RAY OPTICS

LIGHT:- It is a form of energy that produces the sensation of sight.

i) Sources:-

a) Self-luminous:- Sun
b) Non-luminous:- Moon
c) Bio-luminous:- Glow worm

PROPERTIES:-

i) Rectilinear Propagation
ii) Reflection
iii) Refraction

ii) MEDIUM:-

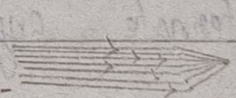
a) Transparent
b) Translucent
c) Opaque

iii) RAY:- ⟶ The direction path at which light travel

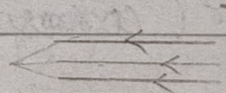
iv) BEAM:- ⟹ A parallel ray of light.

v) PENCIL:- A narrow beam of rays is called pencil.

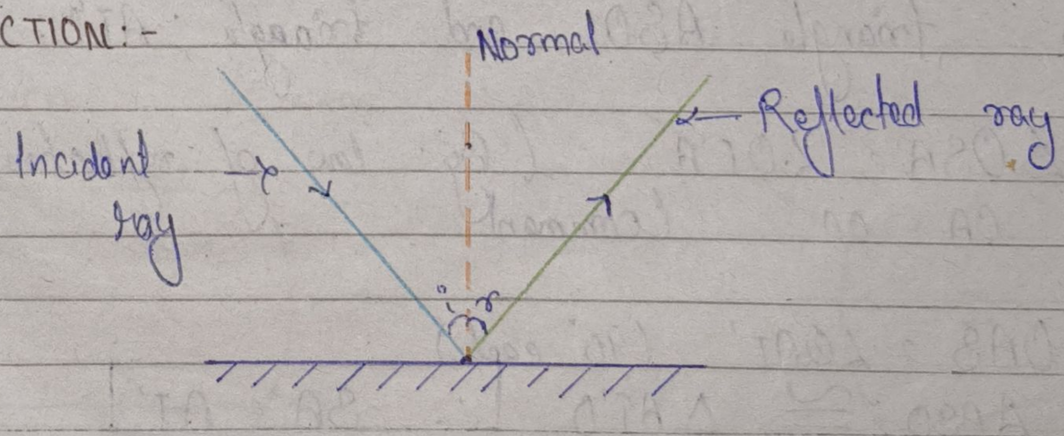
i) Convergent:-



ii) Divergent:-



REFLECTION:-



Types of Reflection:-

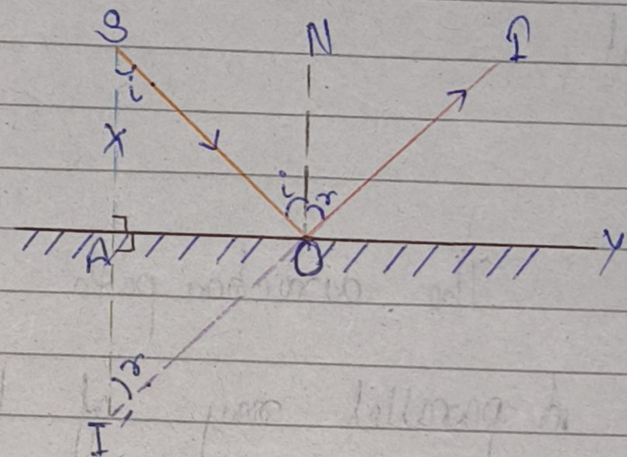
i) Regular
ii) Irregular

LAWS OF REFLECTION

i) The incident, the normal ray to the reflecting surface at the point of incidence, the reflected all lie in a same plane

ii) $\angle i = \angle r$

IMAGE FORMED BY A PLANE MIRROR



$\therefore \angle OSA = \angle SON = i$ (alternate angle)

$\angle OI'A = \angle ION = r$ (corresponding angle)

$\therefore$ In triangle ASO and triangle AI'O

$\angle OSA = \angle OI'A$ (By law of reflection)

$OA = OA$ (common)

$\angle OAS = \angle OAI'$ (90° each)

$\therefore \triangle ASO \cong \triangle AI'O$ $\boxed{\therefore SA = AI'}$

Number of image formed by two plane mirror

If N is even

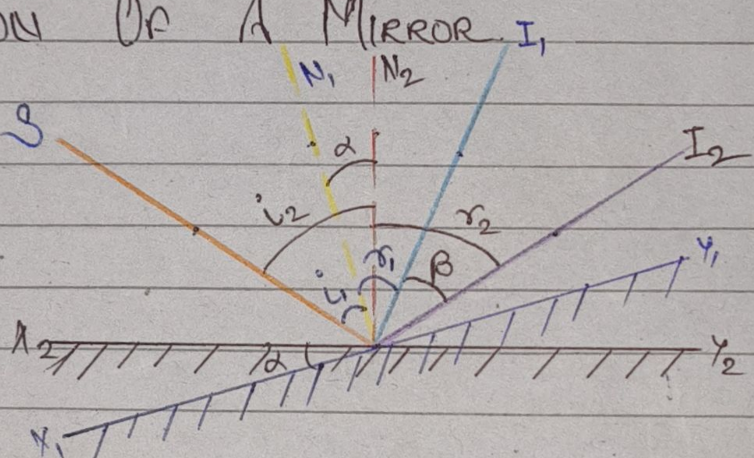
$$n = \frac{360}{\theta} - 1$$

If N is odd

asymmetric : $n = \frac{360}{\theta}$

symmetric : $n = \frac{360}{\theta} - 1$

ROTATION OF A MIRROR



We know, $\angle i_2 = \angle r_2$ and $\angle i_1 = \angle r_1$

$\therefore$ $\angle i_2 = i_1 + \alpha$

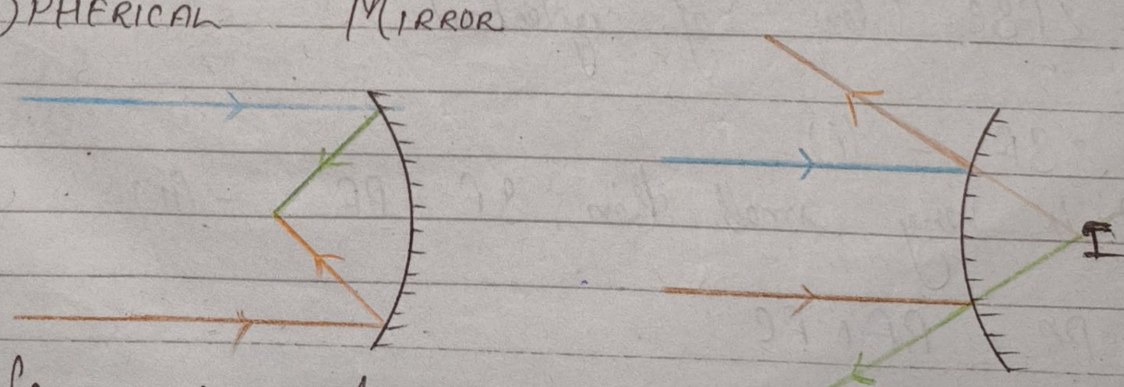
$\angle r_2 = r_1 - \alpha + \beta$

$\therefore$ $i_1 + \alpha = r_1 - \alpha + \beta$

$\alpha = -\alpha + \beta$

$\Rightarrow$ $\boxed{2\alpha = \beta}$

SPHERICAL MIRROR

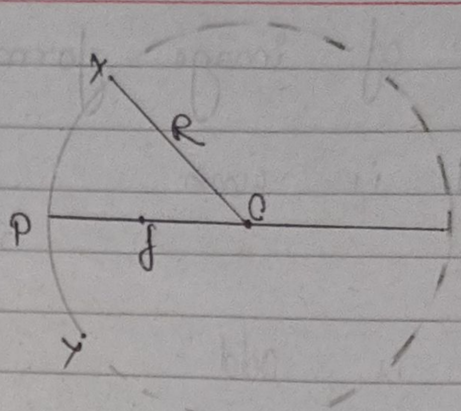


i) Concave mirror

i) Centre of curvature

ii) Radius of curvature

iii) Aperture (XPY)



iv) Pole :- The centre of reflecting surface of a spherical mirror.

