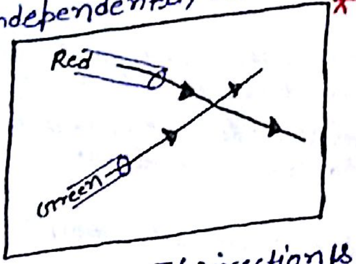
'RAY OPTICS'

Ray → It is imagenary line which show direction of energy propagation.

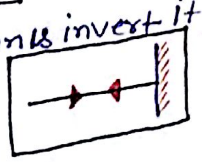
Law of Ray

|i| → **Law OF Rectilenear Propragation** → If Ray Move in homogenous mixture it will Move instraight line path.
IF direction of Ray is change than defnitelly properties OF Medium is changed.

|ii| → **Law OF Independence** → If two or, More than two Ray Intersect at same point it will Move Independentlly Move in initial direction. *



|iii| → **Law OF Reversibility** → If Direction is invert it Retrace/Read its Initial path.



Reflection → Bouncing back OF Ray take place from boundary of two different medium.

NOTE → |i| → Wave Reflected From Riged end only direction is changed & 180° phase difference Ant b/w Incident & Reflected wave.

|ii| → When It is Reflected From Free End or, Rarer Medium only direction is changed.

|iii| → Reflection, Speed, Frequency & Wavelength & Reflected Wave Remain same but velocity & Momentum is changed. (due to change in direction).

Intensity → $\boxed{I \propto a^2 \downarrow}$ * → Amplitude.

Law OF Reflection

|i| → Incident Ray, Reflected Ray & Normal at the point of Incident lies in a same plane.

|ii| → Angle of Reflection is equal to angle of Incident. It is Measured From normal.

$\boxed{\angle r = \angle i}$ *

NOTE → Law OF Reflection is applicable on plane as well as curved surface.

|iii| → Law OF Reflection in vector Form. $\boxed{\hat{R} = \hat{I} - 2(\hat{I}\,\hat{N})\hat{N}}$ *

* $\hat{I}$ ⇒ unit vector along the Incident Ray.
* $\hat{R}$ ⇒ unit vector along the Reflected Ray.
* $\hat{N}$ ⇒ unit vector along the Normal.

$\hat{I} = \frac{\vec{I}}{|\vec{I}|}$, $\hat{R} = \frac{\vec{R}}{|\vec{R}|}$, $\hat{N} = \frac{\vec{N}}{|\vec{N}|}$ | * $\hat{i}\cdot\hat{i} = \hat{j}\cdot\hat{j} = \hat{k}\cdot\hat{k} = 1$
* $\hat{i}\cdot\hat{j} = \hat{j}\cdot\hat{k} = \hat{k}\cdot\hat{i} = 0$ ***

NOTE → Parallel component along the surface Remain same & perpendicular component is Invert.

***
NOTE→ Parallel को छेड़ना नहीं !! Perpendicular को छोड़ना नहीं !!

\# Two adjucent wall & celling in a cubical Room work as a plane mirror. If light ray Incident on one suface & emerged out after Reflecting From both surface than angle b/w Incident & imerging Ray.

$\vec{I} = a\hat{i} + b\hat{j} + c\hat{k}$

$\downarrow$ X-Y plane $\Rightarrow \vec{R_1} = a\hat{i} + b\hat{j} - c\hat{k}$

$\downarrow$ Y-Z plane $\vec{R_2} = -a\hat{i} + b\hat{j} - c\hat{k}$

$\downarrow$ Z-X plane $= \vec{R_3} = -a\hat{i} - b\hat{j} - c\hat{k}$

$\vec{e} = -(a\hat{i} + b\hat{j} + c\hat{k})$

*
$\boxed{e = -\vec{I} = \theta = 180^\circ}$

**
NOTE→ * If light Ray Reflects From three ⊥ mirror then emerging Ray is antiparallel to the Incident Ray.

* Horizontal Light Ray become vertical after Reflection from plane surface then Angle of Inclination of plane surface is 45°

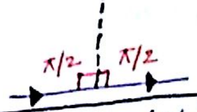
* If light Ray become vertical After Reflection from plane surface then Angle of Inclination is equal to Angle of Incident.

\# Deviation (Deviation Angle) → Angle b/w Initial direction & Reflected wave.

|i| → From one plane surface →

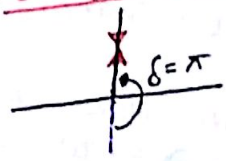
$$\boxed{\begin{matrix} \delta = 180^\circ - 2i \Rightarrow \pi - 2i \\ \text{or} \\ \delta = 180 - 2r \Rightarrow \pi - 2r \end{matrix}}$$

|a| → $i = 90$ (∥ Incident)



*
$\boxed{\delta_{min} = \pi - 2(\pi/2) = 0}$

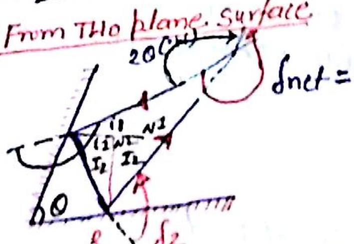
|b| → $i = 0$ (⊥ Incident)



*
$\delta_{Max} = \pi - 2(0)$

$\boxed{\delta_{Max} = \pi}$

|ii| → From Two plane. surface



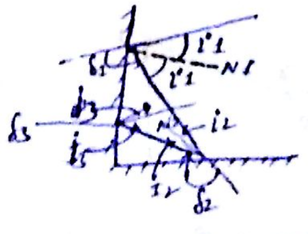
$\delta_{net} = 2\pi - 2\theta$ (A.C.W)

*
$$\boxed{\begin{matrix} \delta_{net} = 2\pi - 2\theta \rightarrow (\text{A.C.W}) \\ \delta_{net} = 2\theta \rightarrow (\text{C.W}) \end{matrix}}$$

NOTE→ * If Light Ray Incident on 1st Mirror & Emerge out From 2nd division Angle is Independent from angle of Incident. Its only depend on angle b/w plane Reflecting surface.

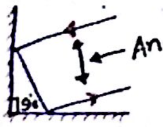
* Devision Angle is Independent from Rotation of Reflecting surface combinati

|iii| → Multiple Reflection →



*
$\boxed{\delta_{net} = \delta_1 - (\delta_2 + \delta_3)}$

1 # Two plane Mirror ⊕nt at angle 90° light Ray Incident on Ist mirror $ Emerge out from 2nd than Angle b/w Incident $ Emerging Ray.



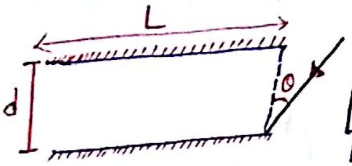
$\boxed{\delta = \pi \text{ or, } 180}$ *

NOTE→ Emerging Ray is always anti-parallel to Incident Ray If two plane mirror is ⊕nt ⊥ to Each other.

If, In upper prob. If Mirror combination rotate by 40° than new value of deviation Angle.

* Ans→ Same i.e 180° (does not depend on Incident angle.)

III



No. of Reflection. *

$$\boxed{N = \frac{L}{d\tan\theta}}$$

$\boxed{n-1}$

i→ Real object $ virtual Image→ point where light ray Really diverge is called Real object $ Appear to diverge is called virtual Image.

ii→ Real Image or, vertual object→ point where light Ray Really converge called Real Image $ Appear to converge called vertual object.

Properties of plane surface.

i→ plane surface Form vertual Image of Real object $ Real Image of vertual object.

ii→ Devision Angle Form plane surface is $\boxed{\delta = \pi - 2i}$

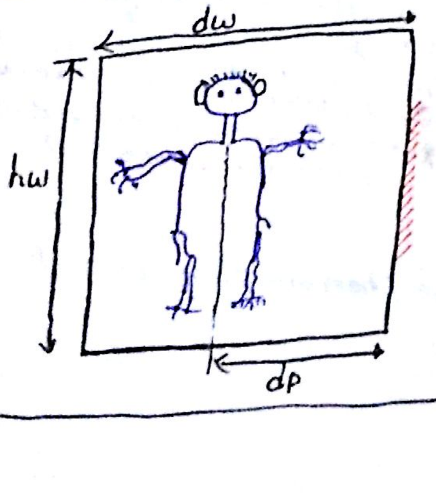
iii→ Distance of Image From Mirror is equal to distance of object From mirror.

$\boxed{d_{OM} = d_{IM}}$ *

iiii→ Height of Image is equal to height of object. ($h_I = h_o$)

NOTE→ * person of Height 'h' want to see complete Image in a plane mirror minimum height of plane mirror is h/2 $ Top point of Mirror is arrange above From eye level.

* If person ⊕nt at centre point of cubical Room $ want to see complete image of back side wall in front of Mirror height of wall H. Then Min height of plane mirror is→ $\boxed{h_M = x + y \Rightarrow h_w/3}$ *



*
$$h_m = \frac{h_w}{1 + \frac{d_w}{d_p}}$$

Mirror.
Distance of wall.
Distance of person.

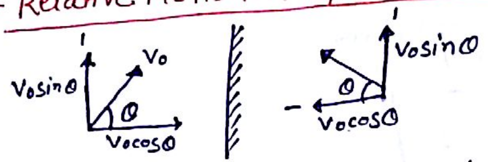
Field OF View → Region Around the Reflecting surface where we completelly observe the Image of object.

NOTE → A person Move || to the plane surface at distance 'na' Then length of Its path in Wich obserb completely the image is $\boxed{(n+1)h}$ *

$\boxed{L=(n+1)h}$ * $\boxed{d=na}$ *

[h = height OF Mirror
d = distance of object From Mirror.]

Relative Motion in a plane surface

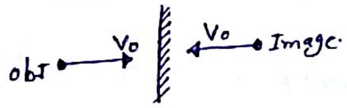


*
$$\boxed{\begin{aligned}\vec{V_o} &= (v_o\cos\theta)\,\hat{i} + (v_o\sin\theta)\,\hat{j}.\\ \vec{V_{IM}} &= -(v_o\cos\theta)\,\hat{i} + (v_o\sin\theta)\,\hat{j}.\end{aligned}}$$

* Relative velocity w.r.t Image ($\vec{V_{oI}}$)

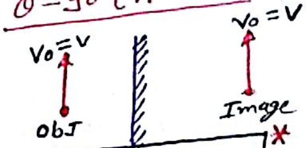
$$\boxed{\vec{V_{oI}} = \vec{V_o} - \vec{V_I} = (2V_o\cos\theta\,\hat{i})}$$ *

|a| → θ = 0 (⊥ Move)



*
$$\boxed{\begin{aligned}\vec{V_{IO}} &= \vec{V_I} - \vec{V_o}\\ &= -2V_o\end{aligned}}$$

|b| → θ = 90° (|| Move)

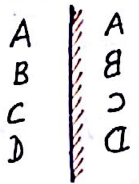


$$\boxed{\vec{V_{IO}} = v - v = 0}$$ *

NOTE → component parallel to the plane Reflecting surface Remain unchanged but perpendicular component is Invert.

That inverson is called Face to Face Inverson & Right hand cordinate system & that coordinate system after Reflection was as left hand cordinate system.

Inverson OF alphabet is called Lateral Invergen.



$\boxed{\text{* A, H, W, M, I, O, U, V, X, Y, T} \Rightarrow \text{convergen are Not possible.}}$

* Sum of Actual time & time of Image of Image of digitless clock is 12 hrs.

Eg → T_A = 5 hr 40 min ⇒ (11 − 5) hrs , (6 − 40) ⇒ 6 hr 40 mint

Two plane mirror placed ⊥ to each other than position of Its Image & locus of Image & object point →

↳ M = 4 , n = M − 1 = $\boxed{3}$

NOTE → *conside point of Mirror take centre of circle & distance b/w object & conc
point Is Radius & draw a circle then object & Image point at circumference
of circle & Locus of object & Image point is circle.

* Two Adjuscent wall & cieling in a cubical room Work as a plane
Mirror & plane Mirror & object placed b/w them . than . Max no. of Image observed by orserbe is '6'

$$\boxed{\underset{\text{Erect}}{3} + \underset{\text{Inverted}}{4} \Rightarrow 7}$$

* Max no. of Image is 7
& Minimum Image is 1.

* Thick Mirror produce More than one Image of single object & 2nd Image is Max. bright.

Effect OF Rotation ⇒

case-I → Mirror at Rest & Incident Ray Rotate

IF Incident Ray Rotate at angle 'θ' then Reflected Ray Rotate at angle -'θ'.

case-II → Mirror is Rotate at angle θ

IF Mirror Rotate an angle 'θ' then Reflected Ray Rotate with '2θ' in Same Direction.

NOTE → If Mirror Rotate With angular speed 'ω' or, angular Acceleration 'α' then Reflected Ray is Rotate with A·velocity '2ω' & Angular Acceleration '2α'.

case-III → Incident Ray Rotate at angle 'α' and mirror Rotate at angle 'β'

|i|→ Same Direction $\angle R_2OR_1 = 2\beta - \alpha$

|ii|→ opposite Direction $\angle R_2OR_1 = 2\beta + \alpha$.

