
RAY OPTICS
अब 40 Mins
में Revision!
PHYSICS
Abhishek...

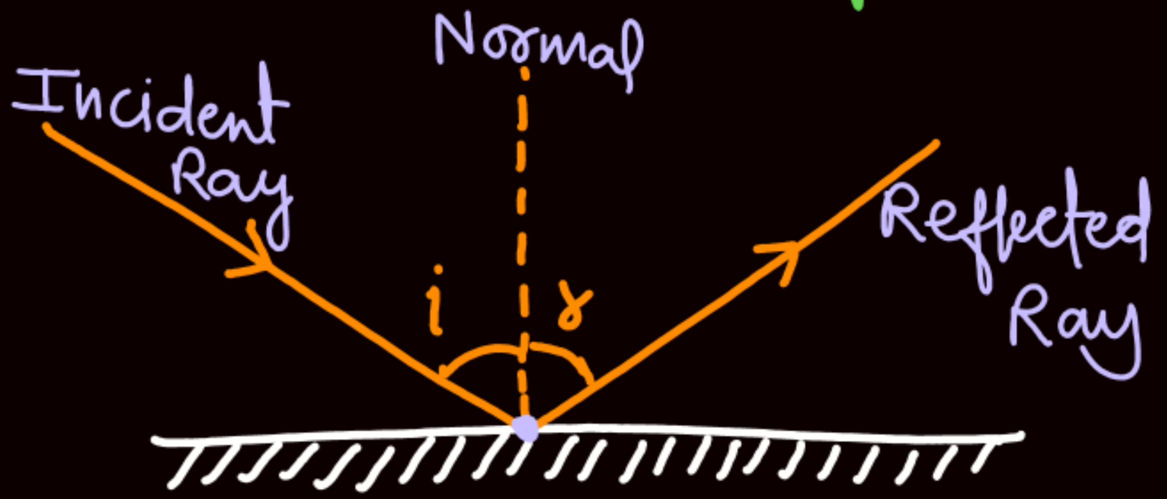
Sample paper link → Description + Comment ✓

Reflection of light → Phenomenon of bouncing back of light after striking to a surface.

Laws of Reflection

(i) $\angle i = \angle r$

(ii) Incident ray, Reflected ray and normal to the surface all lie in same plane.



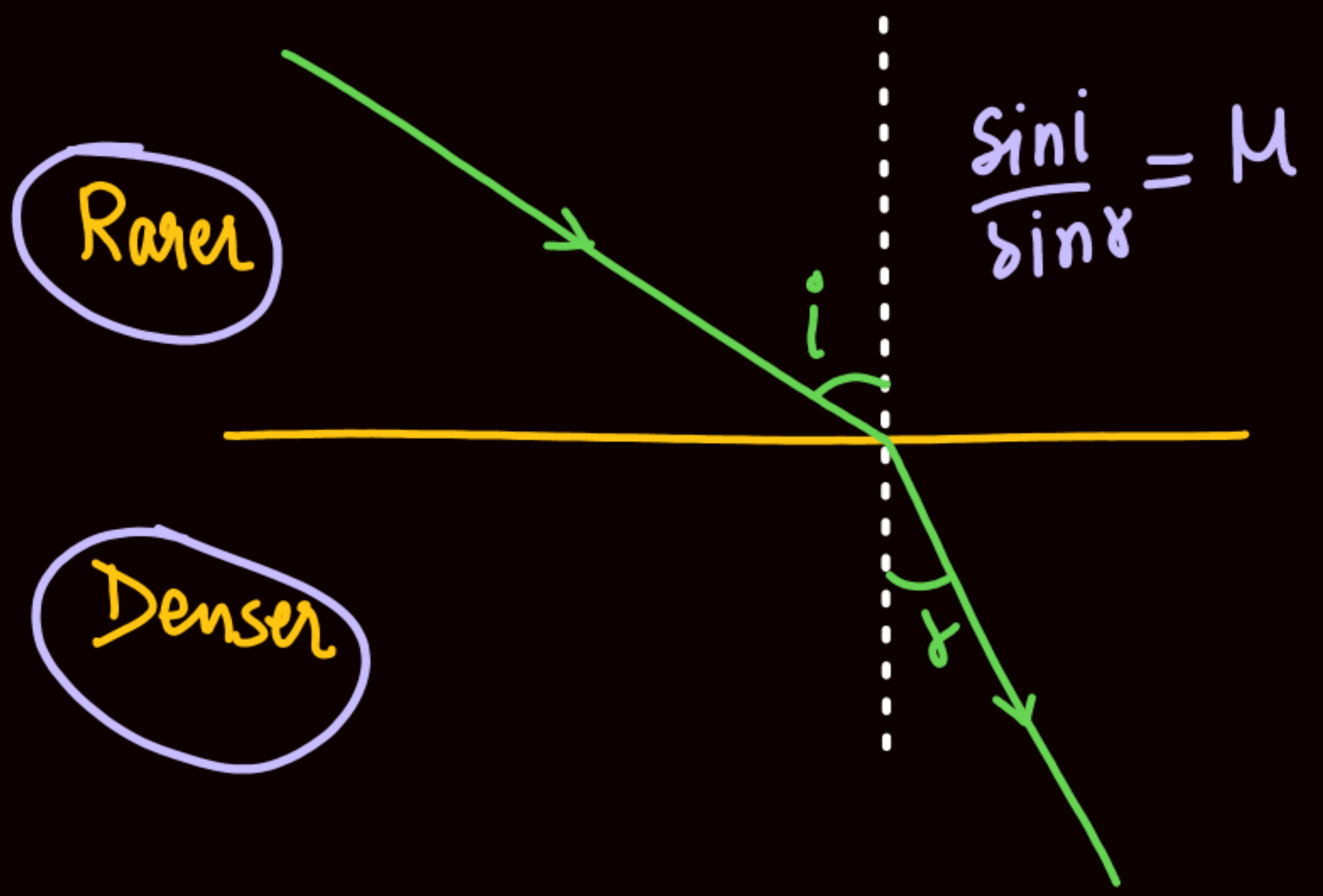
Refraction of light → Bending of light when it passes through one medium to another { Rarer – Away from Normal; Denser – Towards Normal }

Law of refraction → (i) Incident ray, Refracted ray and Normal to the interface all lie in same plane.