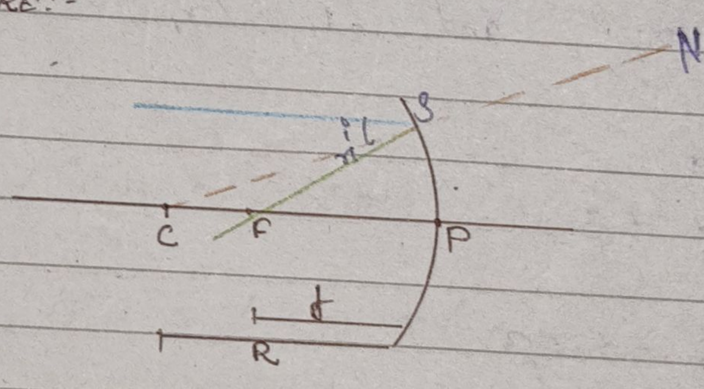
v) Principle axis :- A straight line passing through the centre of curvature and the pole of spherical mirror.

vi) Focus :-

vii) Focal length

viii) Focal plane

RELATIONSHIP BETWEEN FOCAL LENGTH AND RADIUS OF CURVATURE :-



$\angle SCF = i$ (alt. angle)
$\angle FCS = \angle FSC$ (law of reflection)

$\therefore FC = SF$ — (i)
If SP is very small then, $SF = PF$ — (ii)

$PC = PF + FC$

$PC = PF + SF$

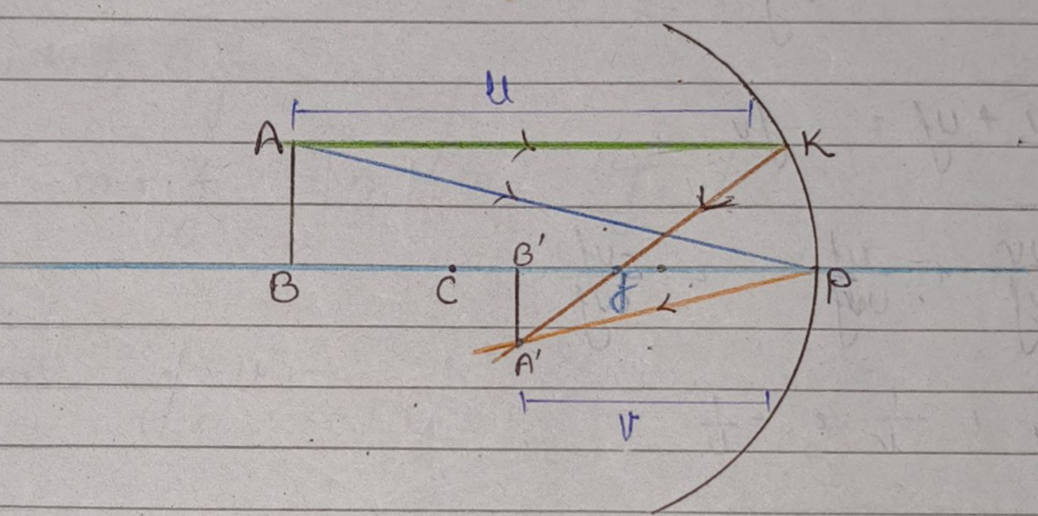
$PC = PF + PF$

$PC = 2PF$

$+R = +2f$

$\boxed{f = \frac{R}{2}}$

MIRROR FORMULA



$\Delta A'PB'$, ΔAPB are simillar :-

$$\frac{AB}{A'B'} = \frac{BP}{B'P} \quad \text{—(i)}$$

$\Delta A'B'f$ and ΔKPf are simillar :-

$$\frac{KP}{A'B'} = \frac{Pf}{B'f}$$

$$KP \cong AB$$

$$\frac{AB}{A'B'} = \frac{Pf}{B'f} \quad \text{— (ii)}$$

from (i) and (ii)