NO of Image produce by plane mirror

- ✱→ single Mirror produce only one Image of object but in case OF Two or More than two mirror due to multiple Reflection No. of Image is possible Two or, More Than Two.
- ✱→ In case of Two Mirror No. of Image depend on Angle b/w Mirror & position of object.

✱

No. of Image Formed.

✱ $n = \frac{360}{\theta}$

		Symmetric	unsymmetric
→ Even →		n-1	n-1
→ odd →		n-1	n
→ Fraction →	No. of Image =	Lower Integer.	

EX → 5·7 , 7·2 ⇓ 5 , 7 ; 2·5 ⇓ 2.

$* \; n = 0 \Rightarrow \frac{360}{0} = \infty$ [Image Formed Infinite symetric & ∞ unssymetric]

Two plane mirror placed at distance 'A' & parallel to Each other. object placed at centre point of combination than distance b/w nth Image of both Image.

✱
- ✱ Distance b/w Ist Image = 2A(1)
- ✱ Distance b/w 2nd Image = 2A(2)
- ⋮
- Distance b/w Nth Image = 2A(N)

✱ $\boxed{F = \frac{R}{2}(2 - \sec i)}$

Focal length

$\boxed{F = R - CF}$

Focal length of curve mirror

$\boxed{AB = BC = R/2}$

|a|→ # For paraxial Ray

$i = 0 \Rightarrow \sec i = 1$

$\boxed{F = R/2}$

|b|→ Focal length of curved mirror depend on Radius of curvature & Angle of Incident It is Independent From surrounding medium.

✱ $\boxed{F_{air} = F_{liquid} = F_{medium}}$

Basic Rule oF or Ray Law of Reflection

|i|→ IF Ray Move || to principle Axis After Reflection it will be pass or, appear to be pass From Focus OF curved Mirror.

|ii|→ IF Ray pass From Focus or, appear to be pass From Focus it becomes || to the principle axis after Reflection From curved Mirror.

|iii|→ If Ray pass From centre of curvature it will Retrace its initial path reflection From curved Mirror.

|iv|→ IF Ray Incident on pole then angle of Incident From principle axis is equal to Angle OF Reflection.

Sign convention

|i|→ Pole OF curved Mirror considered origien oF coordinate system.
|ii|→ Principle axis considered along the X-Axis.
|iii|→ All distance are Measured From pole. Left hand side of pole is ⊖ve $ Right hand side distance is ⊕ve.

$$\boxed{\begin{array}{l}\text{concave Mirror}\\ F = \ominus ve\\ R = \ominus ve\end{array}} * \qquad * \boxed{\begin{array}{l}\text{convex Mirror}\\ F = \oplus ve\\ R = \oplus ve\end{array}}$$

NOTE→ ✱→ Sign oF Real object Real Image distance ⊖ve $ sign oF virtual Image $ vertual object is ⊕ve.

✱→ Height above principle axis take ⊕ve $ below the principle axis take ⊖ve.

✱→ IF object or, Image Rotate anti-clockwise sign of Rotation take ⊕ve $ When Rotate clockwise its sign is ⊖ve.

Mirror Formula

$$\boxed{\frac{1}{V}+\frac{1}{u}=\frac{1}{F}}\ ,\ \boxed{F=\frac{UV}{U+V}}\ ,\ \boxed{V=\frac{UF}{u-F}}\ ,\ \boxed{u=\frac{VF}{V-F}}$$

Magnification oF curved Mirror

$$\boxed{m_T=\frac{hi}{ho}=-\left(\frac{V}{U}\right)=-\left(\frac{F}{u-F}\right)=-\left(\frac{V-F}{F}\right)}$$

NOTE→ *In Mirror Formula $ Magnification Formula given data use With proper sign convention.

Standard

✱→ When object placed b/w 'P' $ 'F' image is virtual, Inlarge, Erect Form behind the Mirror.

✱→ When object placed at Focous Image is Real, Height enlarge, Inverted Form at ∞.

✱→ When object is placet b/w 'C' $ 'F' image is Real, Inverted, enlarge Form b/w 'C' $ ∞.

*→ When object placed at 'c' Image is Real, Inverted, same size Form at 'c'.

*→ When object placed b/w c & ∞ Image is Real, Inverted, diminished Form b/w 'c' & 'F'.

*→ When object placed at ∞ Image is Real, Inverted, highly diminshed & Form at Focus.

For All Mirror & Lens

|i|→ Magnification of Real object & Real Image is $\ominus$ve & For real object & vertual Image is $\oplus$ve.

|ii|→ IF real Image is Formed form Real object it is always Inverted with Respect to object. & virtual image of Real obj. is errect w.r.t object.

NOTE → *→ IF object move with constant speed in principle Axis OF concave Mirror then Real Image Move With variable speed in opposite direction of object.

*→ Distance b/w Real object & Real Image of concave mirror.

[* Min = 0 → at 'c' object.]
[* Max → ∞]

*→ A concave Mirror Form Real or, vertual Image of Real object it depend on position OF object.

*→ concave Mirror Never Form vertual Image OF vertual object.

*→ concave Mirror always produce Real Image of vertual object b/w 'P' & 'F'.

*→ convex Mirror always Form Virtual, Erect & diminished Image of Real object.

*→ IF virtual object placed b/w pole & Focous of convex Mirror then Image is Real Erect w.r.t obj. & Inlarge.

*→ When virtual obj. placed b/w Focous & ∞ of convex Mirror Image is virtual inlarge & Inverted w.r.t object.

Compair virtual Image OF Real object in plane concave & convex Mirror.

Ans→ |i|→ plane Mirror & convex Mirror always Form virtual Image OF Real obJ. (It is Independent From distence) but incase OF concave mirror it is possible when object $\oplus$nt b/w pole & Focous.

|ii|→ Plane Mirror Form same size virtual Image, covex form dimines & concave form enlarge.

*

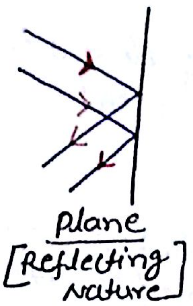
object	Image	m
R	R	$\ominus$ve] → Inverted wrt obJ.
R	V	$\oplus$ve] → Erect wrt obJ
V	R	$\oplus$ve]
V	V	$\ominus$ve] → Inverted wrt obJ.

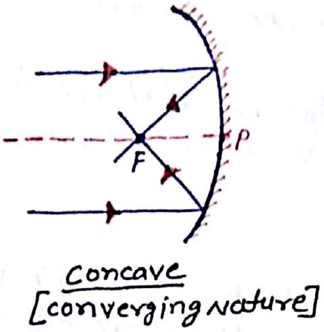
***

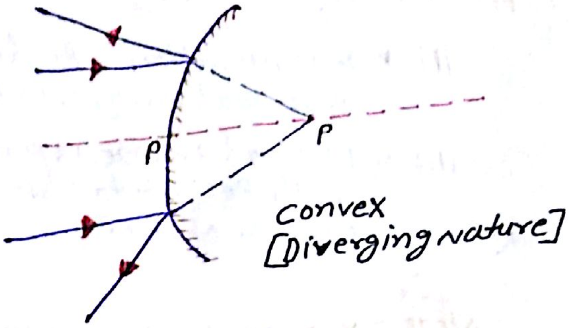
#use OF Mirror

- * Plane Mirror → Drashing Table.
- * Concave Mirror → Saving kit, Makeup kit, *Headlight of vehcle.
- Imp * convex Mirror → *Side Glass of Vehcle.

What happen when // light beam light beam Incident on plane mirror, concave Mirror & convex Mirror.

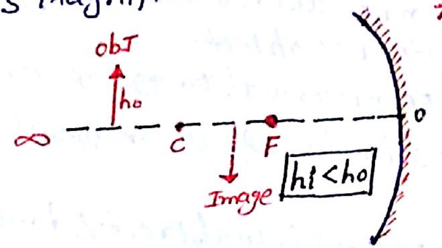






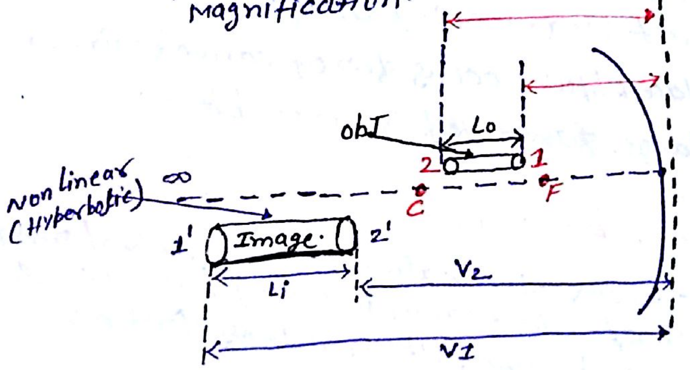
Types OF Magnification

|1| → Transverse Magnification (m_T) → When object placed ⊥ to principle axis Magnification of its height is called transverse magnification.



$$* \quad \boxed{m_T = \frac{h_i}{h_o} = -\left(\frac{V}{U}\right) = -\left(\frac{F}{U-F}\right) = -\left(\frac{V-F}{F}\right)}$$

|2| → Longitudinal Magnification (m_L) → IF obJ. placed alone the length on principle axis Magnification of Its length is called longitudinal Magnification.



$$* \quad \boxed{m_L = \frac{L_I}{L_o} = \frac{V_1 - V_2}{U_2 - V_1} = -\frac{\Delta V}{\Delta U}}$$

$$* \quad \boxed{m_L = \frac{L_I}{L_o} = -\frac{\Delta V}{\Delta U} = \frac{F^2}{(U_1 - F)(U_2 - F)}}$$

Special case

(Small Length Linear object or wire)

Length of obJ. is very small.

$$\boxed{\Delta \longrightarrow d}$$

$$\boxed{m_L = \frac{L_i}{L_o} = -\frac{dv}{dU}}$$

$$\boxed{\frac{dv}{dU} = -\left(\frac{v}{u}\right)^2 = M_T^2}$$

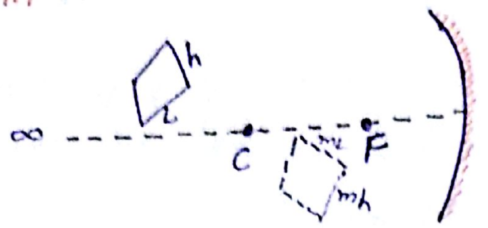
$$\boxed{m_i = \frac{-dv}{du} = -(-m_T^2)}$$

$$\boxed{m_L = m_T^2 = \frac{L_I}{L_o}}$$

$$\boxed{\begin{aligned} L_I &= m_T^2 L_o \\ h_I &= m_T h_o \end{aligned}} \; *$$

|3|→ Areal Magnification (M_A) →

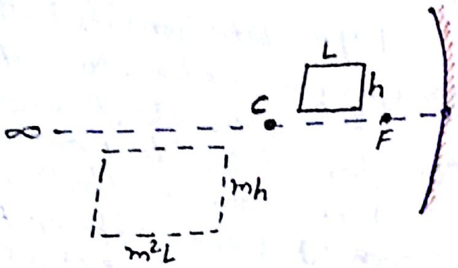
|i|→



$A_o = (L)(h)$, $A_I = (mL)(mh)$

* $$\boxed{M_A = \frac{A_I}{A_o} = m^2_T}$$

|ii|→

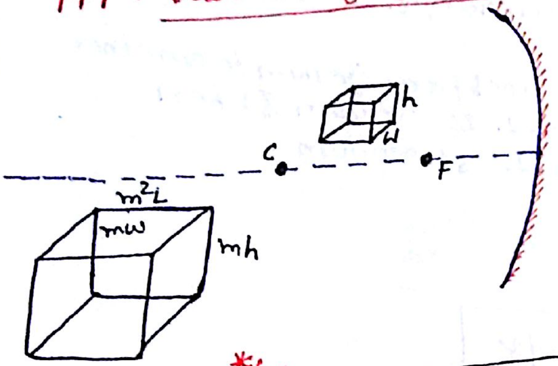


$A_o = (L)(h)$

$I_I = (m^2L)(mh)$

$$\boxed{M_A = \frac{A_I}{A_o} = m^3_T}$$ *

|4|→ Volume Magnification (m_v)



$V_o = (L)(w)(h)$

$V_I = (m^2L)(mw)(mh)$

$V_I = m_T^4 V_o$

$$\boxed{m_v = \frac{V_I}{V_o} = m^4_T}$$ *

***

- * $h_I = m_T h_o$
- * $L_I = m_L L_o = m^2_T L_o$
- * $A_I = m^2_T A_o = m^3_T A_o$
- * $V_I = M^3_T V_o = m^4_T V_o$

⇒ use when length is small.

Newton's Formula

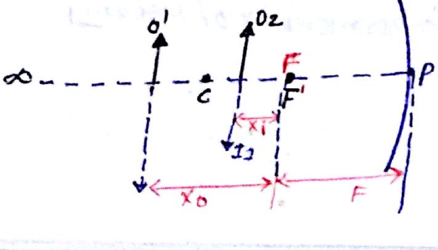
IF distance of obJ. & Image is measure From Focus, then square root of distance of object & Image is equal to Focal length of Mirror.

$$\boxed{F = \sqrt{X_o X_i}}$$ *

- * X_o ⇒ Distance of object From Focus.
- * X_i ⇒ Distance of Image From Focus.
- * F ⇒ Focal length of Mirror.