(ii) Ratio of sin i and sin r is constant for a pair of medium.

$$\mu = \frac{\sin i}{\sin r} \quad \text{(Snell's law)}$$

μ → Refractive index of medium.



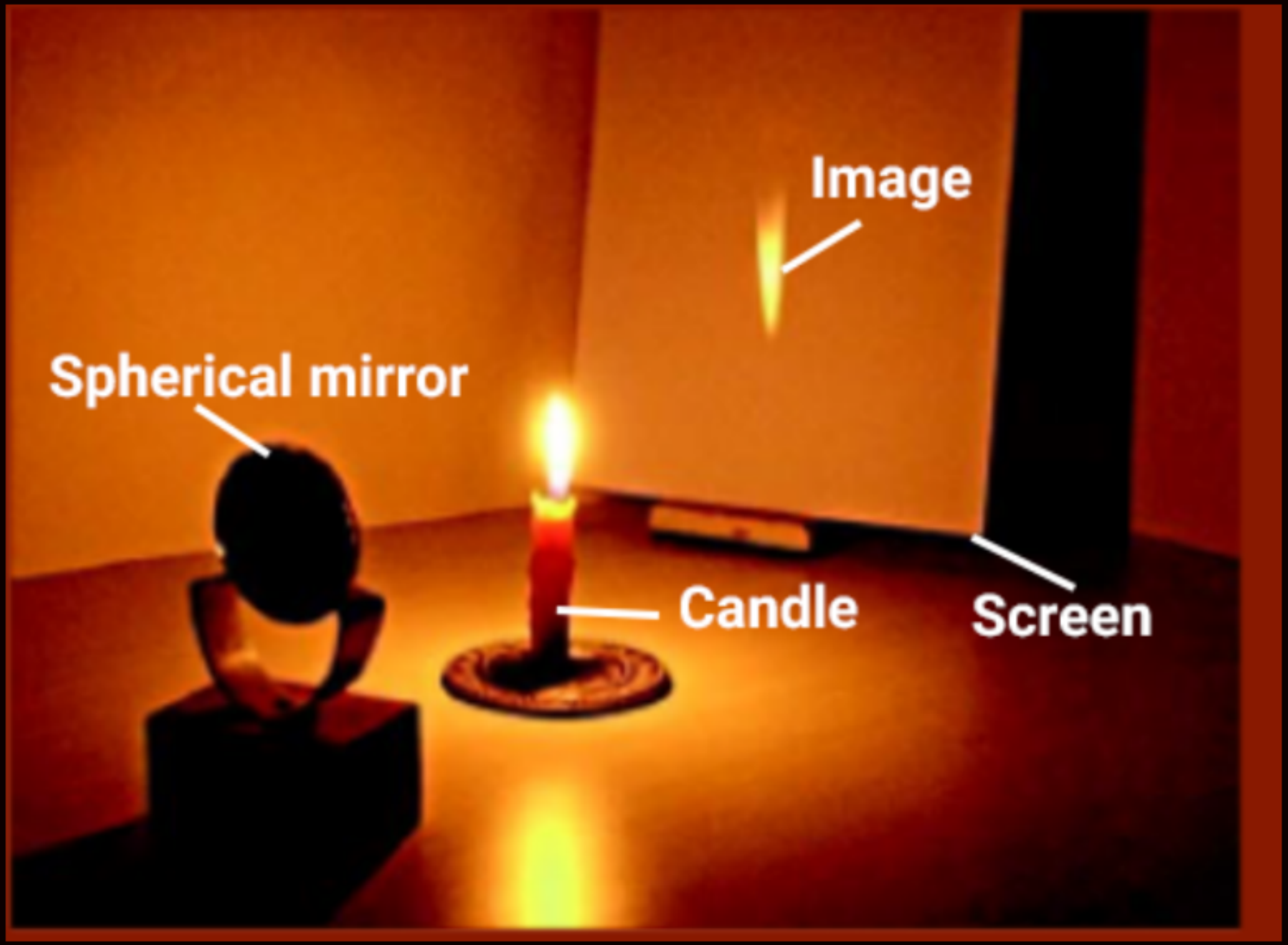
Mirror → It is a reflecting surface whose one surface is polished.

Mirror

- Plane mirror
  - only virtual image
- Spherical mirror
  - Both real and Virtual image
  - → Convex (i)
  - → Concave (ii)

Real Image

- This image can be taken on screen
- Real image is always inverted
- Real images are formed by actual meeting of light rays



Virtual Image

- This image can not be taken on screen
- virtual image is always erect
- virtual images are formed when light rays appear to meet.

Convex mirror

i) Always smaller image

ii) Always Virtual and Erect

iii) Diverging mirror

(light फैलाता है।)

iv) Jahan badi cheez Ko chhota dekhna hai wahan use hoga.

Side view mirror of vehicle

Concave mirror

(ii) All type image (Smaller, Same size, Magnified)

(ii) 5 cases → Real and Inverted

1 case → Virtual and Erect.

(Obj b/w P and F)

(iii) Converging mirror

(iv) Jahan Bada dekha hai wahan use hoga

Dentist, ENT Doctor etc.