$$\frac{BP}{B'P} = \frac{PF}{B'F}$$

$$\Rightarrow \frac{BP}{B'P} = \frac{PF}{B'P - PF}$$

$$\Rightarrow \frac{+u}{+v} = \frac{-f}{-v+f}$$

$$\Rightarrow -uv + uf = -fv$$

$$\Rightarrow \frac{-uv}{uvf} + \frac{uf}{uvf} = \frac{-vf}{uvf}$$

$$\Rightarrow -\frac{1}{f} + \frac{1}{v} = -\frac{1}{u}$$

$$\Rightarrow \boxed{\frac{1}{f} = \frac{1}{u} + \frac{1}{v}}$$ Mirror formula

MAGNIFICATION :-

$m = \frac{I}{O} = \frac{\text{Size of image}}{\text{Size of object}}$

$m = \frac{v}{u} = \frac{\text{Image distance}}{\text{obj distance}}$

$m = -\frac{I}{O}$ or $m = \frac{v}{u}$

$$\frac{I}{O} = -\frac{v}{u}$$

Relationship between m and f:-

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

In terms of v:-

$$\frac{v}{v} + \frac{v}{u} = \frac{v}{f}$$

$$\Rightarrow 1 + \frac{v}{u} = \frac{v}{f}$$

$$\Rightarrow 1 - m = \frac{v}{f} \Rightarrow \boxed{m = \frac{f-v}{f}}$$

In terms of u:-

$$\frac{u}{v} + \frac{u}{u} = \frac{v}{f}$$

$$\frac{u}{v} + 1 = \frac{v}{f}$$

$$-\frac{1}{m} + 1 = \frac{v}{f}$$

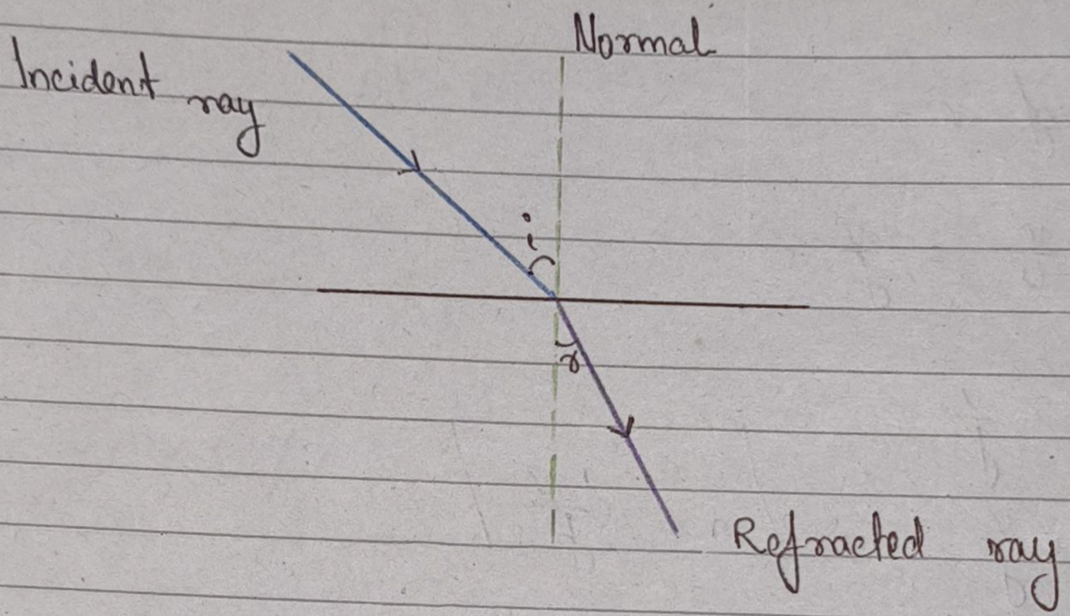
$$\frac{1}{m} = 1 - \frac{u}{f}$$

$$\frac{1}{m} = \frac{f-u}{f} \Rightarrow m = \frac{f}{f-u}$$

22/03/23

REFRACTION :-

The bending of light when it pass obliquely from one transparent medium to another.



Cause:- Because the velocity changes.

Medium:-

Rare to denser:- It comes closer to normal.

Denser to rare :- It goes away from normal.

LAWS OF REFRACTION:-

i) The incident ray, the refracted ray and the normal all lie in the same plane.

ii) Snell's law :- $\frac{\sin i}{\sin r} = \mu$ (Refractive index)

$$R.I = \frac{\text{Velocity of 1st medium}}{\text{Velocity of 2nd medium}} = {}^{1}\mu_2$$

Absolute refractive index :-

When light travels in air, then

$$\boxed{R.I = \frac{c}{v}}$$, $c \to 3 \times 10^8$ m/s

Relation in between the mediums:-

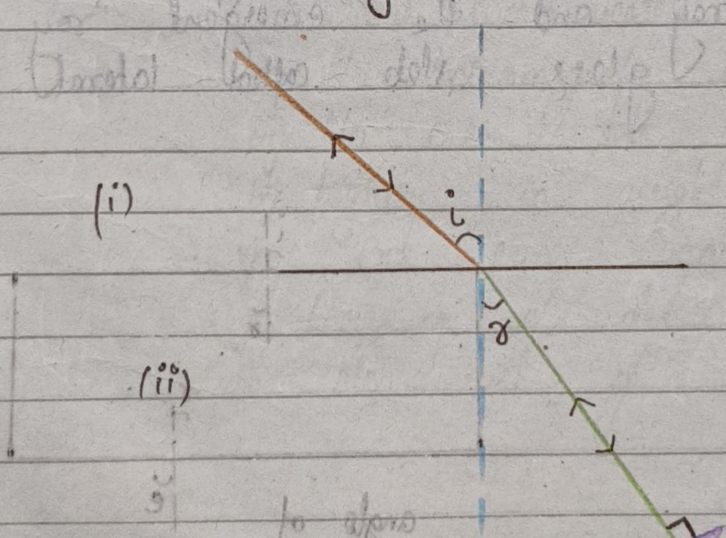
$${}^1\mu_2 \Rightarrow \frac{v_1}{v_2}$$

$$\Rightarrow \frac{\frac{v_1}{c}}{\frac{v_2}{c}} \Rightarrow \frac{v_1}{c} \times \frac{c}{v_2} \Rightarrow \boxed{\frac{1}{\frac{c}{v_1}} \times \frac{c}{v_2}}$$

$$\Rightarrow \frac{1}{v_1} \times v_2$$

$$\therefore \boxed{{}^1\mu_2 = \frac{v_2}{v_1}}$$

Principle of reversibility :-



$${}^1\mu_2 = \frac{\sin i}{\sin r}, \quad {}^2\mu_1 = \frac{\sin r}{\sin i}$$

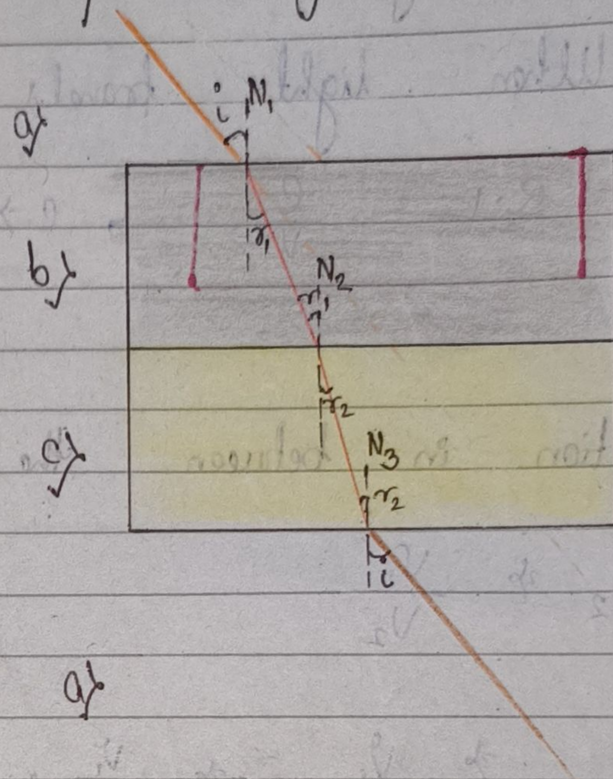
$$\boxed{{}^1\mu_2 \times {}^2\mu_1 = 1} \qquad \boxed{{}^1\mu_2 = \frac{1}{{}^2\mu_2}}$$

