From figure,

$$\angle PCD = i - r_1$$

and, $$\angle PDC = e - r_2$$

Again, In ΔPCD,

$\delta = i - r_1 + e - r_2$

$\Rightarrow \delta = i + e - (r_1 + r_2)$ ——(i)

Also, In quadrilateral XCKD;

$\angle CKD + \angle CXD + \angle XCK + \angle XDK = 360°$

or, $\angle CKD + A + 90° + 90° = 360°$

or, $\angle CKD + A = 180°$ ——(ii)

Also,

In ΔCKD;

$\angle CKD + r_1 + r_2 = 180°$ ——(iii) $[\because \Delta = 180°]$

From eqⁿ (ii) & (iii)

$\Rightarrow A = r_1 + r_2$ ———(iv)

Using eqⁿ (iv) in eqⁿ (i);

We get,

$\delta = i + e - (A)$

$\Rightarrow \boxed{\delta + A = i + e}$ ———(v)

Thus, When a ray is refracted through a prism, the sum of angle of incidence and angle of emergence is equal to sum of angle of deviation and angle of that prism.

Minimum Deviation:-

When angle of incidence is increase generally the angle of deviation δ_m first decreases and become minimum at particular angle of incidence is called Minimum deviation (δ_m) as shown in figure.

Fig: Plot between δ & i

Condition for minimum deviation:-

i) $r_1 = r_2 = r$ (say)

ii) $i = e$

iii) CD // KZ

So, At minimum deviation condition, eqⁿ (i) and eqⁿ (v) becomes

$A = r + r = 2r$

$\Rightarrow r = A/2$ ——(vi)

Now, $\delta_m + A = i + i$

$\Rightarrow i = \frac{\delta_m + A}{2}$ ——(vii)

Again,

Refractive index of prism be,

$a\mu_g = \frac{\sin i}{\sin r}$

$\Rightarrow \boxed{a\mu_g = \frac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin A/2}}$ ——(viii)

Which required relation.

Deviation produced by small angled prism:-

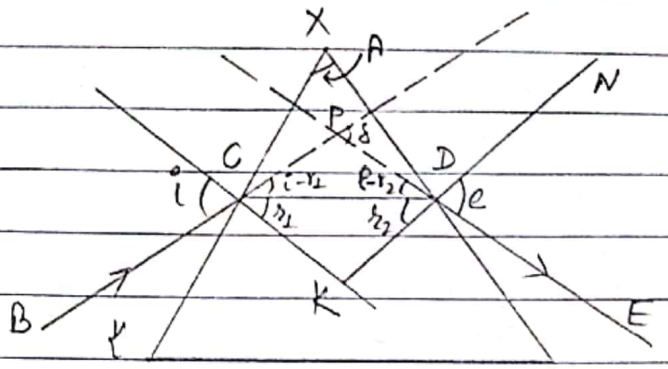

Fig:- Refraction through prism

In ΔPCD,
$\delta = i - r_1 + e - r_2$
$\Rightarrow \delta = i + e - (r_1 + r_2)$ ——(i)

In the figure,
At face XY, Refractive index of glass,

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

For small angle prism, $\sin i \approx i$ & $\sin r_1 \approx r_1$

$$\Rightarrow \mu = \frac{i}{r_1}$$

$$\Rightarrow i = \mu r_1 \quad \text{——(ii)}$$

Also, At face XZ, Refractive index of glass,

$$\mu = \frac{\sin e}{\sin r_2}$$

For small angle prism,
$\sin e \approx e$ & $\sin r_2 \approx r_2$

$$\Rightarrow \mu = \frac{e}{r_2}$$

$$\Rightarrow e = \mu r_2 \quad \text{——(iii)}$$

Using eq^n(ii) & (iii) in eq^n(i)

$\Rightarrow \delta = \mu r_1 + \mu r_2 - (r_1 + r_2)$
$= \mu(r_1 + r_2) - (r_1 + r_2)$
$= (\mu - 1)(r_1 + r_2)$

Since, $A = r_1 + r_2$

$\Rightarrow \delta = (\mu - 1) A$

$\Rightarrow \boxed{\delta = A(\mu - 1)}$ ——(iv)

Which is required relation for deviation produced by small angled prism.

Cases of grazing:-

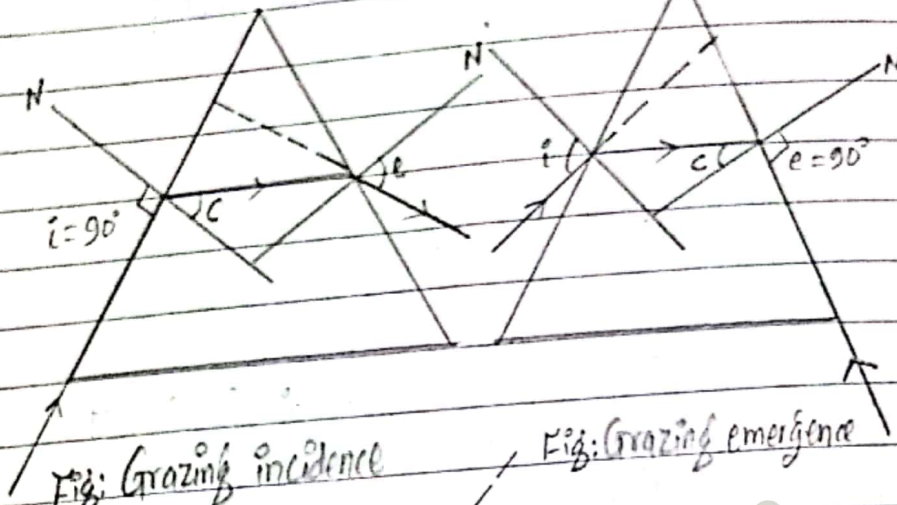

Fig: Grazing incidence

Fig: Grazing emergence

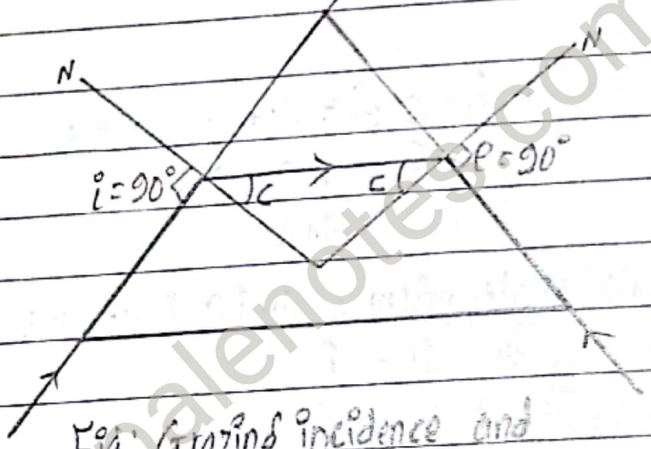

Fig: Grazing incidence and grazing emergence.