Law OF Reversibility

IF object shift towards Image position & Image shift towards obJ position then that position are called conjugation position & product of Magnification at that point is equal to 1.



* Magnification in Ist case of obJ.

$$\boxed{m_i = \frac{h_i}{h_o} = -\left(\frac{X_i+F}{X_o+F}\right)}$$ *

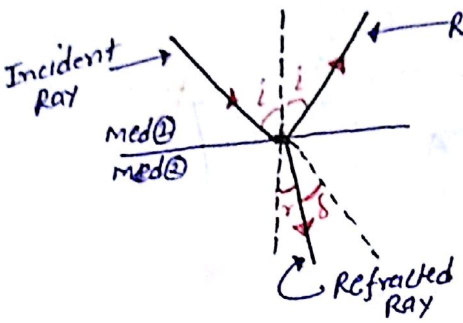
* magnification in 2nd case of obJ.

$$\boxed{m_1 m_2 = 1} \text{ or, } \boxed{m_1 = \frac{1}{m_2}}$$

$$\boxed{h_0 = \sqrt{h_{i1} h_{i2}}}*$$

Refraction

Ray deviate from its path when it Goes From one medium to another.



Ray deviate from its path when goes from one medium to another.

* 'Surface Reflect & Refract some part of Incident energy a/c to capacity of surface, that's why image of clouds and tree appear Faint or, less bright at surface of water.'

NOTE → * In Refraction speed & wavelength change w.r.t medium but Frequency Remain same.

* IF velocity of wave ↑ when it goes from medium to another then 2nd medium is Rarer w.r.t Ist medium & when velocity ↓ then it is denser w.r.t Ist medium.

Velocity of Light [c]

* velocity of Light in vaccum

$$\boxed{c_0 = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = 3 \times 10^8 \, m/sec}$$

* ε_0 = Electric permeability of vaccum

$= 8.85 \times 10^{-12} \frac{Cb^2}{N \times m^2}$ (S.I unit)

* $\mu_0 = 4\pi \times 10^{-7}$ (SI unit)

↪ Magnetic permitivity of vaccum.

* Dimension of $(\mu_0 \varepsilon_0)^{-1/2}$

⇓

velocity of light.

⇓

$\boxed{LT^{-1}}$

* velocity of light in medm.

$$\boxed{C_m = \frac{1}{\sqrt{\mu_m \varepsilon_m}}}*$$

[ε_m ⇒ Electric permeability of med.

μ_m ⇒ Magnetic permetivity of Medium]

1* $\varepsilon_r \Rightarrow$ Relative electric permeablity of medium $\Rightarrow \varepsilon_r = \frac{\varepsilon_m}{\varepsilon_0} > 1$

* $\mu_r \Rightarrow$ Relative magnetic permitivity of medium $\Rightarrow \mu_r = \frac{\mu_m}{\mu_0} > 1$

NOTE →

*→ velocity of light depend on electric & magnetic property of medium.

*→ Electric permeablity & magnetic permitivity of medium is greater than vaccume.

*→ It is Relative value & unitless & Dimensionless & always Greater than one.

$$\frac{C_m}{C_0} = \frac{1/\sqrt{\mu_m \varepsilon_m}}{1/\sqrt{\mu_0 \varepsilon_0}} = \sqrt{\frac{\mu_0 \varepsilon_0}{\mu_m \varepsilon_m}}$$

*
$$\boxed{\frac{C_m}{C_0} = \frac{1}{\sqrt{\frac{\mu_m}{\mu_0} \cdot \frac{\varepsilon_m}{\varepsilon_0}}}}$$

$$\boxed{C_m \leq C_0}$$

*
$$\boxed{\begin{matrix}\mu_r > 1 \\ \varepsilon_r > 1\end{matrix}}$$

Refractive Index of Medium

Ratio of velocity of light in vaccum to velocity of light in medium.

*
$$\boxed{\mu_m = \frac{C_0}{C_m}}$$

C_0 → 'c' in vaccum

C_m → 'c' in medium

μ_m ↑ Refractive Index of med.

*
$$\boxed{\mu_m = \frac{C_0}{C_m} = \sqrt{\mu_r \varepsilon_r}}$$

$\mu_r > 1$

$\varepsilon_r > 1$

$$\boxed{\mu_m > 1}$$ ✓

*
- *$\mu_{air} = \mu_{vac} = 1$
- *$\mu_{Water} = \frac{4}{3} = 1.33$
- *$\mu_{Glass} = 3/2 = 1.5$
- *$\mu_{Diamond} = 1.6$

Relative Refractive Index

* R.I of Medium ① w.r.t ② $\Rightarrow {}_2\mu_1 = \frac{\mu_1}{\mu_2}$

* R.I of Medium ② w.r.t ① $\Rightarrow {}_1\mu_2 = \frac{\mu_2}{\mu_1}$

*
$$\boxed{\begin{matrix}{}_1\mu_2 = \frac{1}{{}_2\mu_1} \\ {}_1\mu_2 \times \frac{1}{{}_2\mu_1} = 1\end{matrix}}$$

Eg → * R.I of water w.r.t air

$$\mu = \frac{\mu_w}{\mu_{air}} = \frac{1.33}{1} = 1.33 > 1$$

* R.I of air w.r.t water

$$\mu = \frac{\mu_{air}}{\mu_w} = \frac{1 \times 3}{4} = 0.75 < 1$$

NOTE → * value of Relative & Refractive Index may be more than one & less than one but value of Absolute Refractive Index is always greater than 1.

* IF Relative Refractive Index is more than Medium is denser w.r.t Relative medium & when it is less than 1 it's rarer w.r.t Relative Medium.

$$c = \overset{\text{same}}{n} \lambda$$

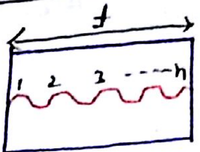
* $\boxed{\lambda_m \propto C_m \propto \frac{1}{\mu_m} \qquad \frac{\lambda_2}{\lambda_1} = \frac{C_2}{C_1} = \frac{\mu_1}{\mu_2}}$

* $\boxed{C_m = \frac{C_0}{\mu_m} \qquad \lambda_m = \frac{\lambda_0}{\mu_m}}$

* $\boxed{\frac{\lambda_m}{\lambda_0} = \frac{C_m}{C_0} = \frac{1}{\mu_m}}$

* $\boxed{n_m = n_{air}}$

Same no. of Wave is passed from 5cm thick water column & 4cm thick transparent Medium. IF R.I of water is 4/3. than Refractive Index of Transparent Medium.



* $\boxed{t = n\lambda}$

* $\boxed{t_m = N_m \lambda_m = N_m \left(\frac{\lambda_0}{\mu_m}\right)}$

* $\boxed{\frac{t_{m1}}{t_{m2}} = \frac{N_{m1}}{N_{m2}} \times \frac{\mu_{m2}}{\mu_{m1}}}$

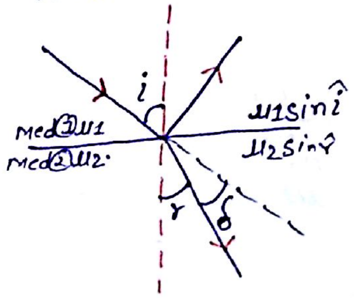
$$\frac{5}{4} = \frac{1}{1} \times \frac{\mu_{m2}}{4/3}$$

$$\mu_{m2} = \frac{5}{\cancel{4}} \times \frac{\cancel{4}}{3} = 1.66$$

Law of Refraction

*→ Incident Ray, Refracted Ray & Normal at the point of Incident lies on same plane.

*→ Product of Refractive Index & sin θ remain same in all medium it is called Snell law.



* $\boxed{\mu_1 \sin\hat{i} = \mu_2 \sin\hat{r}}$

* $\boxed{\mu \sin\theta = \text{const}}$

Refractive Index of Med.

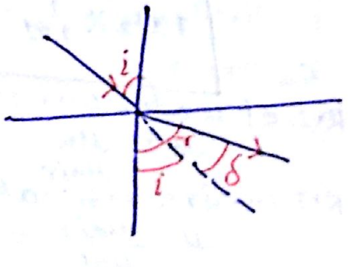
Angle of Ray From ⊥ to surface.

|a| → $\mu_1 > \mu_2$ (Denser → Rarer)

$\sin\hat{r} > \sin\hat{i}$

$\boxed{r > i}$ ⇒ Away From Normal.

* $\boxed{\delta = r - i}$



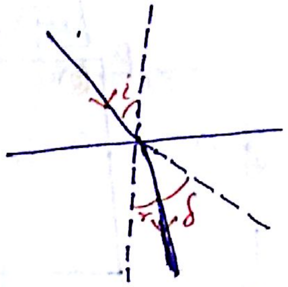
(b) → $\mu_2 > \mu_1$ (RareR → Denser)

$\frac{\mu_1}{\mu_2} < 1$

$\boxed{\sin r < \sin i}$

$\boxed{r < i}$ *

$\boxed{\delta = i - r}$ *



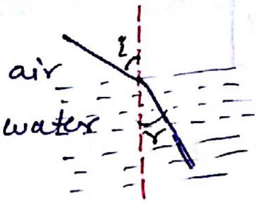
NOTE → When Ray goes From densor to Rarer medium it will deviate away From Normal & When it goes From Rarer to denser medium it will deviate towards Normal & deviation angle of Refracted Ray is

$\boxed{\delta = |i - r|}$ *

$\boxed{r = \sin^{-1}\left(\frac{\mu_1}{\mu_2}\sin i\right)}$ *

Ex →

(i) → Light Wave

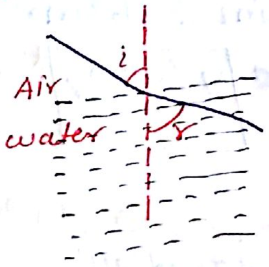


Cair > C water

R ↙ ↘ D

$\boxed{r < i}$

(ii) → Sound wave/Ray



Vair < Vwater

↑ D ↑ R

$\boxed{r > i}$

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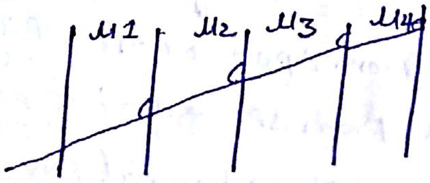
Light Ray pass From || surface of different medium Refractive Index Resp. $\mu_1, \mu_2, \mu_3, \mu_4$ & Emerging Ray || to incident Ray than Relation b/w μ_1 & μ_4.



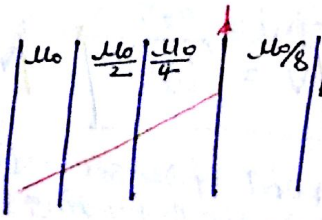
e = 1

$\mu \sin\theta = \text{const}$

$\mu_1 \sin i = \mu_4 \sin i$

$\boxed{\mu_1 = \mu_4}$ *

Light Ray pass From surface of medium of Refractive index Resp. $\mu_o, \mu_o/2, \mu_o/4, \mu_o/8$. If emergining Ray || to surface than value of Angle of Incident.



$\boxed{e = 90°}$

$\mu_o \sin i = \frac{\mu_o}{8} \sin 90°$

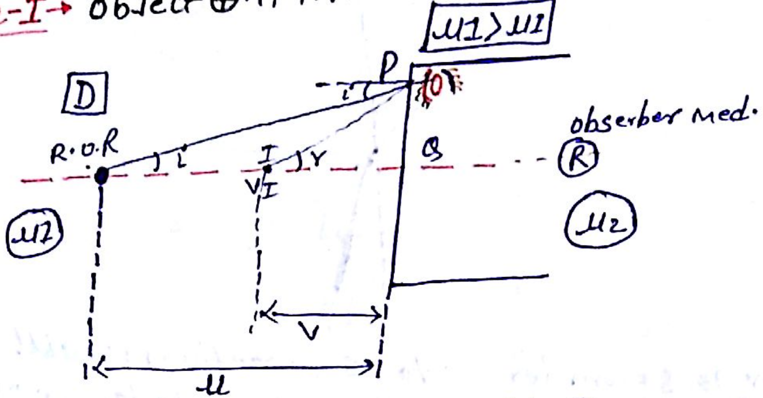
$\sin = 1/8$

$\boxed{i = \sin^{-1}(1/8)}$ *

Position of Image

Object ⊕nt in densor Medium & observer ⊕nt in Rarer Medium.