Refraction through compound glass slab:-

$${}_a\mu_b = \frac{\sin i}{\sin r_1}$$

$${}_b\mu_c = \frac{\sin r_1}{\sin r_2}$$

$${}_c\mu_a = \frac{\sin r_2}{\sin i}$$

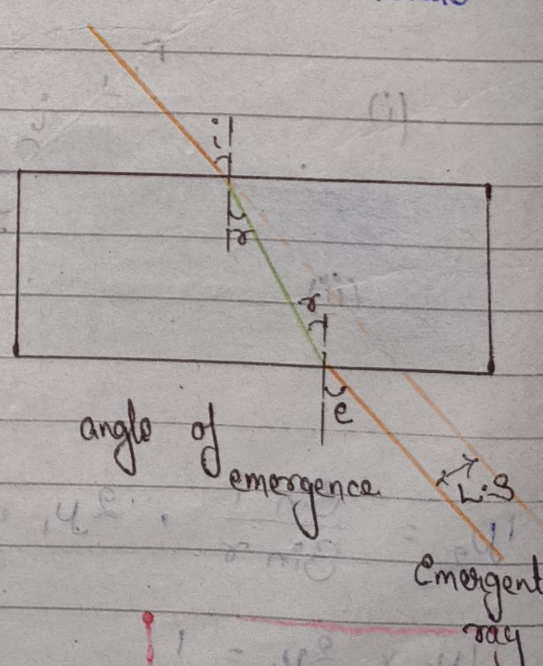


$$\boxed{{}_a\mu_b \times {}_b\mu_c \times {}_c\mu_a = 1}$$

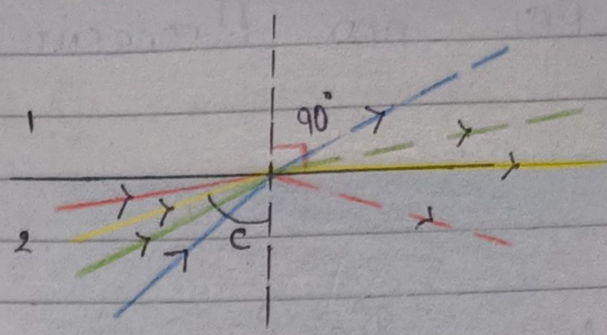
$\Rightarrow$ ${}_a\mu_b \times {}_b\mu_c = \frac{1}{{}_c\mu_a}$ $\Rightarrow$ $\boxed{{}_a\mu_b \times {}_b\mu_c = {}_a\mu_c}$

LATERAL SIFT:-

The perpendicular distance between the orignal path of the incident ray and the emergent ray coming out of glass slab called lateral sift.



CRITICAL ANGLE:-



$${}_2\mu_1 = \frac{\sin C}{\sin 90^\circ}$$

$${}_1\mu_2 = \frac{\sin 90^\circ}{\sin C}$$

$$\boxed{{}_1\mu_2 = \frac{1}{\sin C}}$$

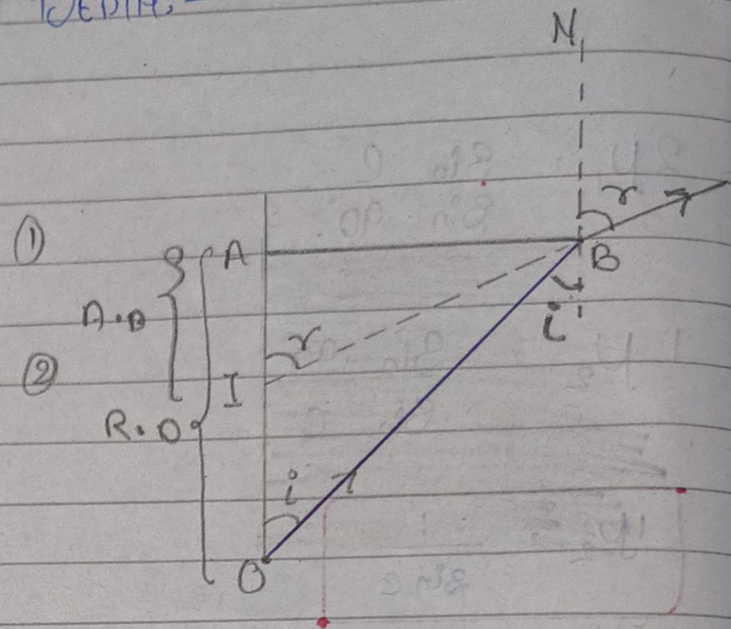
Total Internal Reflection

Conditions:- i) Denser to rarer
ii) Angle of incidence must be greater than critical angle.

Mirage:- Inferior looming (Ex:- Water in desert, or Highways)
Superior looming (Ex:- Ship in sky)

OPTIC FIBRE:-
i) Data communicated at higher speed
ii) No electromagnetic interference, lighting strikes.
iii) No cross talk or reflection problem
iv) Lighter in weight
v) Bit error one in 10^9
vi) Tempering of data is not easy
vii) No risk of short circuits.

REAL AND APPARENT DEPTH:-



$\therefore \; {}_2\mu_1 = \dfrac{\sin i}{\sin r}$

In Δ ABO :-

$\sin i = \dfrac{AB}{OB}$

In Δ AIB :-

$\sin r = \dfrac{AB}{IB}$

$\therefore \; {}_2\mu_1 = \dfrac{AB}{OB} \times \dfrac{IB}{AB}$ or $\dfrac{IB}{OB}$

${}_2\mu_1 = \dfrac{IB}{OB}$

$\therefore$ If AB is very small then

$IB \approx IA$

$OB \approx OA$

$\therefore \; {}_2\mu_1 = \dfrac{IA}{OA} = \dfrac{A.O}{R.O}$

Or $\boxed{{}_1\mu_2 = \dfrac{R.O}{A.O}}$

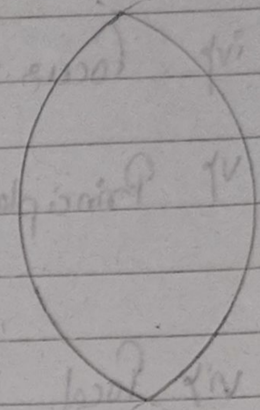
$\therefore$ shift $= R.O - A.O$

$= R.O\left(1 - \dfrac{A.O}{R.O}\right)$

$= R.O\left(1 - \dfrac{1}{{}_1\mu_2}\right)$

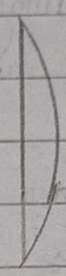
LENS:-

Convex - It is thicker at the middle and thinner at the edges. It is converging lens and has real focus.

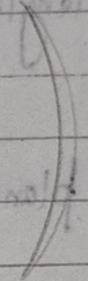


i) Bi- Convex

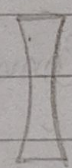
ii) Plano convex



iii) Concave convex

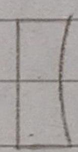


CONCAVE - It is thicker at the middle and thicker at the edges. It is diverging lens and has virtual focus.

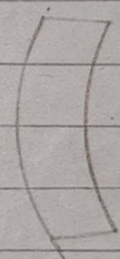


i) Bi. Concave

ii) Plano- Concave

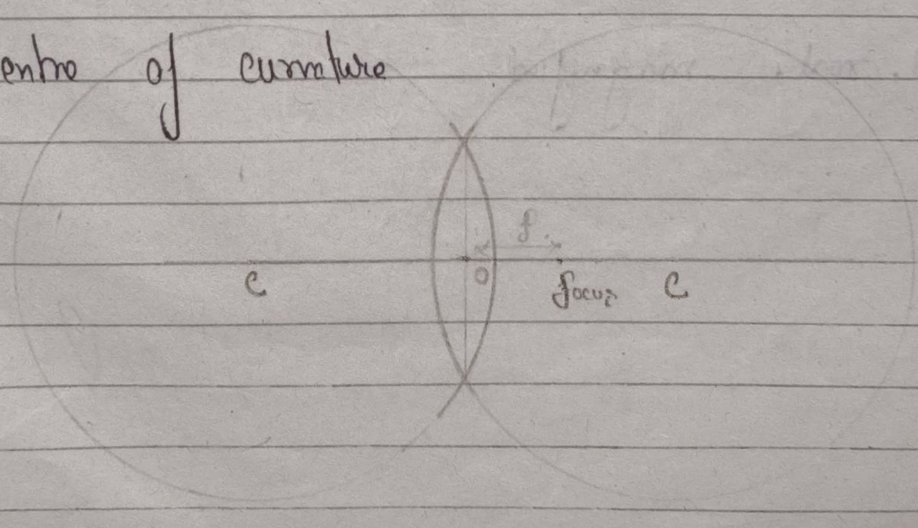


iii) Convexo . Concave



Definations:-

i) Centre of curvature



ii) Radius of curvature:-

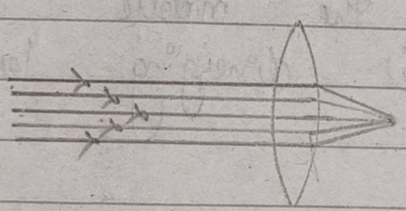
iii) Optical Centre:- Geometric centre of lens.

