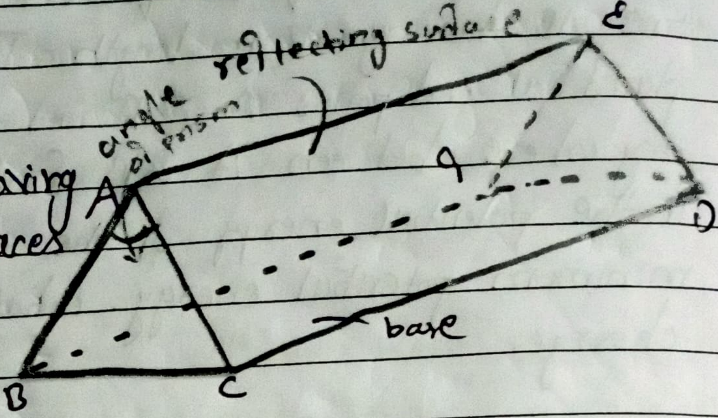
Refraction through Prism

(i) Prism :- The Solid transparent glass having three rectangular surfaces and two triangular surfaces is called prism



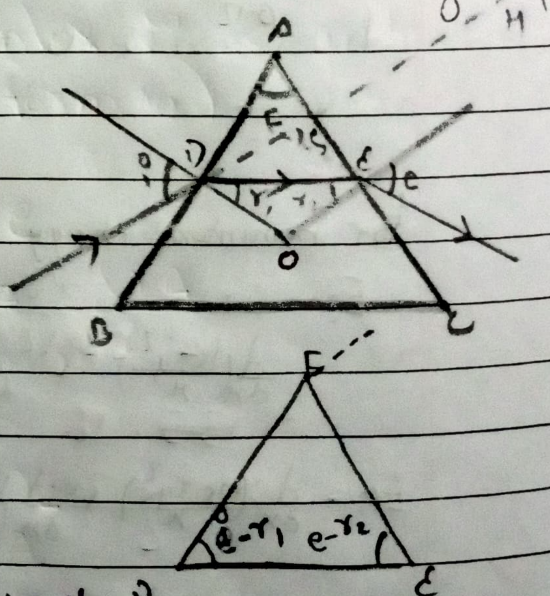
(ii) The two adjacent rectangular surfaces from which light is refracted is known as reflecting surface and angle made by these two surfaces is known as angle of prism (A)

ΔABC = principle section

fig: Prism

(iii) The rectangular surface opposite to angle of prism is known as base.

Relation between angle of deviation δ and angle of prism



let consider a principle section ABC of prism as shown figure
let $\angle i$ = angle of incident on the surface of AB, $\angle r$ angle of reflection on surface AB, $\angle r_2$ = angle of incident on AC, $\angle e$ = angle of emergence

The angle between the original direction of incident ray and emergent ray is known as angle of deviation.

from figure,

In Δ FDE

$\angle EFD = \angle FDE + \angle FED$

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

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

from Δ DEO

$\angle ODE + \angle ODE + \angle OED = 180°$

$r_1 + r_2 + \angle DOE = 180°$

$\angle DOE = 180° - (r_1 + r_2)$

from quadrilateral

ADOEA

$\angle A + \angle ADO + \angle DOE + \angle OEA = 360°$

$A + 90 + 180 - (r_1 + r_2) + 90 = 360$

$A + 180 - (r_1 + r_2) = 180$

$A = r_1 + r_2$ --- (ii)

using (i) & (ii)

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

which is required eqn of angle of deviation in prism

Angle of minimum deviation

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

when the angle of incident of light is increased, the angle of deviation decreases till minimum at particular angle of incident.