Case-I → object ⊕nt in densor medium



*From ΔPQR ∴ $\tan\hat{i} = \frac{PQ}{OQ} = \frac{PQ}{u}$ -(I)

*From ΔPIQ ∴ $\tan r = \frac{PQ}{IQ} = \frac{PQ}{v}$ =(II)

For parxial Ray $(i = 0, r = 0)$

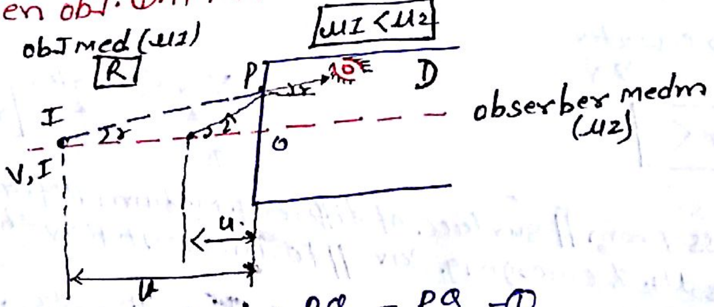
$\sin\theta = \tan\theta$

$$\boxed{\begin{aligned}\sin i = \tan i = \frac{PQ}{u} \\ \sin r = \tan r = \frac{PQ}{v}\end{aligned}}$$

* $\mu_1 \sin i = \mu_2 \sin r$

$\boxed{V\left(\frac{\mu_2}{\mu_1}\right)V}$ * $\mu_1 > \mu_2$ $\boxed{\frac{\mu_2}{\mu_1} < 1}$ * $\boxed{V < \mu}$

Case-II → When obJ. ⊕nt in Rarer med. & obserber ⊕nt in denser medium.



* From ΔPOQ → $\tan i = \frac{PQ}{OQ} = \frac{PQ}{u}$ -①

* From ΔPIO → $\tan i = \frac{PO}{IQ} = \frac{PQ}{V}$ -②

From paraxial Ray $(i = 0, r = 0)$

$\sin\theta = \tan\theta$

$\sin i = \tan i = \frac{Po}{u}$

$\sin r = \tan r = \frac{PQ}{V}$

$\mu \sin i = \mu_2 \sin r$ *

$\boxed{V = \left(\frac{\mu_2}{\mu_1}\right)V}$ $\boxed{V > \mu}$

NOTE → When obJ. of Denser medium is seen From Rarer medm it appear close to the Refracting Surface. & when obJ. of Rarer Med is seen From denser Medium it will apear away From obJ.

Plane Refractive surface

$v = \left(\frac{\mu_{observer}}{\mu_{object}}\right) u$

distance of image (v); dist. of object (u)

- * $\mu_{observer} > \mu_{obJ} \rightarrow v > u$
- * $\mu_{observer} < \mu_{obJ} \rightarrow v < u$

(R) (D)

\# $V_I = \frac{\mu_{observer}}{\mu_{obJ}} V_o$

velocity of Image (V_I); velocity of obJ. (V_o)

- * $\mu_{observer} > \mu_{obJ} \Rightarrow V_I > V_o$ (D) (R)
- * $\mu_{observer} < \mu_{obJ} \Rightarrow V_I < V_o$

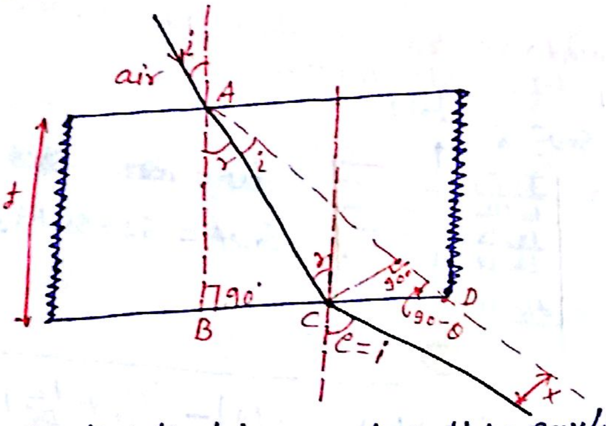
Relative speed

⇓

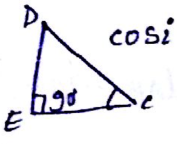
- * Both in same direction → ⊖ve
- * Both in opposite direction → ⊕ve

Refraction from slab

Slab is a body wich has 2 plane || reflecting surface.



Due to slab Angular deviation is zero but light Ray linearly deviate from its path that displacement is called lateral disp. or, lateral shift.



$\cos i = \frac{CE}{CD} = \frac{x}{CD}$

$CD = \frac{x}{\cos i}$

* $CD = BD - BC$ — (I)

* From ΔABC — $\tan r = \frac{BC}{AB} = BC = t\tan r$ (II)

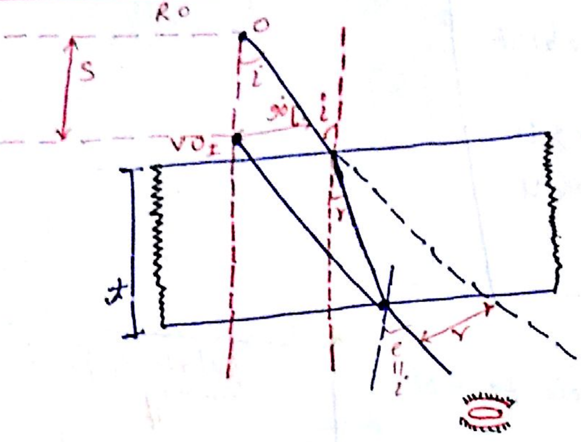
* From $\Delta ABD = \tan i = \frac{BD}{AB} = \frac{BD}{t}$

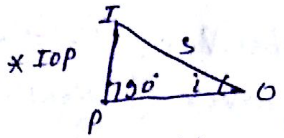
$\Rightarrow BD = t\tan i$ — (III)

$\frac{x}{\cos i} = t\left[\frac{\sin i \cos r - \cos i \sin r}{\cos i \cos r}\right]$

$$\boxed{x = \frac{t\sin(i-r)}{\cos r}}$$

Shift In Image position Due to slab





$\sin i = X/S$

$S = \frac{X}{\sin \hat{i}} = \frac{1}{\sin \hat{i}}\left[\frac{t\sin(i-r)}{\cos r}\right]$

↑ Shift in Image position.

*

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

t ⇒ Thicknes of slab.

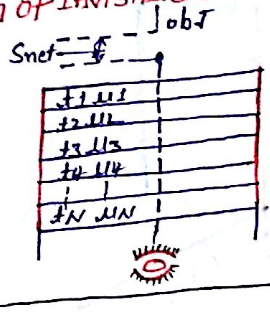
μ = R.I of slab material.

S = shift in Image position.

NOTE→ Shift in image position due to slab is Independent From dist. of obJ. & obser~~se~~ver From slab.

Special case (Shift due to 'n' slab)

case : I→ Shift due to 'n' slab. Net shift in Image position is ~~scalar~~ scalar Addition of Invisible shift of slab.



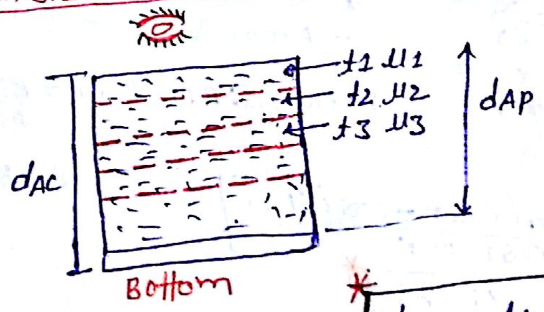
~~d_{ap}~~ = ~~d_{ac}~~ - ~~Snet~~

$S_{net} = S_1 + S_2 + S_3 + \dots - S_N$

*

$$\boxed{S_{net} = (t_1 + t_2 + \dots t_N) - \left(\frac{t_1}{\mu_1} + \frac{t_2}{\mu_2} + \dots \frac{t_N}{\mu_N}\right)}$$

case-II→ Immisible liquid Fill in a container

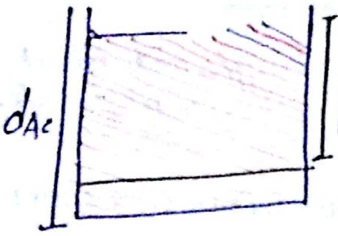


$d_{AP} = d_{AC} - S_{net}$

*

$$\boxed{d_{AP} = \frac{t_1}{\mu_1} + \frac{t_2}{\mu_2} \dots \frac{t_N}{\mu_N} \quad \boxed{d_{AP} = \sum_{i=1}^{i=N} \frac{t_i}{\mu_i}}}$$

1 # Effective Refractive Index of Mixture



$\boxed{d_{AP} = \frac{d_{AC}}{\mu_{eff}}}$ *

$$d_{AP} = \frac{d_{AC}}{\mu_{eff}} = \frac{t_1}{\mu_1} + \frac{t_2}{\mu_2} + \text{------} \frac{t_N}{\mu_N}$$

$$\frac{t_1 + t_2 + \text{---} t_N}{\mu_{eff}} = \frac{t_1}{\mu_1} + \frac{t_2}{\mu_2} \text{---} \frac{t_N}{\mu_N}$$

$$\boxed{\mu_{eff} = \frac{t_1 + t_2 \text{---} t_N}{\frac{t_1}{\mu_1} + \frac{t_2}{\mu_2} + \text{---} \frac{t_N}{\mu_N}}}$$

N = 2

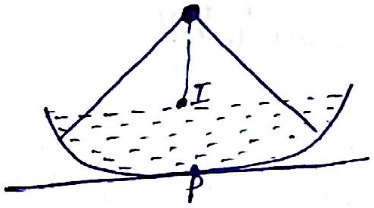
$\boxed{\mu_{eff} = \frac{t_1 + t_2}{\frac{t_1}{\mu_1} + \frac{t_2}{\mu_2}}}$ *

N=2 $(t_1 = t_2)$

* $\boxed{\mu_{eff} = \frac{2\mu_1 \mu_2}{\mu_1 + \mu_2}}$

concave Mirror of Radius of curvature 'R' is placed on horizontal floor $ its principle axis ⊕nt in vertical direction. Some amount of water is filled in a mirror $ point object placed at centre of curvature than final position of Image.

Ans→ B/w pole $ centre of curvature.



AIIMS

Total Internal Reflection (T.I.R)

When light Ray Goes From denser to Rarer medium it will deviate away from Normal. When Angle of Incident ↑, then angle of Refraction also ↑ at certain value of angle of Incident light Ray become parallel to the Refracting surface that certain value of Angle of Incident is called critical angle. And when <i become More than critical angle. Refracting Ray come back in denser Medium phenomena of complete Reflection of Energy is called T.I.R.

$\boxed{\mu_D > \mu_R}$ $\boxed{\mu_D \sin\theta_c = \mu_R \sin 90^\circ}$ $\boxed{(\theta_c)_V < (\theta_c)_R}$

$\boxed{\sin\theta_c = \frac{\mu_R}{\mu_D} = \frac{1}{\mu}}$

Difference b/w ordinary Reflection & T.I.R.

(i)→ ordinary Reflection can take place boundry of densor as well as Rarer Medium but T.I.R is takes place only from Rarer medium

(ii)→ ordinary Reflection can take place for any value of angle of Incident but for T.I.R is only possible angle of Incident more than critical angle.

$$\boxed{\angle i > \theta_c}$$

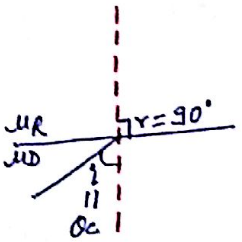
(iii)→ In ordinary Reflection 100% Energy does not Reflect in same Medium but in T.I.R, It is possible.

* Condition of T.I.R

* D → R

* i > θc

Critical Angle



$\mu_R \sin\theta_c = \mu_R = \mu_R \sin 90°$ *

$$\boxed{\begin{aligned} \sin\theta_c &= \frac{\mu_R}{\mu_D} \\ \theta_c &= \sin^{-1}(\mu_R/\mu_D) \end{aligned}}$$

$\mu_R = 1$ (air)

$$\boxed{\sin\theta_c = 1/\mu_D}$$

$$\boxed{\theta_c = \sin^{-1}(1/\mu_D)}$$

(a)→ Water → air = $\theta_c = \sin^{-1}(3/4)$

(b)→ Glass → air = $\theta_c = \sin(2/3)$

* (c)→ Glass → Water = $\theta_c = \sin^{-1}\left(\frac{4/3}{3/2}\right) = \sin^{-1}(8/9)$ AIIMS

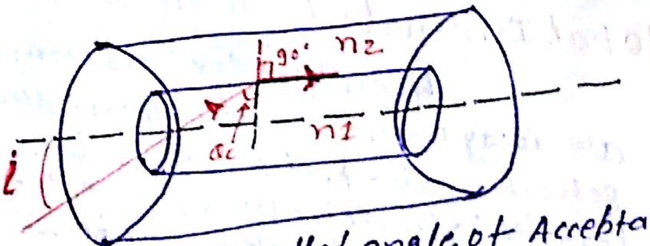
AIIMS

R.I of Inner core of optical Fibre is 'n1' & R.I of outer core is 'n2' than Max. value of <i in air & Inner core If light Ray not Emerged out from optical Fibre.

**

Max

$$\boxed{i = \sin^{-1}\sqrt{n_1^2 - n_2^2}}$$



NOTE → Max. value of angle of Incide is called angle of Acceptance. IF light Ray not Emerged out From Inner core.