iv) Focus:-

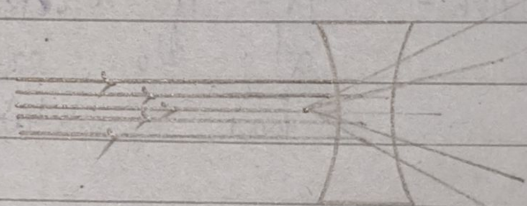
v) Principle axis:- A imaginary straight line passing through the two centre of curvature of a lens.

vi) Focal length:- Distance between optical centre and principle focus

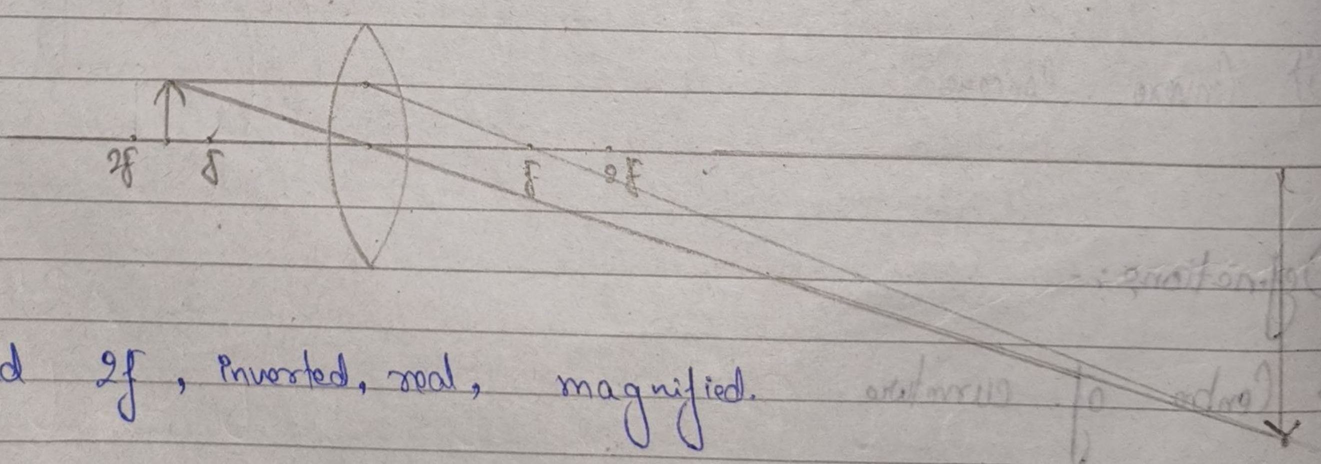
vii) Focal plane:- A imaginary line passing through focus of lens and perpend to principal axis is called focal plane.



Converging lens

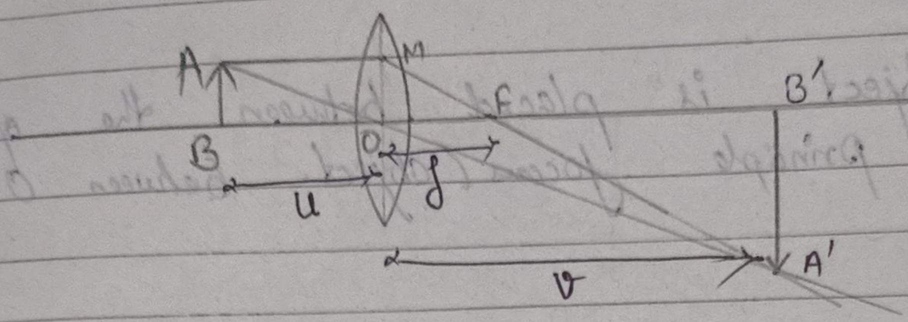


Diverging lens.



Beyond 2f, Inverted, real, magnified.

LENS FORMULA:- $\left(\frac{1}{f} = \frac{1}{v} - \frac{1}{u}\right)$



If ΔABO & $\Delta A'B'F$ are simillar:-

$$\frac{AB}{A'B'} = \frac{BO}{B'O} \quad \text{—(i)}$$

If ΔMOF & $\Delta A'B'F$ are simillar:-

$$\frac{MO}{A'B'} = \frac{OF}{FB'}$$

$\because MO = AB$

$$\frac{AB}{A'B'} = \frac{OF}{FB'} \quad \text{—(ii)}$$

From eq. (i) and eq (ii), we got:-

$$\frac{BO}{B'O} = \frac{OF}{FB'}$$

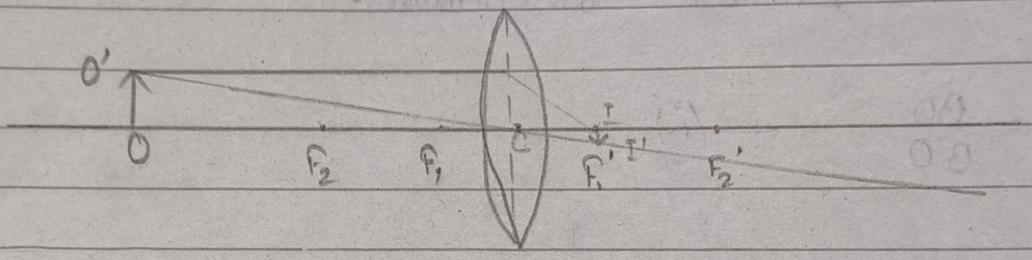
$$\Rightarrow \frac{-u}{v} = \frac{f}{(OB' - OF)} \Rightarrow \frac{-u}{v} = \frac{f}{(v-f)}$$

$$\Rightarrow -uv + uf = vf \Rightarrow \frac{-uv}{uvf} + \frac{uf}{uvf} = \frac{vf}{uvf}$$

$$\Rightarrow -\frac{1}{f} + \frac{1}{v} = \frac{1}{u} \Rightarrow \frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