The minimum value of angle of deviation is called ~~m~~ the angle of minimum deviation

Note:- It is not parabola

(i) $r_2 > r_1$

(ii) $i = e$

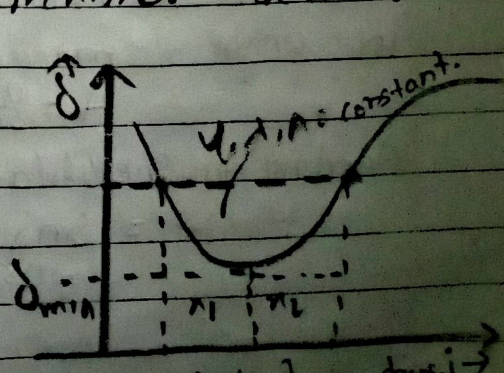


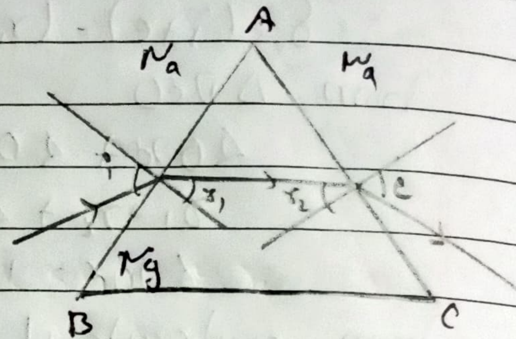
fig:- Angle of min deviation

condition for min deviation.

The condition for min deviation is given by by:-

1. angle of incidence (i) = angle of emergence

$i = e$, $r_1 = r_2$



According to snell's law
for face AB

$$\mu_a \sin i = \mu_g \sin r_1$$

$$\frac{\mu_g}{\mu_a} = \frac{\sin i}{\sin r} \quad \text{--- (i)}$$

for face AC

$$\mu_a \sin e = \mu_g \sin r_2$$

$$\frac{\mu_a}{\mu_g} = \frac{\sin r_2}{\sin e} \quad \text{--- (ii)}$$

from 1st & 2nd,

$$\frac{\sin i}{\sin r} = \frac{\sin e}{\sin r_2}$$

for $r_1 = r_2$, $\sin i = \sin e$

$\therefore i = e$ proved

=> The relation betn refrective index μ & angle of prism
(Prism formula)

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

from angle of min deviation $i = e$

$$\delta_{min} = 2i - A \Rightarrow i = \frac{\delta_m + A}{2}$$

Also $A = r_1 + r_2$

for angle of min deviation $r_1 = r_2$

$$A = 2r_1 \Rightarrow r_1 = \frac{A}{2}$$

According to snell's law

$$\mu = \frac{\sin i}{\sin r} = \frac{\sin\left(\frac{\delta_{min} + A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

which is required reln betn refrective index of a matrial & angle of prism

Deviation through Small angle prism

let us consider a principle section ABC as shown in figure;

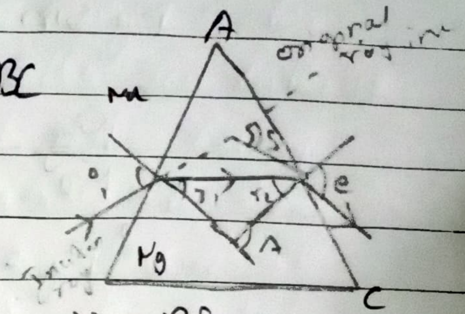


fig: Refraction through Small angle prism

let $\angle i$ = angle of incident on AB

$\angle r_1$ = angle of refraction on AB

$\angle r_2$ = angle of inciden on AC

$\angle e$ = angle of emergen on AC,

from figure;

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

$$= (i+e) - A \quad \text{--- (1)}$$

According to snell's law on surface AB,

$$\mu_a \sin i = \mu_g \sin r_1$$

$$\frac{\mu_g}{\mu_a} = \frac{\sin r_1}{\sin i} \Rightarrow \mu = \frac{\sin i}{\sin r_1}$$

for small angle prism;