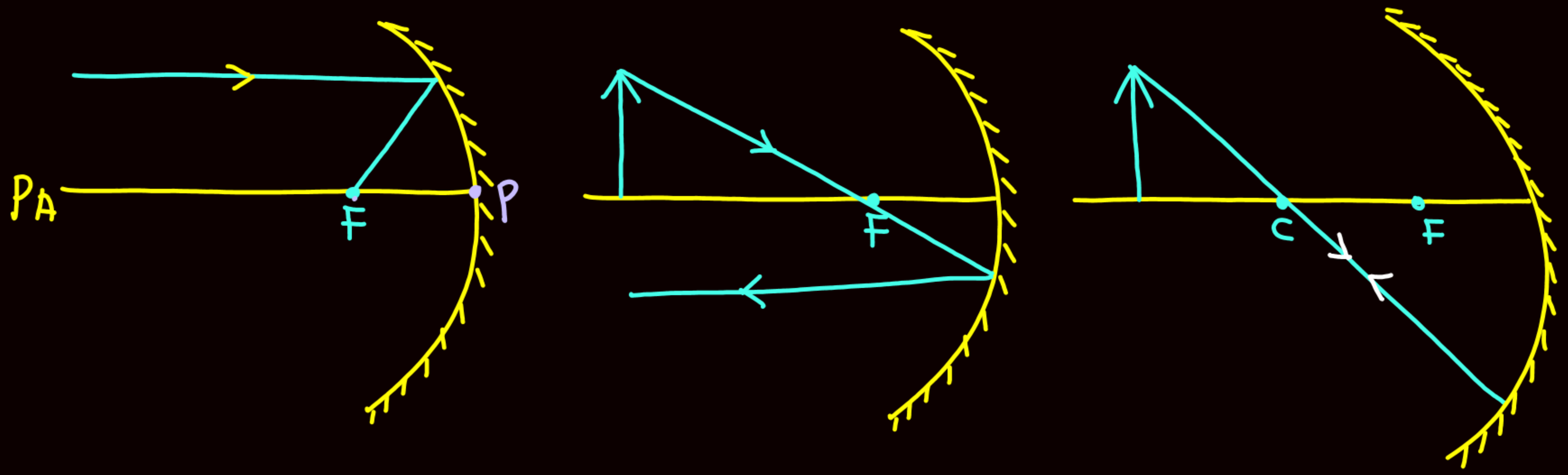
Shaving mirr.

Ray diagram

Rule 1 Ray Parallel to PA will pass through focus.

Rule 2 Ray passing through center of curvature will return back undeviated.