AIIMS

Exemple OF T·I·R

|1|→ **Mirage**→ In desert temp. of Air is max for bottom layer it ↓ses botom to top. When light Ray comining From top to bottom, it will deviate From Normal & its suffer T·I·R From atmospheric layer & object apper to Inverted.

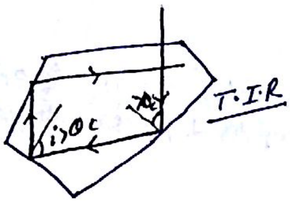
|2|→ **Looming**→ In cold area temp ↑ bottom to top. when light Ray suffer T·I·R from atm. layer, it come back in downward direction & object appear in air.

|3|→ **optical Fibre**→ Dimeter of each Fibre is of order of 10^{-4}cm With Refractive Index of Material being of the order of I·S.

$$\boxed{i_{min} = \sin^{-1}\sqrt{n_1^2 - n_2^2}}$$ *

*use to study Internal organ.

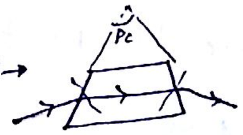
|4|→ **Brillions of Diamond** **



Refraction From prism

|i|→

|ii|→

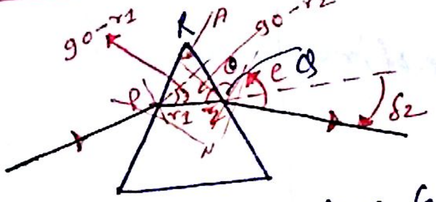


Body Wich has 2 Non-parallel Reflecting surface called prism.
Body Wich has 2 Non-parallel Reflecting surface.

Prism Angle→ Angle b/w non-parallel Reflecting surface.

Base OF Prism → opposite side of prism angle.

Deviation From prism



* Deviation From Ist surface $\delta_1 = 1 - r1$ —①
* Deviation From 2nd surface $\delta_2 = e - r$ —⑪

Net deviation $\delta_{net} = \delta_1 + \delta_2$

$$\boxed{\delta_{net} = 1 + e - (r1 + r_2)}$$ *

From ΔPQR $A + 90 - r1 + 90 - r_2 = 180'$
$r1 + r_2 = A$

$$\boxed{\delta_{net} = i + e - A}$$

$i \Rightarrow$ Angle of Incident
$e \Rightarrow$ Angle of emergence
$A \Rightarrow$ prism Angle
$r_1 \Rightarrow$ Angle of Refraction on 1st surface.
$r_2 \Rightarrow$ Angle of Inciden t on 2nd surface.

NOTE → Deviation Angle depends on Angle of Incident & Prism angle.

Special case

case-I → Deviation from thin prism

$\boxed{A \leq 5}$

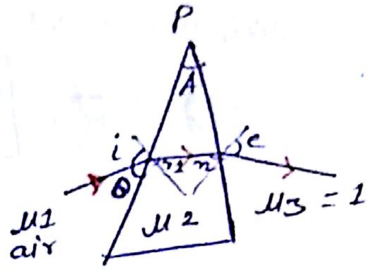
Angle is very small

$\sin\theta = \theta$

$\sin i = i$

$\sin r_2 = r_2$

$\sin e = e$



$$\boxed{\delta = (\mu - 1)A}$$ *

NOTE → Deviation From thin prism is Independent from angle of Incident and prism Angle.
It depend on refractive index of prism.

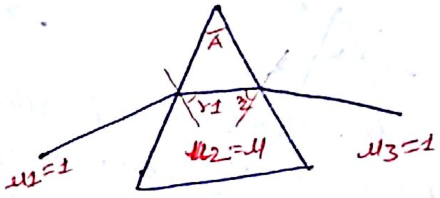
case II → Minimum deviation condition

$\delta_{min} = 2i - A = 2e - A$

$r_1 = r_2 = A/2$

$r_1 = A/2$

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



**

- * $e = i$
- * $r_1 = r_2 = A/2$
- * Refracting Ray is || to the base of prism
- * $\delta_{min} = 2i - A$
- * $\mu = \frac{\sin\left(\frac{A+\delta_{min}}{2}\right)}{\sin A/2}$

case-III Max deviation condition

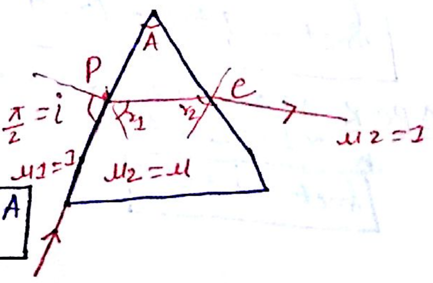
*

$i_{max} = \frac{\pi}{2} = \delta_{max}$

$e = \sin^{-1}(\mu\sin(A - \theta_c)$

$\delta = i + e - A$

$\delta_{max} = \frac{\pi}{2} + \sin^{-1}(\mu\sin(A-\theta) - A$

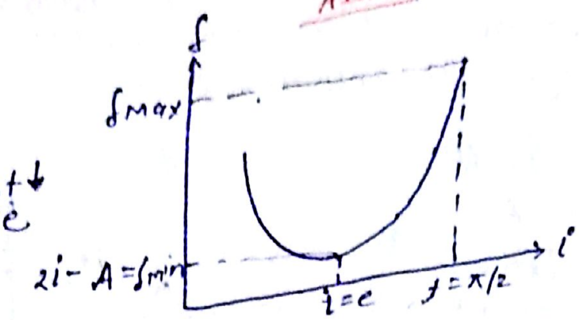


AIIMS

Graph

δ v/s i (For prism)

* Deviation of prism Ist ↓ & then ↑ with angle of Incident.

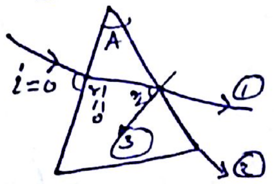


Case iv → No Emergence condition

$[$Ist Ray ⇒ $r_2 < \theta_c$
2nd Ray ⇒ $r_2 = \theta_c$
3rd Ray ⇒ $r_2 > \theta_c]$

|a| → $i_{Min} = 0$

$r_1 + r_2 = A \Rightarrow (r_2 = A)$



No Emergence condition.

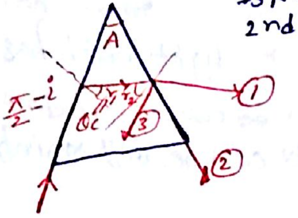
$$\mu \geq \frac{1}{\sin A}$$ *

$$\boxed{\mu \geq \operatorname{cosec}(A)}$$

|b| → $i_{Max} = \pi/2$

Is Ray ⇒ $r_2 < \theta_c$
2nd Ray ⇒ $r_2 = \theta_c$
3rd Ray ⇒ $r_2 > \theta_c$

* $r_1 + r_2 = A \Rightarrow (r_2 = A - \theta_c)$



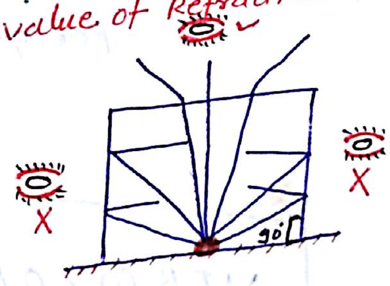
No emergence condn.

$$\sin(A/2) \geq (1/\mu)$$ *

$$\boxed{\mu \geq \operatorname{cosec}(A/2)}$$

NOTE → If light Ray not Emerge out From 2nd surface of prism Refractive Index of prism Material is Greater than cosec A/2 (For any value of < of i).

Transparent cube placed on point object if It is invisible or, disappear from Vertical side of cube than Minimum value of Refractive Index of cube.



Not appear from vertical side
∵ TIR is occuring, so light Not coming out.
∴ No Emergence condn.

$$\mu \geq \operatorname{cosec}(A/2)$$

$$\mu \geq \operatorname{cosec}(45^\circ)$$

$$\boxed{\mu_{min} \geq \sqrt{2}}$$

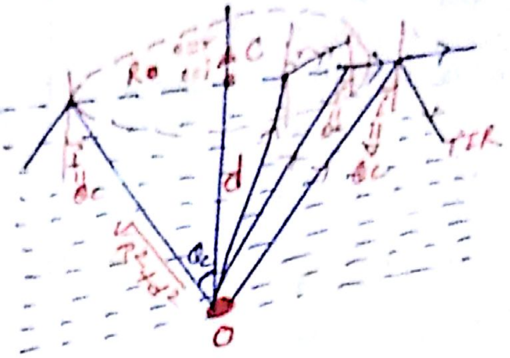
A point light source Placed at bottom at dipth 'd' from the surface then minimum area of dark floating disck If light ray not Emerge out from Water surface.

$\sin\theta_c = \frac{1}{\mu_c}$ ①

$\sin\theta_c = \frac{R}{\sqrt{R^2+d^2}}$ = ⑪

$$\boxed{R = \frac{d}{\sqrt{\mu^2-1}}}$$ *

$$\boxed{A_{min} = \pi R^2 = \frac{\pi d^2}{\mu_L^2-1}}$$ *



Dispersion

|a|→ Monochromatic light → Light wich has single colour, single Freq.

|b|→ Bichromatic light → Light wich has 2 colour, 2 Freq.

|c|→ polychromatic → Light wich has More than two colour & more than two Freq.

|d|→ White light → light which has ∞ colour & ∞ Freq.

NOTE → ∞ colour are ⊕nt in the visible Region but our eye easily can be diff mainly seven colour.

Dispersion

When polychromatic light incident on Refracting surface It will divide in its basic colour. This phenomena called disperson.

→ Reason → Velocity of light (c) & R.I of different colour is same in air but in a Medium R.I is change with wavelength of Radiation as Relation.

Kochey. → $\boxed{\mu_m = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4} + ----}$

λ = Wavelength

μ = R.I. of Med.

A+B+C = const

**

$$\boxed{\begin{array}{c} \text{VIBGYOR} \xrightarrow{} \\ \lambda\uparrow, \mu\downarrow, \sin r\uparrow \Rightarrow r\uparrow \\ \mu_{Rmin} < \mu_{Vmax} \end{array}}$$

$\boxed{\sin r < \frac{1}{\mu}}$

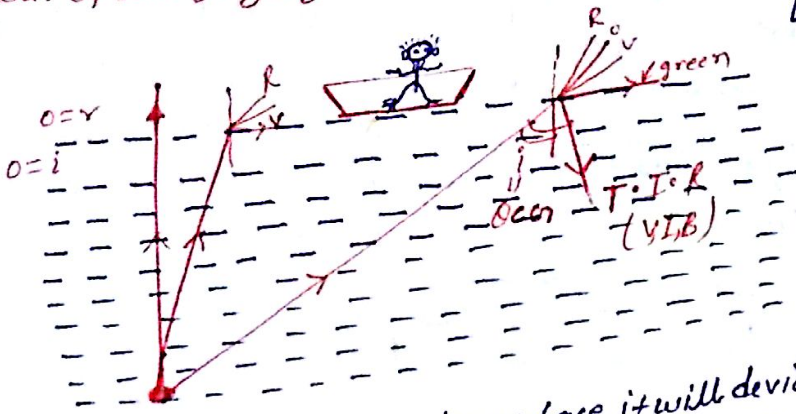
$\boxed{r_{Rmax} > r_{Vmin}}$ *

$\boxed{\delta_{Rmin} < \delta_{Vmax}}$ *

Shift colour → $\boxed{(S_V)_{max} > (S_R)_{min}}$

AIR

A White light source is placed at some depth from Water surface & observer Moving away From H₂O surface & obserber Moving away From light source than colour of Emerging light when source become Invisible.



Let $i = \theta_c$ of Green

$\sin\theta_c = \frac{1}{\mu}$

$\xrightarrow{VIB(G)YOR}$

$\lambda\uparrow, \mu\downarrow, \theta_c\uparrow$

$\boxed{(\theta_{cR})_{max} > (\theta_{cV})_{min}}$

When white light incident on water surface it will devide in its basic 7 colour, When person moving away From light source, angle of Incident is ↑. When it become more than 'θ_c' of all colour, light source will disappear in air, θ_c of voilet colour is min & For Red colour is max. When angle of Incident is ↑, vailet light disappear Ist & Red light last, thats why last colour & Ist colour in sunset & sunrising condition appear Red.