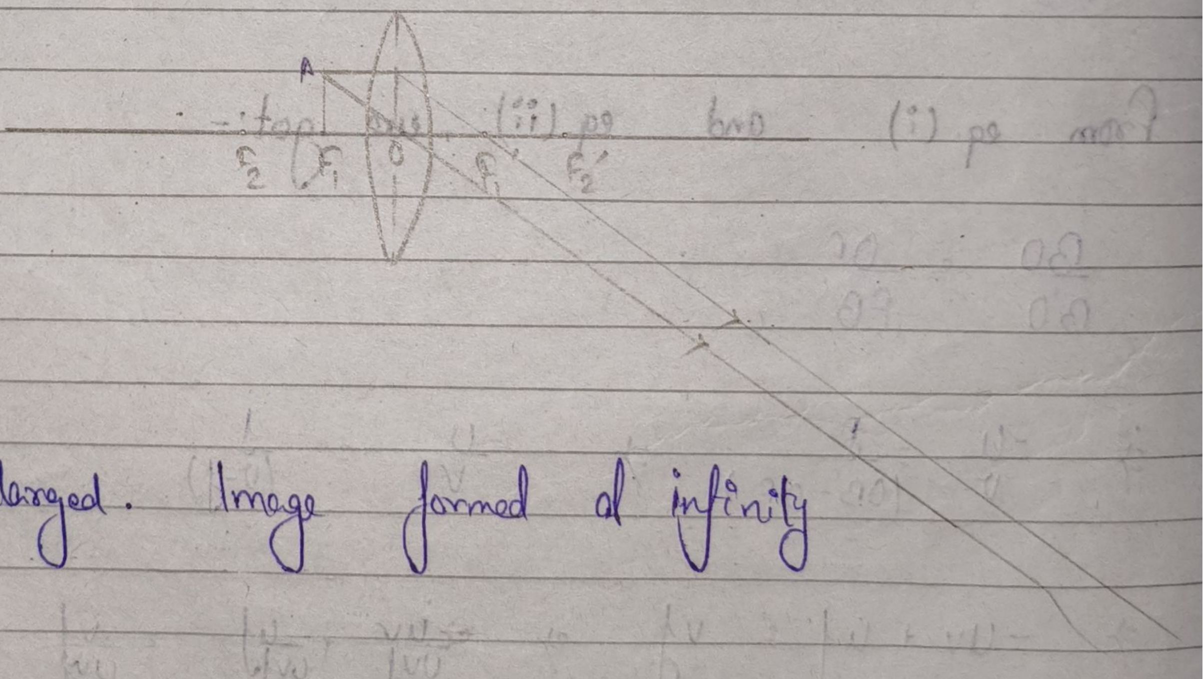
Image Formed By Lens For Different Position:-

i) When the object is placed between the optical centre and principle focus (object between O and F_1).



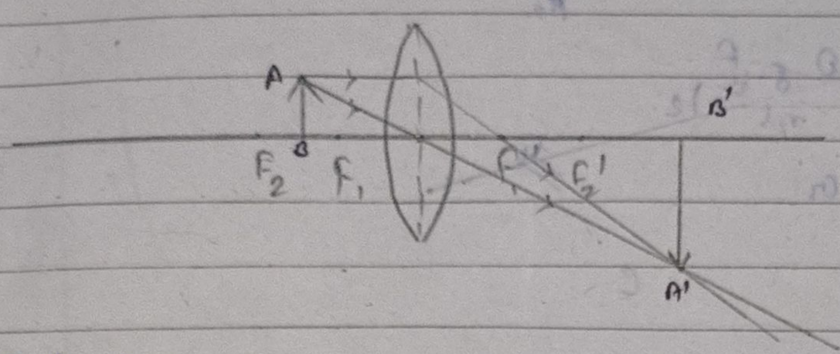
- smaller
- real
- inverted

ii) Object at F_1



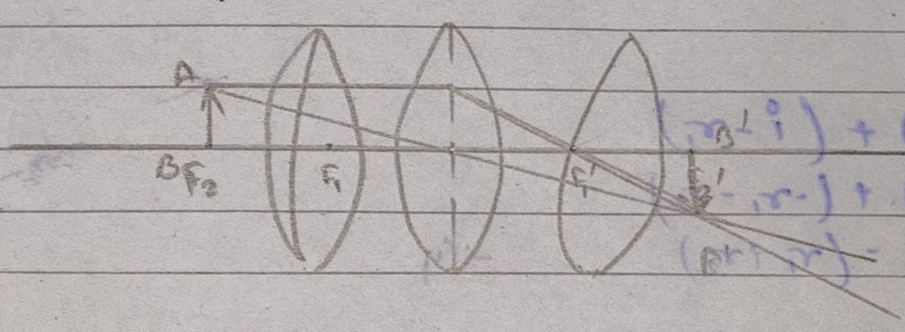
- Real
- Inverted
- highly enlarged. Image formed at infinity

iii) When the object is between F_1 and F_2



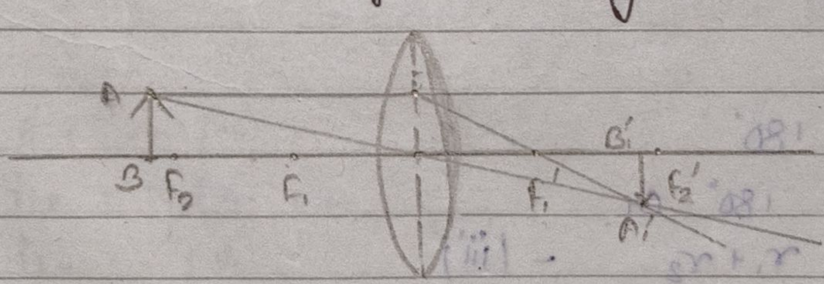
- Real image
- Inverted image
- Enlarged image
- Image formed beyond $2F_2'$ on the other side of lens.

iv) When object is at F_2



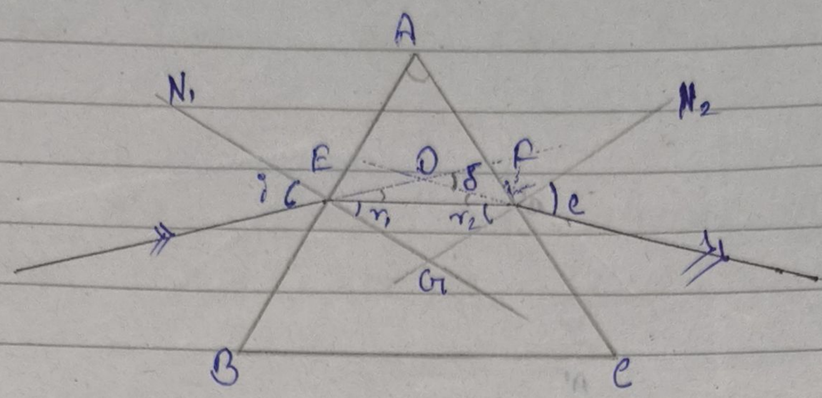
- Real image
- Inverted
- Same size as the object
- Image formed at $2F_2'$

v) When the object is beyond $2F_1$



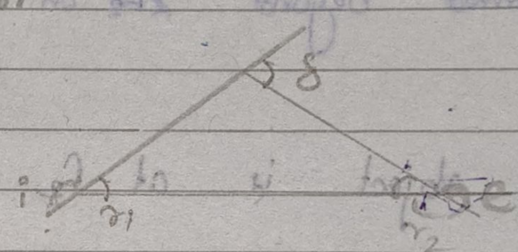
- Real
- Inverted
- Smaller than object, Between F_1' and F_2'