Rule 3 Ray passing through focus becomes parallel to PA



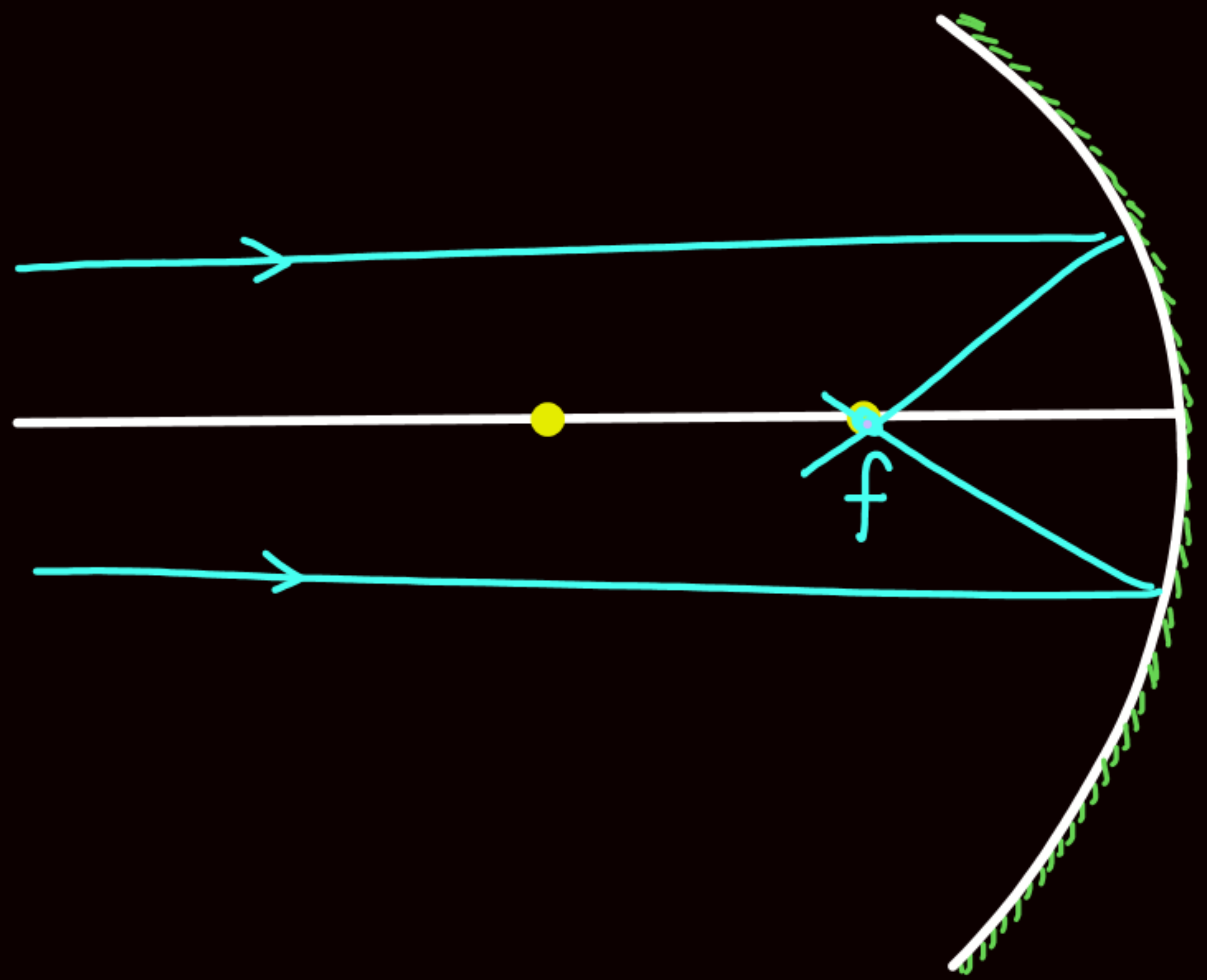
case1

Object at infinity, Image at focus

Image-point size

Nature -Real and

Inverted

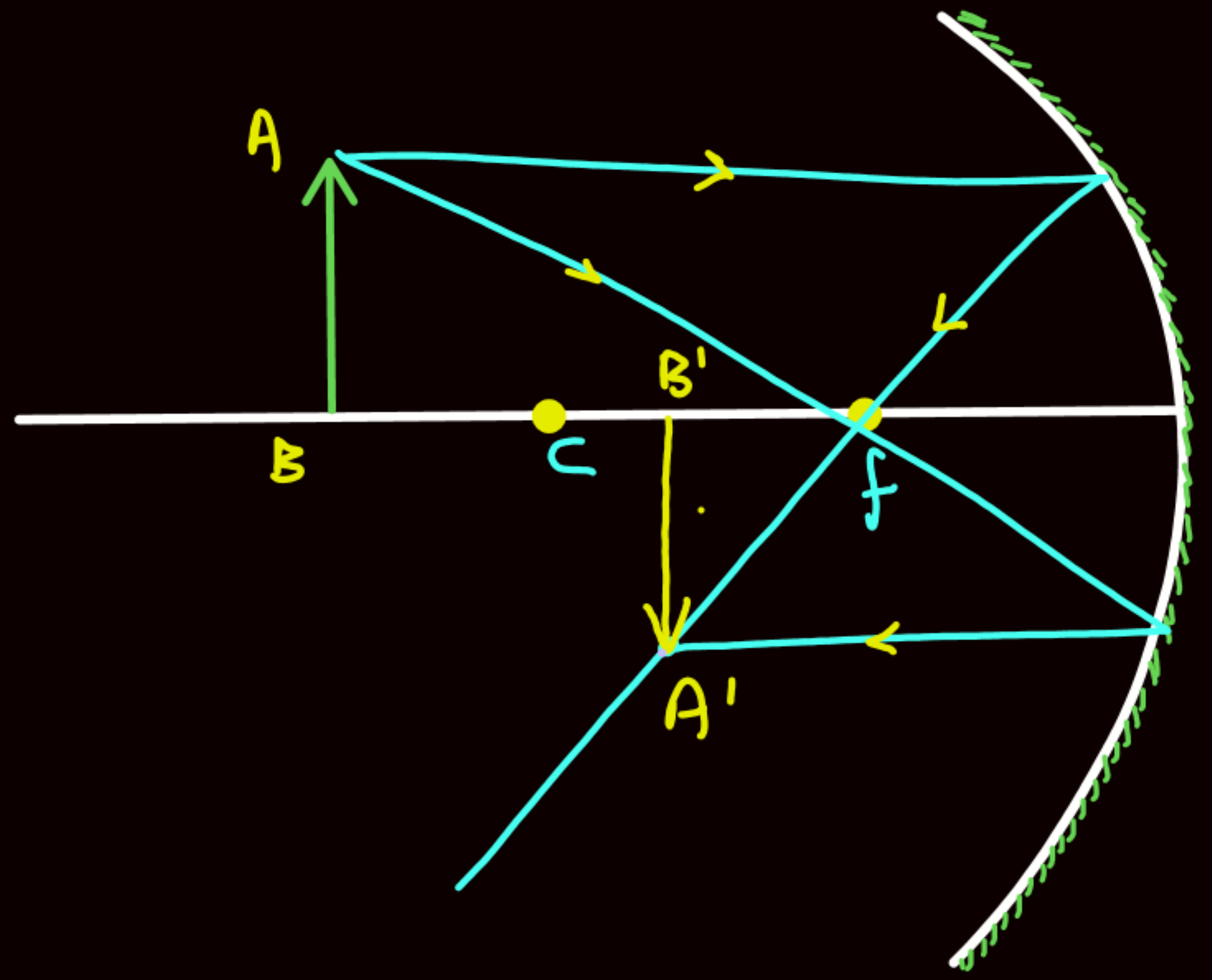