Angular dispersion (δ)

Diff. b/w Red & voilet colour division is called Angular disperson.

$$\boxed{\delta = \delta_V - \delta_R}$$ *

For thin prism

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

$\delta_V = (\mu_V - 1)A$

$\delta_R = (\mu_R - 1)A$

$$\boxed{\delta = \delta_V - \delta_R}$$

$$\boxed{\delta = \Delta\mu A}$$

Average deviation (δ_{Avg})

Avg. of max & min deviation.

$$\boxed{\delta_{Avg} = \frac{\delta_{max} + \delta_{min}}{2} = \frac{\delta_V + \delta_R}{2}}$$ *

For thin prism

$$\boxed{\begin{aligned}\delta_{Avg} &= (\mu_{Avg} - 1)A \\ \delta_{Avg} &= (\mu_y - 1)A = \delta_{y}\end{aligned}}$$ *

Dispersive power (ω)

Ratio of Angular disperson & Avg. deviation.

$$\boxed{\omega = \frac{\delta}{\delta_{Avg}} = \frac{\delta_V - \delta_R}{\delta_Y}}$$

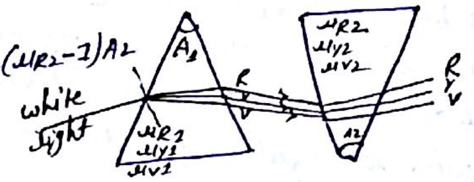
For thin prism *

$$\boxed{\begin{aligned}\omega &= \frac{(\mu_V-1)A - (\mu_R-1)A}{(\mu_R-1)A} \\ \omega &= \frac{\mu_V - \mu_R}{(\mu_Y - 1)} = \frac{2(\mu_V-\mu_R)}{\mu_V+\mu_R-2}\end{aligned}}$$

combination of Prism

$*\delta_{net} = \delta_1+\delta_2$

$*\delta_R = \delta_{R1} + \delta_{R2} = (\mu_{R1}-1)A_1 + (\mu_{R2}-1)A_2$



$*\delta_Y = (\mu_{Y1}-1) + (\mu_{Y2}-1)A_2$

$*\delta_V = (\mu_{V1}-1)A_1 + (\mu_{V2}-1)A_2$

condition Ist

Dispersion Without Deviation

IF emerging yellow Ray is // to the incident white Ray but emerging voilet & Red ray is not //.

$\delta = \delta_V - \delta_R \neq 0$

$\delta_{Avg} = \delta_Y = 0$

$\delta_Y = 0$

$$*\ \boxed{\frac{A_1}{A_2} = -\left[\frac{\mu_{Y2}-1}{\mu_{Y1}-1}\right] = -\left[\frac{\mu_{R2}+\mu_{V2}-2}{\mu_{R1}+\mu_{V1}-2}\right]}$$

condition 2nd

Deviation without disperson *

$$\boxed{\begin{bmatrix}\delta = 0 \\ \delta_{avg} = \delta_Y \neq 0\end{bmatrix}} \quad \boxed{\delta_V = \delta_R} \quad \boxed{\frac{A_1}{A_2} = -\left(\frac{\mu_{V2}-\mu_{R2}}{\mu_{V1}-\mu_{R1}}\right)}$$

If emerging voilet & Red ray // to each other but emerging yellow ray is not // to incident white light condition c/a deviation without disperson.

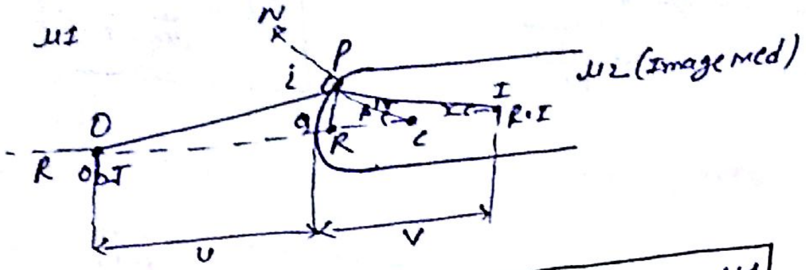
NOTE→ * IF Prism combined in even no→ deviation & disperson can be cancel.
* If prism combined in odd no→ deviation & " can't cancel.

Refraction From curved surface

Its centre of curvature is not in the direction of light Ray Refracting surface is called convex & when centre of curvature is ⊕nt in opposite direction of light Ray called concave surface.

Refracting Formula

Relation b/w position of obj. image & R.I of obj & image Medium.



$i = \alpha + \beta$ = ①

$\beta = r + \gamma \Rightarrow r = \beta - \gamma$ ⑪

$\mu_1 i = \mu_2 r$ = ③

$\mu_1 (\alpha + \beta = \mu_2 (\beta - \gamma)$ ④

$$\boxed{\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}}$$

For plance surface

$$\boxed{V = \left(\frac{\mu_2}{\mu_1}\right)\mu}$$

Mirror Formula

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

Refracting Formula

$$\boxed{V = \frac{V}{\mu_2}} , \boxed{F = \frac{R}{\mu_2 - \mu_1}}$$

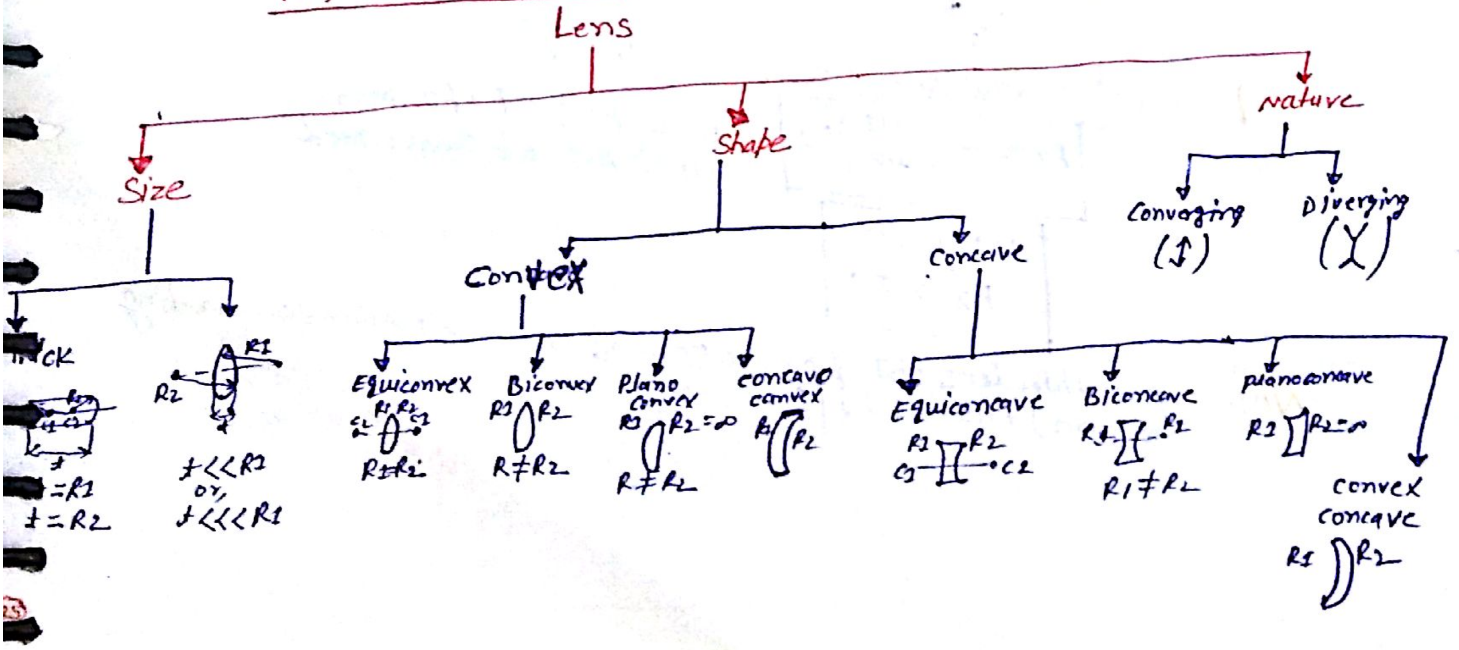
$$\boxed{\mu = -\left(\frac{\mu}{\mu_1}\right)}$$

Magnification Formula *

$$\boxed{m = \frac{h_i}{h_o} = \frac{\mu_1}{\mu_2} = \left(\frac{v}{u}\right)}$$

NOTE → Refrecting Formula & magnification Formula is used with sign conversion (sign convention same as mirror).

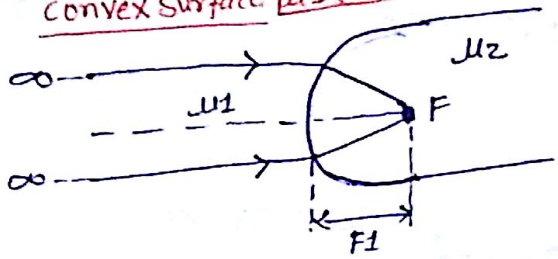
Refraction From Lens



First & 2nd Focus of Refracting surface

First Focus → Image point on principle axis is called Ist Focus when when obJ ⊕nt at ∞.

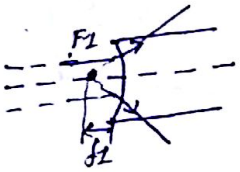
Convex surface $\boxed{\mu_1 < \mu_2}$



$$\mu_2 = \frac{\mu_1}{u} = \frac{\mu_2 - \upsilon_1}{R}$$

$$\boxed{f_1 = \frac{\mu_2 R}{\mu_2 - \mu_1}}$$

Concave surface (μ1=μ2)

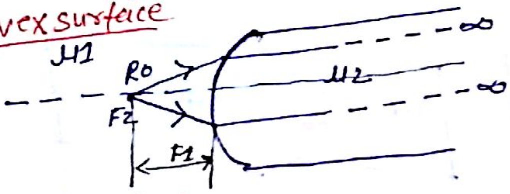


$$\boxed{\frac{\mu_2}{v} - \frac{\mu_1}{-\infty} = \frac{\mu_2 - \mu_1}{-R}}$$

$$\boxed{f_1 = -\frac{\mu_2 R}{(\mu_2 - \mu_1)}}$$

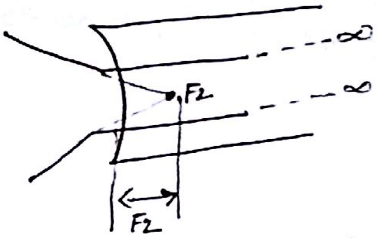
2nd Focous → object point on principle axis is called 2nd Focous when image Formed at ∞.

Convex surface



$$\boxed{f_2 = \frac{\mu_1 R}{\mu_2 - \mu_1}}$$

Concave surface



$$\boxed{F_2 = \frac{\mu_1 R}{\mu_2 - \mu_1}}$$

Relation b/w Ist & 2nd Focal length.

$$\boxed{F_2 = -\left(\frac{\mu_1}{\mu_2}\right) F_1}$$

μ1 = R·I of obJ. Med.
μ2 = R·I of Image Med.

$$\boxed{\begin{matrix} \mu_1 \neq \mu_2 \\ F_2 \neq F_1 \end{matrix}}$$

***

NOTE → For thin lens obJ. & Image Formed in same Medium (surrounding medium) that's why $\boxed{f_1 = -f_2}$

Lens Formula

Lens Maker Formula

$$\boxed{\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = ({}_1\mu_2 - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)}$$

${}_1\mu_2$ = Refractive index of lens w.r.t surrounding.

Lens Formula

$$\boxed{\frac{1}{v} - \frac{1}{u} = \frac{1}{f}}$$

$$\boxed{v = \frac{uf}{u+f}} \quad \boxed{u = \frac{vf}{f-v}} \quad \boxed{f = \frac{uv}{u-v}}$$

Magnification Formula of lens *

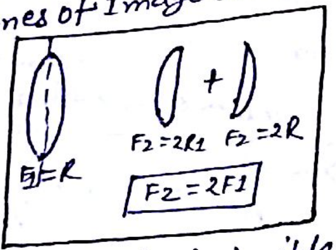
$$\boxed{m_{Lens} = \frac{h_i}{h_o} = \frac{v}{u} = \frac{f}{u+f} = \frac{f-v}{f}}$$

NOTE→ Lens Formula & Lens Maker Formula is used with proper sign conversion.

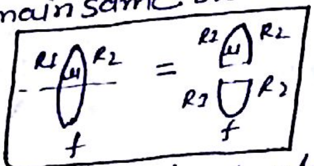
convex = F = ⊕ve
concave = F = ⊖ve

NOTE→

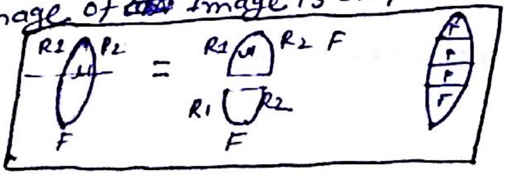
- * Focal length of equiconvex glass lens & equiconcave glass lens is equal to Radius of curvature.
- * Focal length of glass lens (any type) in H_2O is 4 times of air.
- * Focal length of plano convex glass lens & plano concave glass lens is equal to 2 times of Radius of curvature.
- * IF equiconvex or, equiconcave lens cut ⊥ to Principle axis then Focal length become double. position of Image w.r.t to same obJ is change but brightnes of Image remain same (dimeter is same).



- * If lens cut along the principle axis Focal length of Each part is equal to Focal length of lens. position of Image remain same w.r.t same position of obJ. but its brightness ↓. (as dimeter ↓)

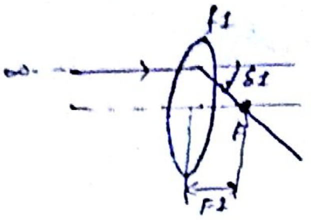


- * IF lens devide in diff part along the principle axis then no. of Image of ~~obJ~~ Image is only one.