$$\sin i \simeq i$$

$$\sin r \simeq r$$

$$\therefore \mu = \frac{i}{r_1} \qquad i = \mu r_1$$

P.T.O

MCQ

(1) when angle of incidence ($\angle i$) increases, angle of deviation

⇒ (i) decreases than increases (ii) Increases

(ii) In which condition angle of incident is found to have two values

(i) $\delta > \delta_{min}$ (ii) $\delta = \delta_{min}$,

(iii) The curve of i vs δ is

(i) Non parabolic (ii) Curved at $n=0$,

for AC

$$\mu_g \sin r_2 = \mu_a \sin e$$

$$\frac{\mu_g}{\mu_a} = \frac{\sin e}{\sin r_2}$$

$$^a\mu_g = \frac{\sin e}{\sin r_2}$$

For small angle prism

$$\sin e \approx e \quad \& \quad \sin r_2 \approx r_2$$

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

$$e = \mu r_2$$

$$\delta = (i + e) - A$$
$$\delta = (\mu r_1 + \mu r_2) - A$$
$$\delta = \mu(r_1 + r_2) - A = \mu A - A$$
$$\delta = A(\mu - 1)$$

which is the required expression for deviation due to small angle prism.

Note:- The deviation due to small angle prism is independent of angle of incident.

Grazing incidence

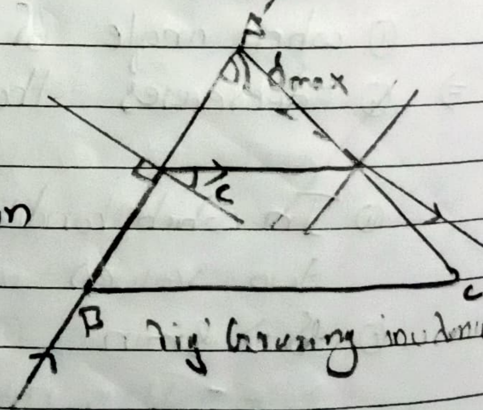


fig Grazing incidence

when the angle of incidence $\angle i = 90$ the angle of incidence is known as grazing incident. In such case the refracted ray makes an angle equal to the grazing critical angle at the 1st face.

The max dev (δ) occurs for an angle of 90° or when a ray of light is incident on a face of a prism with an angle of incident 90°, the ray of light graze on the surface and refracted through the prism such refraction of light is known as grazing incidence.

For grazing incidence $\delta = \delta_{max}$

since we have

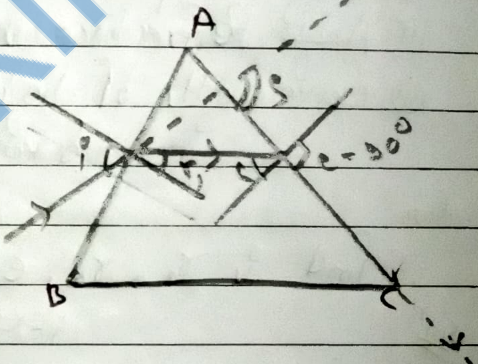
$$\delta = (i+e) - (r_1 + r_2)$$

$$\delta_{max} = (90 + e) - (c + r_2)$$

$$\delta_{max} = (90 + e) - (c + r_2),$$

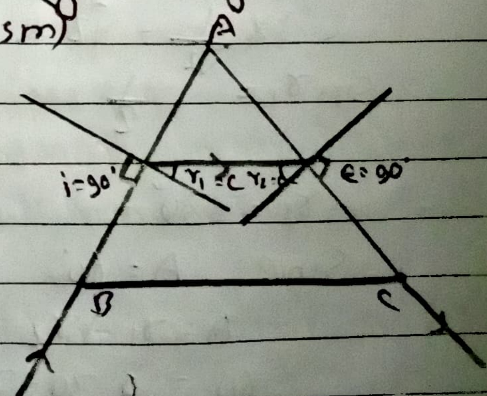
Grazing emergence

The process of passing of emergent ray by making an angle 90° with normal from refracting surface is called grazing emergence



Grazing incidence and Grazing emergence.

(critical angle of prism)



Since,

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

$$\delta = 180 - (r_1 + r_2)$$

$$\delta = 180 - 2c$$

also,

$$A = r_1 + r_2$$

$$= 2c$$

$\therefore A = 2c$,, (It is also case