case2 - Object beyond center of curvature, Image between F and C

Image-diminished

Nature _ Real and

Inverted

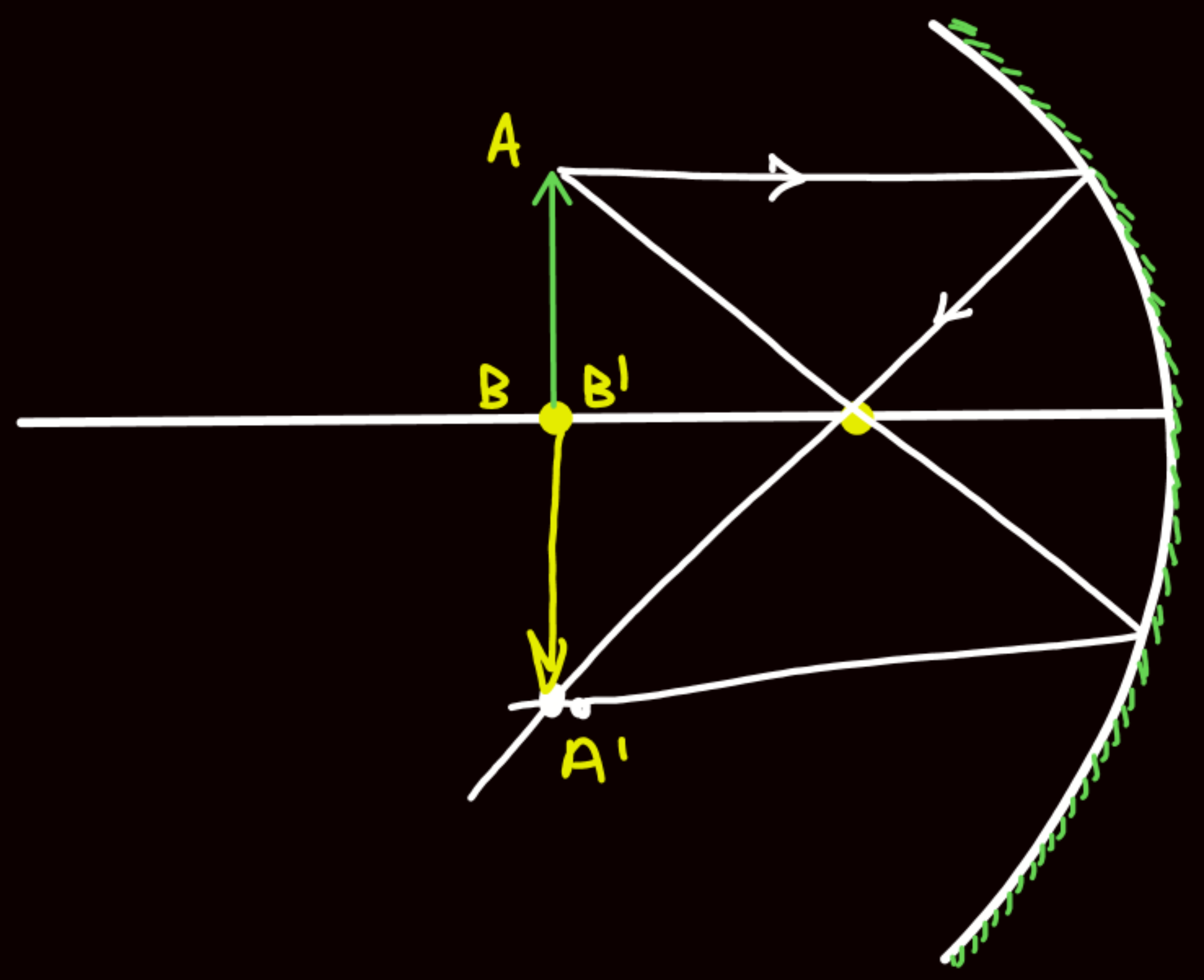


case3 Object at center of curvature Image of center of curvature

Image-same size