Poller of lens & Mirror

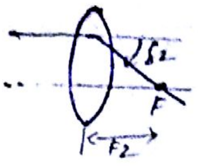
converging & diverging capacity of Optical Represent its power.



$\delta_1 > \delta_2$

$P_1 > P_2$

$$\boxed{P \propto \frac{1}{f}}$$



unit of power

* Diapter (S.I)
$(1D = 1m^{-1})$

Sign convension

* converging → $P = \oplus ve$, $f = \ominus ve$
* Diverging → $P = \ominus ve$, $f = \oplus ve$.

|a|→ concave Mirror
$P = \oplus ve$ (converging)
$F = \ominus ve$

|b|→ convex Mirror
$P = \ominus ve$ (Diverging)
$F = \oplus ve$

|c|→ convex lens
$P = \oplus ve$
$F = \oplus ve$
(converging)

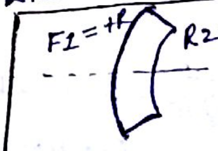
|d|→ concave lens
(Diverging)
$P = \ominus ve$
$F = \ominus ve$

*

$$\boxed{\begin{aligned} P_m &= -\frac{1}{F_m} = -\left(\frac{1}{V_M} + \frac{1}{U_M}\right) \\ P_L &= +\frac{1}{F_L} = \left(\frac{1}{V_L} - \frac{1}{U_L}\right) = \left(\frac{U_L}{U_S} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \end{aligned}}$$

AIFMS
NOTE → * power of Mirror is Indebendent From Surrounding Medium. but power of Lens depend on surrounding medium.
* power of plane Reflecting & Refracting surface is zero.

AIIMS
* sunglass has curved surface but its power is zero bcoz sunglass has two curfaced surface of same Radius of curvature Wich is parellel to each other.



$$P_L = \frac{1}{F_L} = \left(\frac{\mu}{1} - 1\right)\left(\frac{1}{R} - \frac{1}{R}\right)$$
$$= 0$$

NOTE → * Convex
* $\mu_1 < \mu_2$ → Converging
* $\mu_1 > \mu_2$ → Diverging
* $\mu_1 = \mu_2 = P_L = 0$

* Concave
$\mu_1 < \mu_1$
Diverging
* $\mu_1 > \mu_2$ → [illegible].

NOTE → * When surrounding med. is ↑, power of lens ↓.
* When μ of surrounding meedium more them μ of lens nature of lens is Invert.

NOTE→

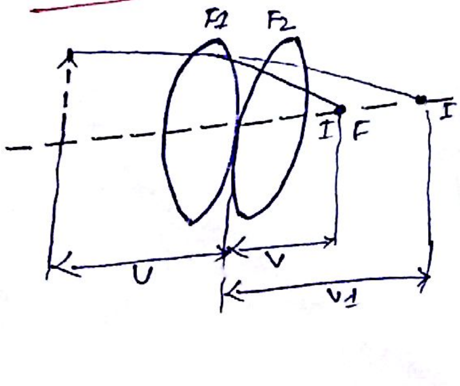
- * IF light ray Move || to the principle axis after Refracting from lens. It will pass or, appear to be pass From Ist Focus.
- * IF light Ray pass From 2nd Focus it Will become || to the Principle axis after Refracting From lens.
- * IF light Ray Incident on optical centre. It will pass undeviate afterRefracting from lens.
- * When obJ. placed b/w optical centre (o) $ Focus. Image is Erect, virtual, Inlarge and form behing the obJ.
- * When obJ. placed at Focus, Image is Real, Highly enlarge $ Form at ∞.
- * When obJ. placed b/w F $ 2F, Image is Real, Inverted, $ Form b/w 2F $ ∞.
- * When obJ. placed at '2F', Image is Real Inverted, same size $ Form at 2F.
- * When obJ. placed b/w 2F $ ∞, Image is Real, Inverted, small in Size $ Form b/w 'F' $ '2F'
- * When obJ. placed at ∞, Image is Real, Inverted, Diminshed and form at Focus.
- * Concave lens always Form virtual, Erect, diminsh image of Real obJ. b/w 'O' $ 'F'.

"Result of convex lens is similar to concave Mirror $ Result of concave lens similar to convex ~~lens~~ Mirror

- * convex lens Always Form Real Image of Vertual obJ. b/w 'O' $ 'F' Image is Erect $ Small in size.
- *→ virtual obJ. placed b/w 'O' $ 'F' of concave lens. Image is Real Erect, Inlarge Form at Focus.
- * When vertual obJ. placed at Focus of concave lens. Image is Real, errect, Height enlarge $ Form at ∞.
- * concave lens Form Real Image of vertual obJect when obJ. ~~ont~~ b/w 'O' $ 'F' $ Its Real image is erect $ inlarge.
- * When virtual obJ. placed b/w 'F' $ ∞ of concave lens, Image is vertual $ Form in opposite side of Lens.

Special case

Case-I → combination of Lens. When Lens placed in contact



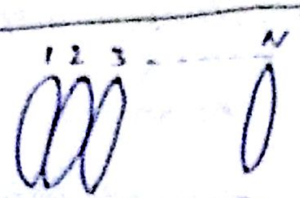
$$\boxed{\frac{1}{V} - \frac{1}{U} = \frac{1}{F1} + \frac{1}{F2}}$$

$$\boxed{\frac{1}{V} - \frac{1}{U} = \frac{1}{Fc}}$$

$$\boxed{\frac{1}{Fc} = \frac{1}{F1} + \frac{1}{F2}}$$

$$\boxed{Pc = P_1 + P_2}$$

#



$P_c = P_1 + P_2 - - - P_N$

$\frac{1}{F_c} = \frac{1}{F_1} + \frac{1}{F_2} \cdots \frac{1}{F_N}$

$m_c = m_1 m_2 m_3 \cdots m_N$

NOTE → If two or, more than two place incontact then net power of combination is scalar addition of Indivisual power of Lens.

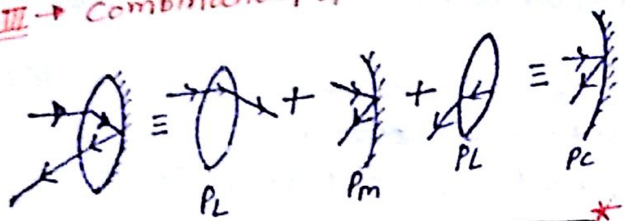
Case-II → When lens placed at distance

*

$P_c = P_1 + P_2 - dP_1P_2$

$\frac{1}{f_c} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$

Case III → Combination of lens & mirror or, 1 side of lens is silvered.



$P_L = P_L + P_m + P_L$

*

$P_c = 2P_L + P_M$

$\frac{1}{f_c} = \frac{1}{f_m} - \frac{2}{f_L}$

NOTE → One side of lens is silvered combination work as a concave mirror.

NOTE → When equiconvex lens cut ⊥ to the principle axis place in contect with " plane side and curved side Focal length of combination is equal to Focal length of equiconvex Lens.

Newton Formula

If distane of obJ. & Image is measured from focus then sq. root of product of distance is equal to Focal lengh of lens.

$$F = \sqrt{x_0 x_i}$$

Law of Reversibility

$m_1 m_2 = 1 \Rightarrow m_1 = \frac{1}{m_2}$

$$h_0 = \sqrt{h_{i_1} h_{i_2}}$$

To calculate focal length of convex lens with disp. method.

In this exp. position of obJ. & screen remain unchanged but convex lens is shift b/w two congugate position & image of same obJ form on screen.

*

$$\boxed{\begin{array}{l} y = \frac{D+d}{2} \\ x = \frac{D-d}{2} \end{array}}$$

*

$$\boxed{F = \frac{D^2 - d^2}{4D}}$$

D ⇒ Distance b/w obJ. & screen

d ⇒ Distance b/w two congugate position or, convex lens or, disp. b/w convex lens.

In Displacement method distance b/w two conjugate position of convex lens is 'd' & magnification in this condition resp. M1 M2 then Focal length of convex lens.

*

$$\boxed{F = \frac{d}{m_2 - m_1}}$$

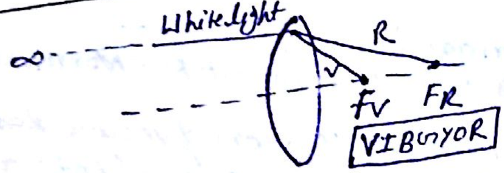
chromatic Abbration

ⓋIBGYOⓇ

$\lambda\uparrow, c\uparrow, \mu\downarrow, F\uparrow$

$$\boxed{\frac{1}{F} = \left(\frac{\mu}{1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)}$$

$$\boxed{F(R)_{max} > F_V(min)}$$



Focal length of Lens is max For Red colour & min For Voilet colour ~~colour~~ that's why Blurred image of coloured obT. is observed phenomena of light called chromatic abbration.

Longitudnal chromatic abbration (LCA)

$$\boxed{L.C.A = F_R - F_V = \Delta F \simeq dF}$$

$$\boxed{\omega = \frac{\delta}{\delta_{Avg}} = \frac{\Delta UA}{(\mu_y - 1)A} = \frac{\mu_V - V_R}{\mu_Y - 1}}$$

dispersive power.

$$\boxed{df = \omega f}$$

*

combination of lens

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} + \cdots$$

$$\frac{\omega_c}{f_c} = \frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} + \frac{\omega_3}{f_3}$$

$$\omega_c P_c = \omega_1 P_1 + \omega_2 P_1 + \cdots$$

← power of combination.

↑ Dispersive power of combination

$$\boxed{\omega_c = \frac{\omega_1 P_1 + \omega_2 P_2 + \cdots \omega_N P_N}{P_1 + P_2 + \cdots P_N}}$$

Condition of chromatic abberation

$$\omega_c = 0 = \omega_1 P_1 + \omega_2 P_2$$

or,

$$0 = \frac{\omega_1}{F_1} + \frac{\omega_2}{F_2}$$

NOTE → one lens is convex & other is concave.

Optical Instrument

* Advantage & Limitation of Normal eye.

(i) → Human eye can see electromagnetic wave of wavelength 3800A° to 7800A°

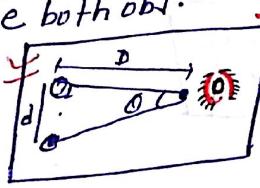
VIBGYOR
↓
W

(ii) → Normal eye can see image b/w 25cm to ∞. 25cm is near point & ∞ is Far point For Normal vision.

(iii) → Human eye is most sensitive for green & yellow Radiation bcz Image of green & yellow colour Form of Retina.

'If time taken by two different image on Retina is 1/10 sec. We differentiate both image. The time is called Time of persistance.'

* Min Angular width b/w two close obJ. is $\left(\frac{1}{60}\right)^\circ$ to clearly observe both obJ.

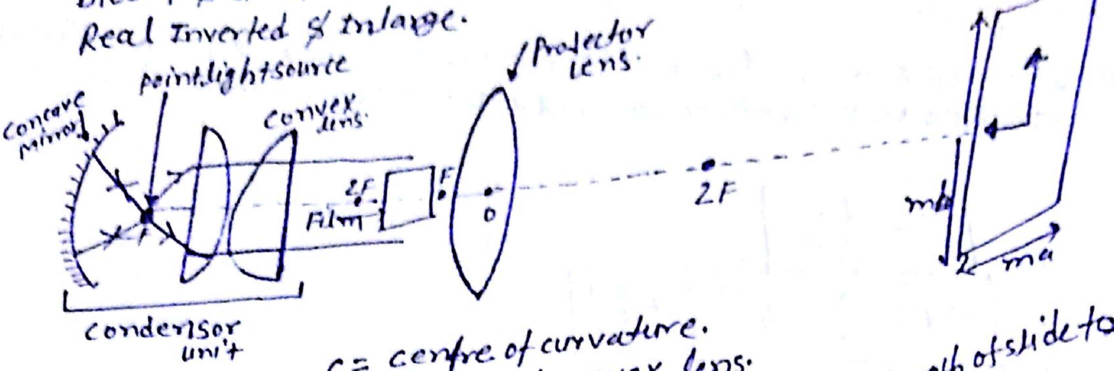


$$\theta \geq 1$$

$$\frac{d}{D} \geq \frac{1}{60} \times \frac{\pi}{180}$$

Projector

In a condensor unit point light source placed at centre of curvature & concave mirror & Focus of convex lens & Film placed b/w F & 2F of convex lens & Image formed beyond 2F. Image is Real Inverted & Inlarge.



C = centre of curvature.
F = Focus of convex lens.

$A_0 = a \times b$
$A_I = (ma)(mb)$
$= m^2(ab)$
$\boxed{A_I = m^2 A_0}$

$\boxed{I \propto \frac{1}{A}}$

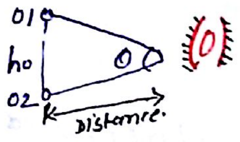
$\boxed{I_I = \frac{I_0}{m^2}}$

Length of slide to lens
slide to screen distance

$\boxed{\text{Lenth of theater} (L) = |U| + |V|}$ *

Microscope → Microscope ↑ angular width of closed obJ.