PRISM



A prism have 5 surface 3 rectangular and 2 triangle

$\delta \rightarrow$ angle of deviation



In ΔDEF

$$\delta = (e - r_2) + (i - r_1)$$
$$\delta = (i + e) + (-r_1 - r_2)$$
$$\delta = (i + e) - (r_1 + r_2) \quad \text{—(i)}$$

In quadrilateral AEFG:

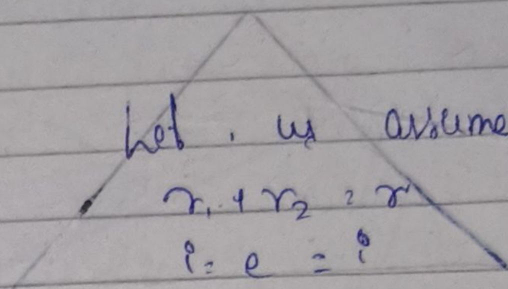
$$A + E + F + G = 360^\circ$$
$$\therefore E = F = 90$$
$$\therefore A + G = 360^\circ - 180^\circ$$
$$A = 180^\circ - G \quad \text{—(ii)}$$

In ΔEFG

$$G + r_1 + r_2 = 180^\circ$$
$$r_1 + r_2 = 180^\circ - G$$
$$A = r_1 + r_2 \quad \text{—(iii)}$$

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

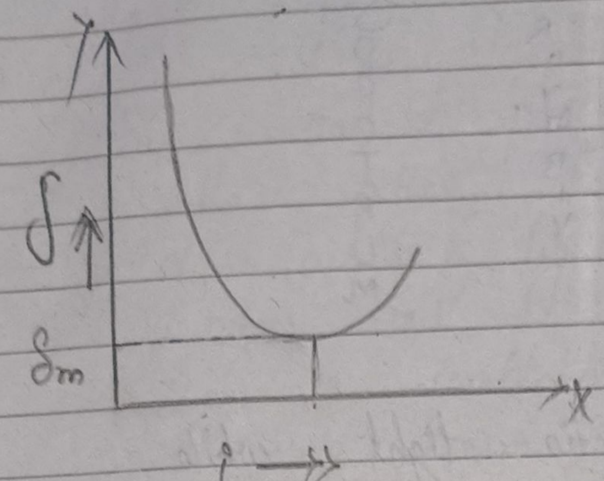
Angle of minimum deviation:-



Let, us assume

$r_1 + r_2 = r$

$i = e = i$



$r_1 + r_2 = A$

$2r = A$

$r = \frac{A}{2}$ —(i)

$\delta_m + A = i + e$

$\delta_m + A = 2i$

$((\delta_m + A)/2) = i$ —(ii)

$\mu = \sin i / \sin r$

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

$\therefore \mu = \dfrac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

From very small angle of incidence

$\therefore \mu = \dfrac{\sin i}{\sin r}$ $\left[\begin{matrix}\sin i \approx i \\ \sin r \approx r_1\end{matrix}\right]$

$\mu = \dfrac{i}{r_1}$

Similarly, $e = \mu r_2$

$A + \delta_m = i + e$

$\delta_m = \mu A - A$

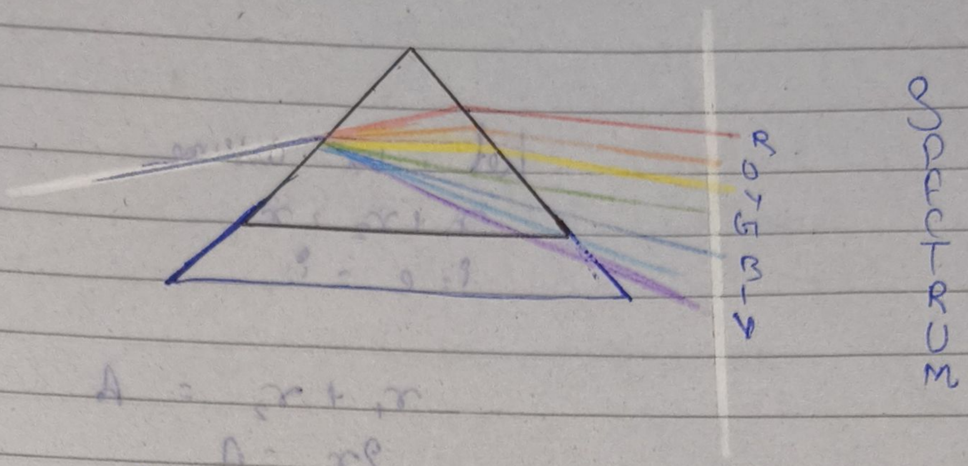
$\delta_m = A(\mu - 1)$

$A = r_1 + r_2$

$i + e = \mu(r_1 + r_2)$

$i + e = \mu A$

DISPERSION:-



Deviation:- A ray of mono cromatic light while passing through a prism suffers a change in it's path, the phenomena is known as deviation.

$$\delta = (\mu - 1)A \quad or \quad d = (\mu - 1)A$$

DISPERSSION:- A ray of light while passing through a prism splits into two of rays, the phenomena is called dispersion

$$d_v = (\mu_v - 1)A$$
$$d_r = (\mu_r - 1)A$$

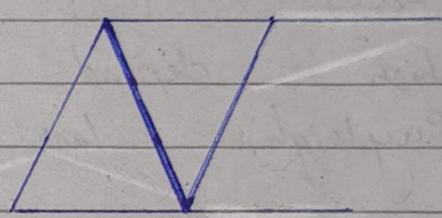
$$d_v - d_r = A(\mu_v - 1 - \mu_r + 1)$$

$$\frac{d_v - d_r}{d} = \frac{(\mu_v - \mu_r)\cancel{(A)}}{(\mu - 1)\cancel{(A)}} = \mu_\omega$$

Dispersive power (μ_ω) :- It is defined as the ratio between angle dispersion to mean deviation produced by a prism.

PRISM COMBINATION

1) DEVIATION WITHOUT DISPERSION:- The materials and the angle of two prism are selected in such a way that the dispersion produced by one prism gets exactly cancelled by the other. In this case a ray of white light entering the combination comes out as a ray of white light. Such a combination of prism is known as "achromatic prism."



$$d_v - d_r = d_v' - d_r'$$

$$(\mu_v - \mu_r) A = (\mu_v' - \mu_r') A'$$

$$\left(\frac{\mu_v - \mu_r}{\mu - 1}\right) A = \left(\frac{\mu_v' - \mu_r'}{\mu' - 1}\right) A$$

$$dw = dw'$$

2) DISPERTION WITHOUT DEVIATION:- By selecting a prism of suitable angles, it is possible to get dispertion without deviation. Such a combination is known as direct vision prism.