Nature -Real and

Inverted

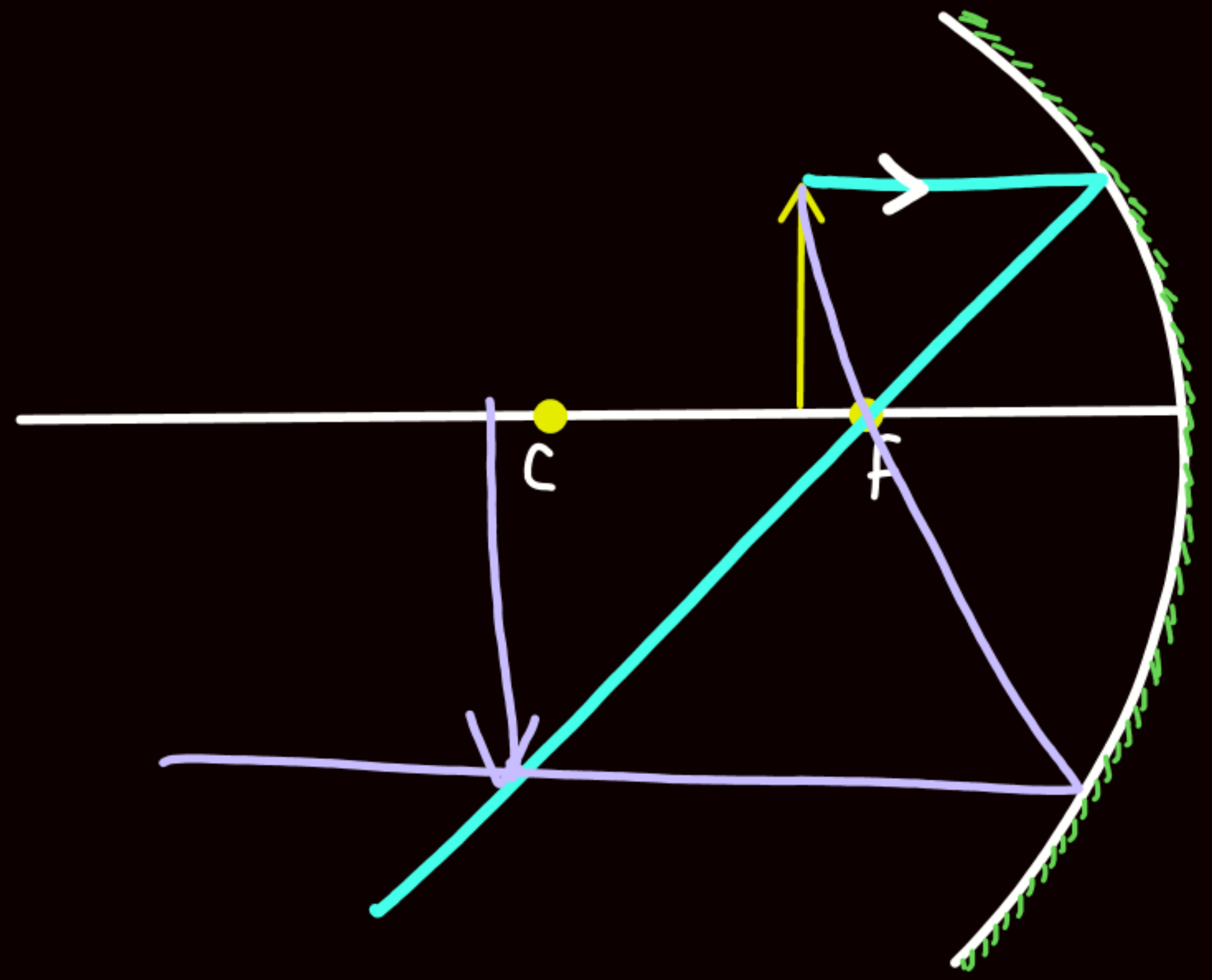


case4 Object between focus, and center of curvature Image Beyond C

Image-enlarged

Nature -Real and

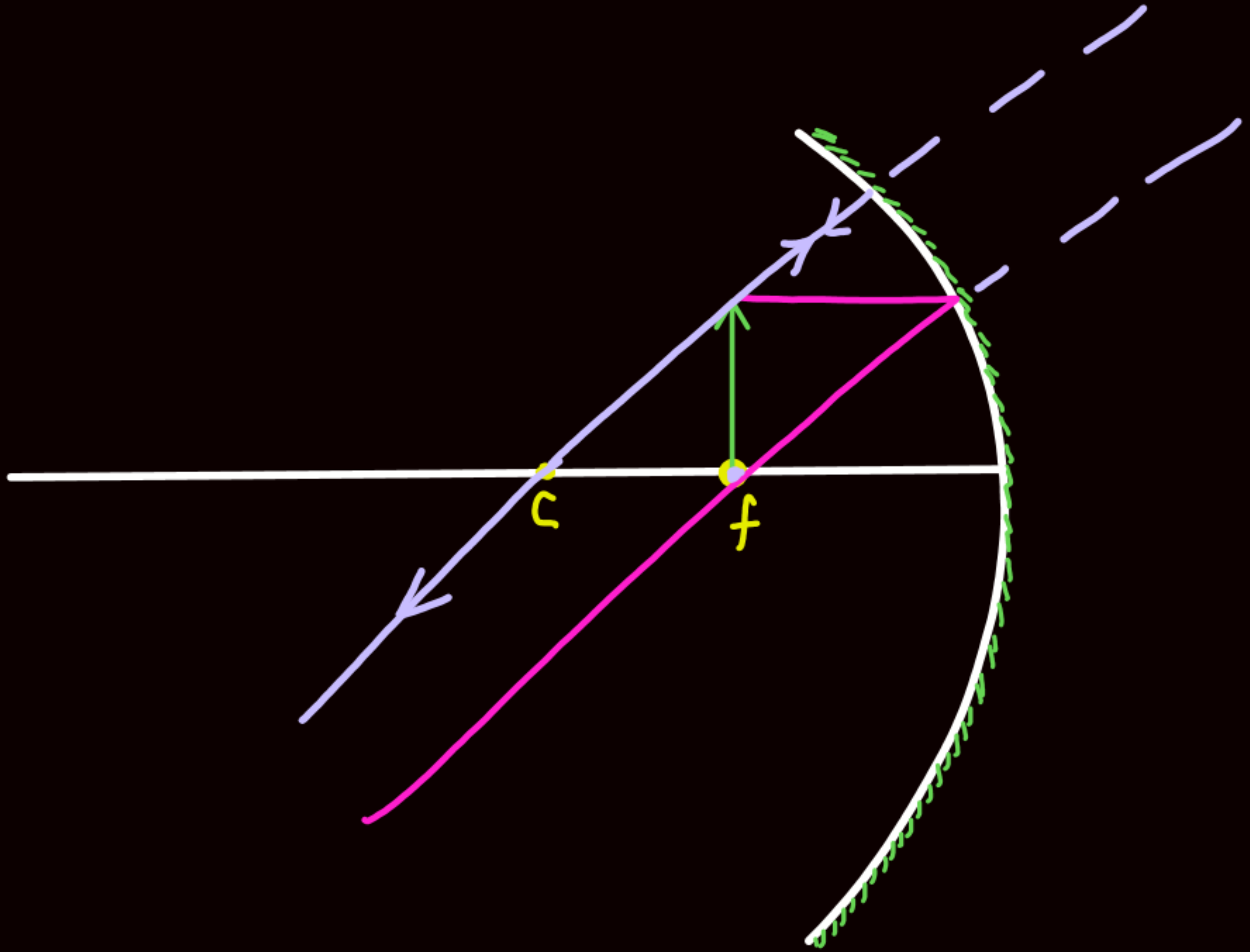
Inverted