$\boxed{M \cdot P = \frac{\theta}{\theta_0}}$ → It is the ratio of Angular width of optical Fibre & Max angular width of Normal eye.



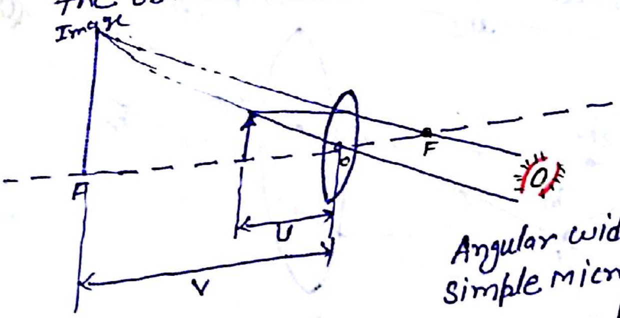
* $\boxed{\underset{\uparrow \text{Max}}{\theta} = \frac{h_o}{(\text{Distance})\text{min.}}}$

* $\boxed{\theta_0 = \frac{h_o}{25cm} = \frac{h_o}{D}}$ max

Simple Microscope

It is simple microscope convex lens is used to magnifed the image of obJ.

* obJ. placed b/w 'O' & 'F' of convex lens & Image formed behind the obJ. It is Virtual, Irect & Inlarge.



Angular width of simple microscope
$\boxed{\theta = \frac{h_o}{u} = \frac{h_i}{V}}$

$$\boxed{M\cdot P = \frac{\theta}{\theta_0} = \frac{h_0/u}{h_0/D}} \cdot \quad \boxed{D = 25cm}$$

$$\boxed{M\cdot P = \frac{D}{u}}$$

(i) → Near point

If image formed at 25cm distance from convex lens. condition is called max strain condition & also near point condition.

$$\boxed{U = \frac{DF}{D+F}}$$

$$\boxed{M\cdot P = \frac{D}{U} = D\left(\frac{1}{D}+\frac{1}{F}\right)}$$

$$\boxed{MP_{near} = 1+\frac{D}{F}} \ (max)$$

(ii) → Far point

If image of object formed at ∞. condition is called min strain & far point condition.

$$\boxed{|U| = F}$$

$$\boxed{MP_{far} = \frac{D}{U} = \frac{D}{F}}$$

$$\boxed{\text{Range of } M\cdot P = \frac{D}{F} \text{ to } 1+\frac{D}{F}} \ *$$

NOTE → If in question point is not define the magnifiying power is calculated at far point.

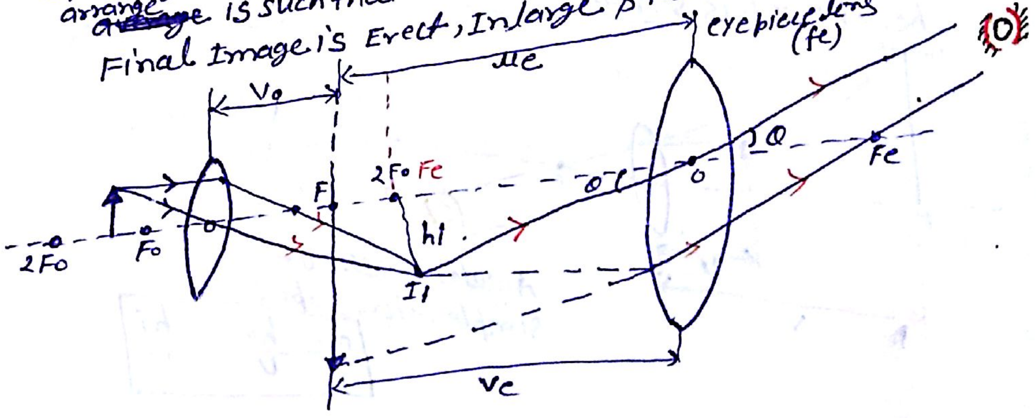
compound microscope

→ In a compound microscope two convex Lens is used lens near the obJ is called objective lens. & Near the eye is called eye piece lens.

→ In a microscope aperture (dimeter) eyepiece lens is greater then from objective lens obJ place b/w F & 2F of objective lens & Image form beyond 2F.

→ Image of objective Lens work as a obJ. or eyepiece lens & eyepies lens arrange ~~arrange~~ is such that image point b/w optical centre & Focus & Form behind the obJ.

Final Image is Erect, Inlarge



$$\boxed{\theta = \frac{hi_1}{ve} = \frac{hi_2}{ve}}$$

$$\boxed{M \cdot P = \frac{\theta}{\theta_0} = \frac{hi/ue}{h_0/D} = \frac{hi_1}{h_0} = \frac{D}{ue}}$$

$$\boxed{M \cdot P = m_0\left(\frac{D}{ue}\right) = m_0 m_e}$$

m_e → Magnification of eye piece lens.

m_0 → Magnification of objective lens.

$$\boxed{L = |v_0| + |v_e|}$$

(i) → Magnifying power at Near point

$$\boxed{\frac{1}{V_e} = -\left(\frac{1}{D} + \frac{1}{f_e}\right)}$$

$$\boxed{M \cdot P_{near} = m_0\left(1 + \frac{D}{f_e}\right)}$$

$$\boxed{L_{near} = |v_0| + \frac{DF_e}{D+F_e}}$$

(ii) → Magnifying power at far point

$$\boxed{\left|\frac{1}{V_e}\right| = \frac{1}{F_e}}$$

~~MP far = mo~~

$$\boxed{\begin{aligned} M \cdot P_{far} &= m_0\left(\frac{D}{ue}\right) \\ &= m_0\left(\frac{D}{F_e}\right) \end{aligned}}$$

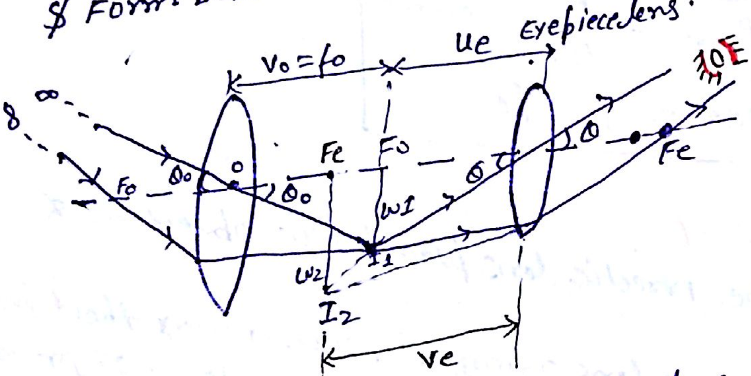
$$\boxed{L_{far} = |v_0| + F_e}$$

$$\boxed{L\uparrow = M \cdot P\downarrow}$$

Telescope

Astronomical telescope

In this telescope diameter of objective lens is greater than from eyepiece lens. objective lens Form Image of distinct object at its Focus $ Image of objective lens Work as obJ of eyepice lens $ eyepiece lens adjust in such a way then image ⊕nt in optical centre $ Focus of eyepiece lens, then Final image is Erect, Enlarge $ Form behind the obJ.



Ratio of Angular width of eye piece lens to objective lens Represent M.P of telescope.

$$\boxed{M \cdot P = \frac{\theta}{\theta_0}} \; *$$

$$\boxed{\theta = \frac{hi_1}{Ue} = \frac{hi_2}{Ve}} \; *$$

$$\boxed{\theta = \frac{hi_1}{F_0}} \; *$$

$$* \; \boxed{M \cdot P = \frac{hi_1}{hi_1/F_0} = \frac{F_0}{Ue}}$$

M·P at Near point (max)

$$\boxed{\frac{1}{u_e} = -\left(\frac{1}{D}+\frac{1}{f_e}\right)}$$

$$\boxed{\begin{array}{l} M\cdot P_{near} = \frac{f_o}{u_e} = f_o\left(\frac{1}{D}+\frac{1}{f_e}\right) \text{ max} \\ L_{Near} = f_o + u_e = f_o + \left(\frac{Df_e}{D+f_e}\right) \text{ min.} \end{array}}$$

M·P at Far point (min)

$$\boxed{\frac{1}{v_e} = \frac{1}{F_e}}$$

$$\boxed{MP_{Far} = \frac{f_o}{v_e} = \frac{f_o}{f_e}}$$

$$* \boxed{L_{Far} = f_o + v_e \; \cancel{=} = f_o + f_e}$$ ✓

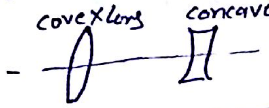
NOTE → * M·P of Microscope & Telescope ↓ when length of tube ↑.

* When Length Remain same Focal length of the obj. lens ↑, M·P of Microscope is ↓ but M·P of telescope is ↑.

* When Fe is ↑ Magnifing power of microscope ↑ but M·P of telescope ↓.

Galellio telescope

use concave lens in a eyepiece lens & lenth of telescope ↓ without change its M·P



$$\boxed{\begin{array}{l} M\cdot P_{Far} = \frac{F_o}{F_e} = \text{same} \\ L_{Far} = f_o - f_e \end{array}} *$$

Terrestial Telescope

In this telescope irrectic lens placed b/w objective & eyepiece lens.

Errective convex lens arrange in such a way that image of objective lens ⊕nt at 2F. of Errective lens. It produce Real Image of same size but Inverted w.r.t object & eyepiece lens arrange in such a way that object ⊕nt b/w 'O' & 'F' & Final Image is irrect, inlarge & virtual.

$$\boxed{L_{Far} = F_o + 4F + F_e} *$$

$$\boxed{M\cdot P_{Far} = \frac{F_o}{F_e}} *$$

Reflecting Telescope

In Teresstrial telescope chromatic abbration is possible to prevent this defect to Reflecting telescope is used.

Defect of Image

* Shortsightness or, Myopia

In this difect person can't see clearly distinct object. In this defect Far point of object shift from ∞ 'to Remove the defect diverging lens (concave) is used.

	Near point	Far point
		∞
* Normal vision →	25cm	x ⟶ ∞
* short shightness →	25cm	

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

$$\frac{1}{\infty} - \frac{1}{x} = \frac{1}{F}$$

*$\boxed{f = -x}$

*$\boxed{P = \frac{1}{f} = -\frac{1}{x}}$

* Longsightness or, Hypermetropia

In this defect person can't seen clear near object & Image of near obJ. Form behind the Retina. to Remove the defect converging lens (convex) is used.

	Near point	Far point
		∞
Normal vision	25cm	∞
Longshightness	Ycm	

$$\frac{1}{V} - \frac{1}{U} = \frac{1}{F}$$

$$\frac{1}{y} - \frac{1}{-D} = \frac{1}{F}$$

$$\frac{1}{F} = \frac{1}{D} - \frac{1}{y}.$$

*$\boxed{F = \frac{\overset{25cm}{D}\,y \rightarrow cm}{y - D}}$

*$\boxed{P = \frac{1}{f}}$

* Pressbiopia

In this defect person can't seen clearly near & Far obJ. Near point shift above 25cm & Far point from before ∞. To Remove this defect bifocal lens is used.

$\boxed{F = \frac{(Y)D}{Y - D}}$

* Astimatism

Cyllindrical lens is used to Remove the diffect. in this defect Radius of curvature of eye lens Found different in different position.

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Camera

convex lens is used in camera & obrect place b/w 2F & ∞ then Image capture b/w F & 2F.

* Image is Real Inverted & diminshed.

* Focal No → Ratio of Focal lenth & Apperture of lens is called Focal no. of camera lens. $\boxed{\text{Focal no} = F/D}$

* Time of exposal t → Min. Required time to capture the image of obrect is called exposal time

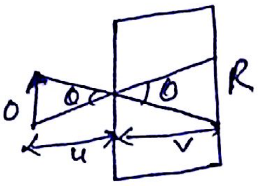
$$\boxed{t \propto \frac{1}{I} \propto \frac{1}{A} \propto \frac{1}{D^2}}$$

Area of lens.

$$\boxed{\frac{t_1}{t_2} = \frac{(f_{No_1})^2}{(f_{No_2})^2}}$$

* pin hole camera

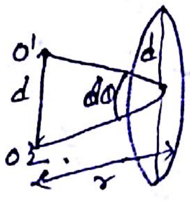
$$\boxed{\theta = \frac{O}{u} = \frac{I}{v}}$$



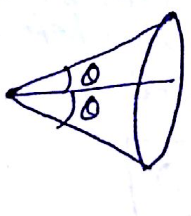
Resolving limit & Resolving power of Telescope

$$\boxed{R \cdot L(d\theta) = \frac{1.22\lambda}{d} = \frac{d}{r}}$$

$$\boxed{R \cdot P = \frac{1}{R \cdot L} = \frac{a}{1.22\lambda}}$$



Resolving limit & Power of Microscope



$$\boxed{R \cdot L = \frac{\lambda}{2\mu \sin\theta}} *$$

$$\boxed{R \cdot P = \frac{1}{R \cdot L} = \frac{2\mu \sin\theta}{\lambda}} *$$