SCATTERING

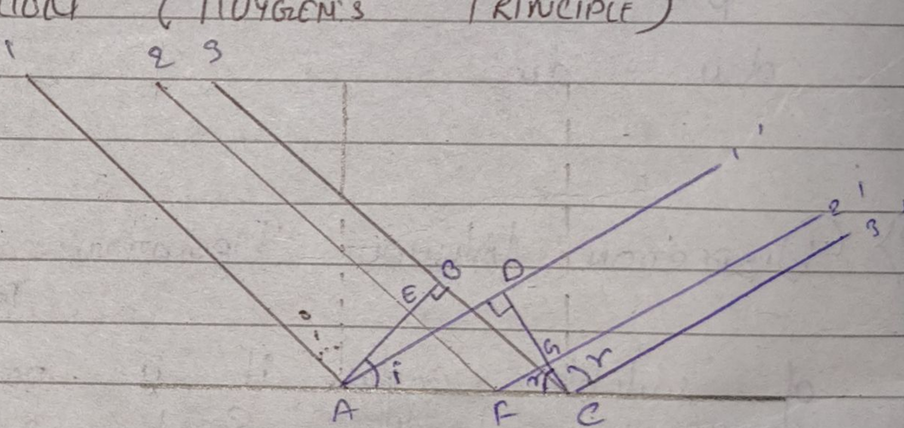
SCATTERING - When a beam of light is incident on particle of very small size, smaller than the walength of light, light proceeds in all possible direction. The phenomena is called scattering.

The intensity of a particular radiation in the scattered light depend upon it's wavelength, which depend upon a law known as Rayleigh's law of scattering.

It states that the intensity of a scattered light, having a wavelength (λ) varies inversely as the 4^{th} power of it's wavelength.

$$\boxed{I \propto \frac{1}{\lambda^4}}$$

LAWS OF REFLECTION (HUYGEN'S PRINCIPLE)



$$t = \frac{EF}{c} + \frac{FG}{c}$$

In ΔAEF, $\sin i = \frac{EF}{AF} \Rightarrow EF = AF \sin i$

In ΔFGC, $\sin r = \frac{FG}{FC} \Rightarrow FG = FC \sin r$

$$t = \frac{AF \sin i}{c} + \frac{FC \sin r}{c} \Rightarrow \frac{AF \sin i + AC \sin r - AF \sin r}{c}$$

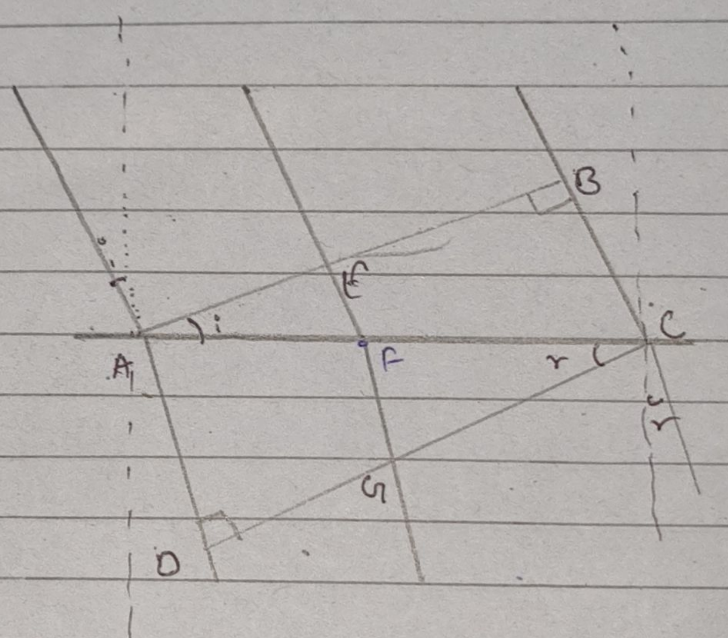
$$\frac{AC \sin r + AF(\sin i - \sin r)}{c}$$

so t should not depend on AF

$\sin i - \sin r = 0$

i.e. $\sin i = \sin r$ $\angle i = \angle r$

LAWS OF REFRACTION AT A PLANE SURFACE:-



$$t = \frac{EF}{v_1} + \frac{FG}{v_2}$$

In ΔAFE, $\sin i = \frac{EF}{AF} = AF \sin i$

In ΔFGC, $\sin r = \frac{FG}{FC} \Rightarrow FG = FC \sin r$

Optical Instrument

Power of accomodation of eye -

Lens has a power to change it's focal length and it is because of this we can see clearly nearby as well as distance objects.

This power of lens of changing the focal length of the eye is called power of accomodation.

A normal eye can see distinctly an object at infinity. which is called far point of normal eye.

The nearest distance (D) upto which eye can see clearly (by applying maximum power of accomodation) is called the least distance of distinct vision. For normal eye, the distance (D) is 25 cm. The point at a distance (D) from the eye is called nearpoint of the eye.

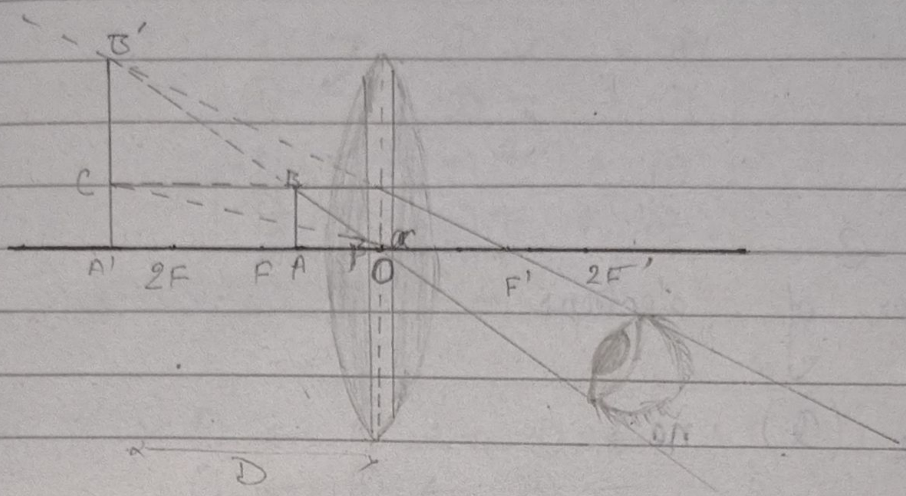
Visual Angle :-

The angle which an object subtends at our eye is called visual angle.

Magnifying Power :-

The magnifying power of an optical instrument is defined as the ratio of the visual angle subtended by the image formed by the instrument at the eye to the visual angle subtended by the object at unaided eye.

SIMPLE MICROSCOPE



$$M = \frac{\beta}{\alpha}$$

$\because$ β and α are smaller

$\therefore$ $\beta = \tan\beta = \frac{AB}{OA}$

$\alpha = \tan\alpha = \frac{CA'}{D}$

$$M = \frac{AB/OA}{AB/D} = \frac{D}{u}$$

$$M = \frac{D}{u}$$

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \Rightarrow \frac{1}{f} = \frac{1}{-D} - \frac{1}{-u}$$

$$\Rightarrow \frac{1}{f} = \frac{1}{u} - \frac{1}{D} \Rightarrow \frac{D}{f} = \frac{D}{u} - 1$$

$$\Rightarrow \frac{D}{f} = m - 1$$

$$\Rightarrow \boxed{m = 1 + \frac{D}{f}}$$