case5 - Object at focus Image at Infinity

Image-highly Magnified

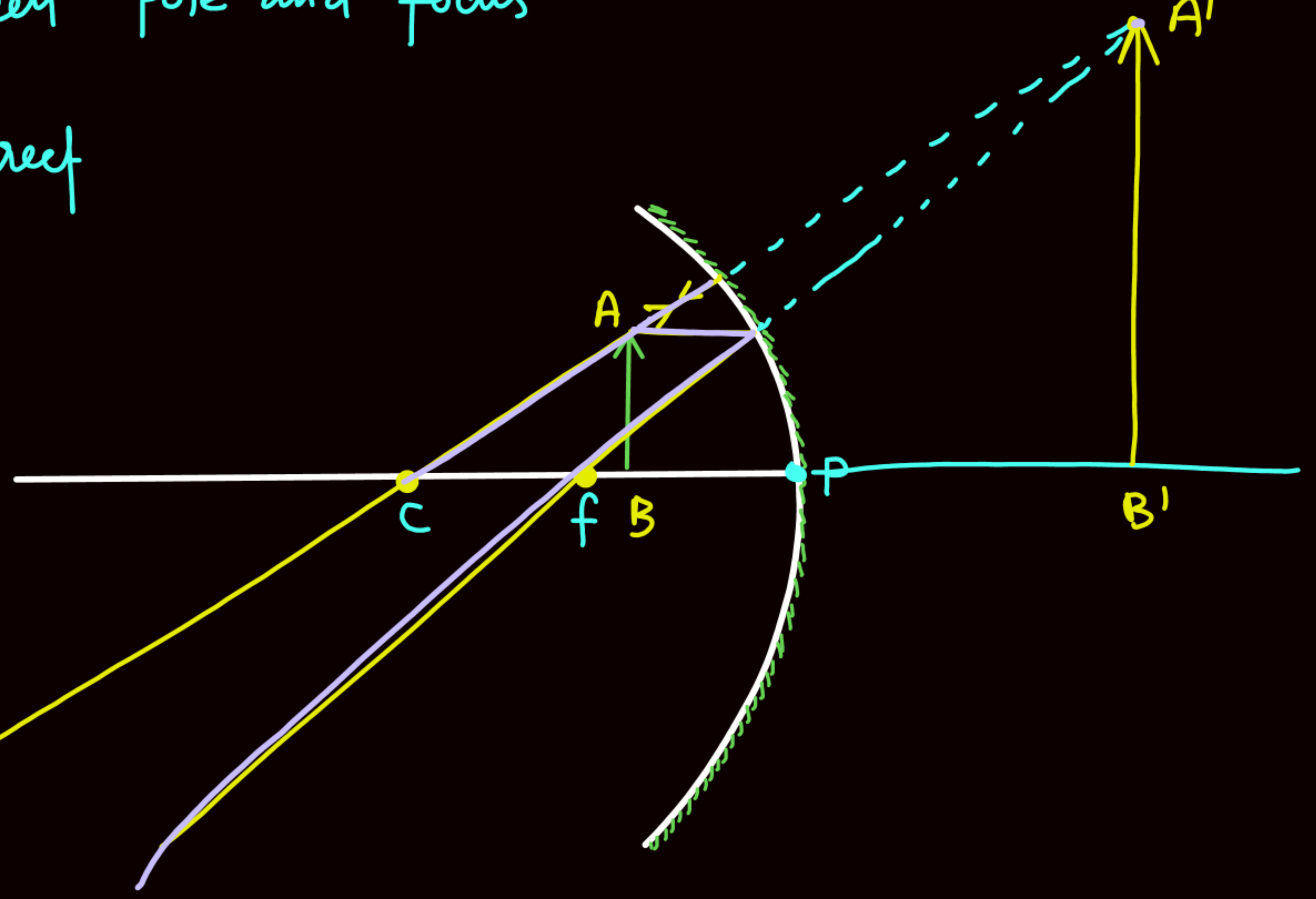
Nature-real and Inverted



Case6 Object between pole and focus

Nature → Virtual and erect

Highly magnified



Convex Mirror

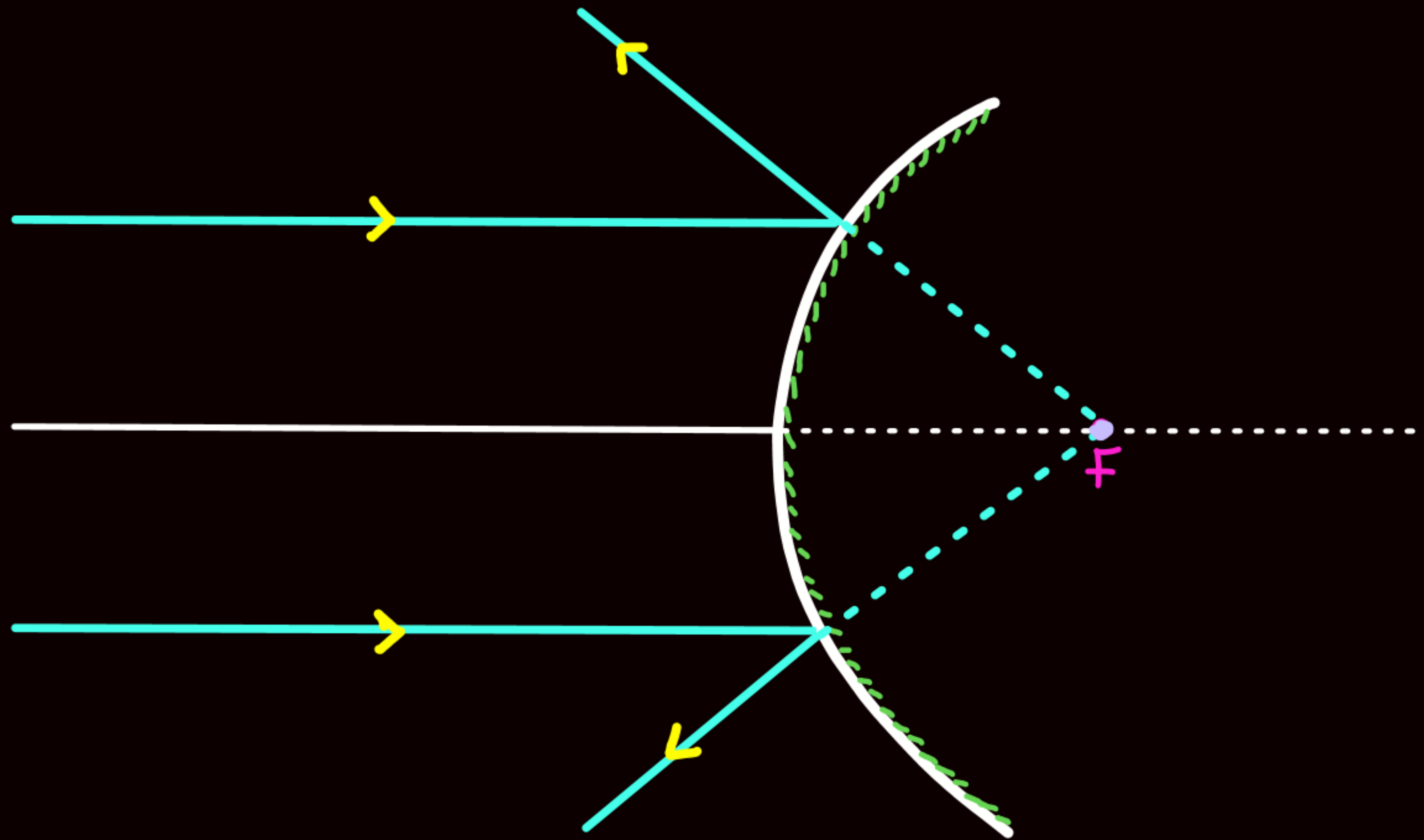
case1

Object at infinity Image focus

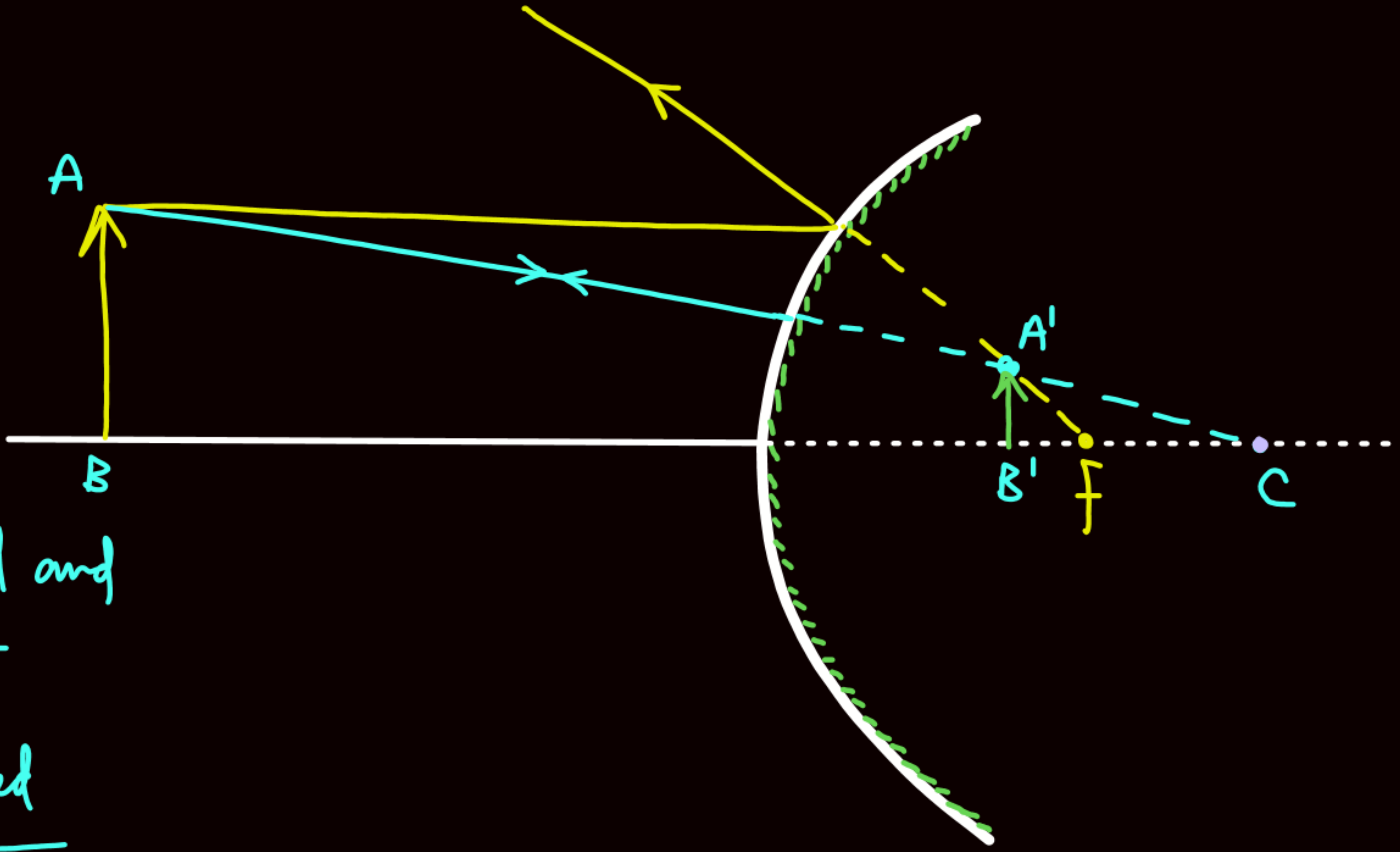
Image Nature

↳ Virtual and erect

↳ Diminished



Case 2: Object Anywhere on P.A



Always Virtual and Erect

+ Diminished

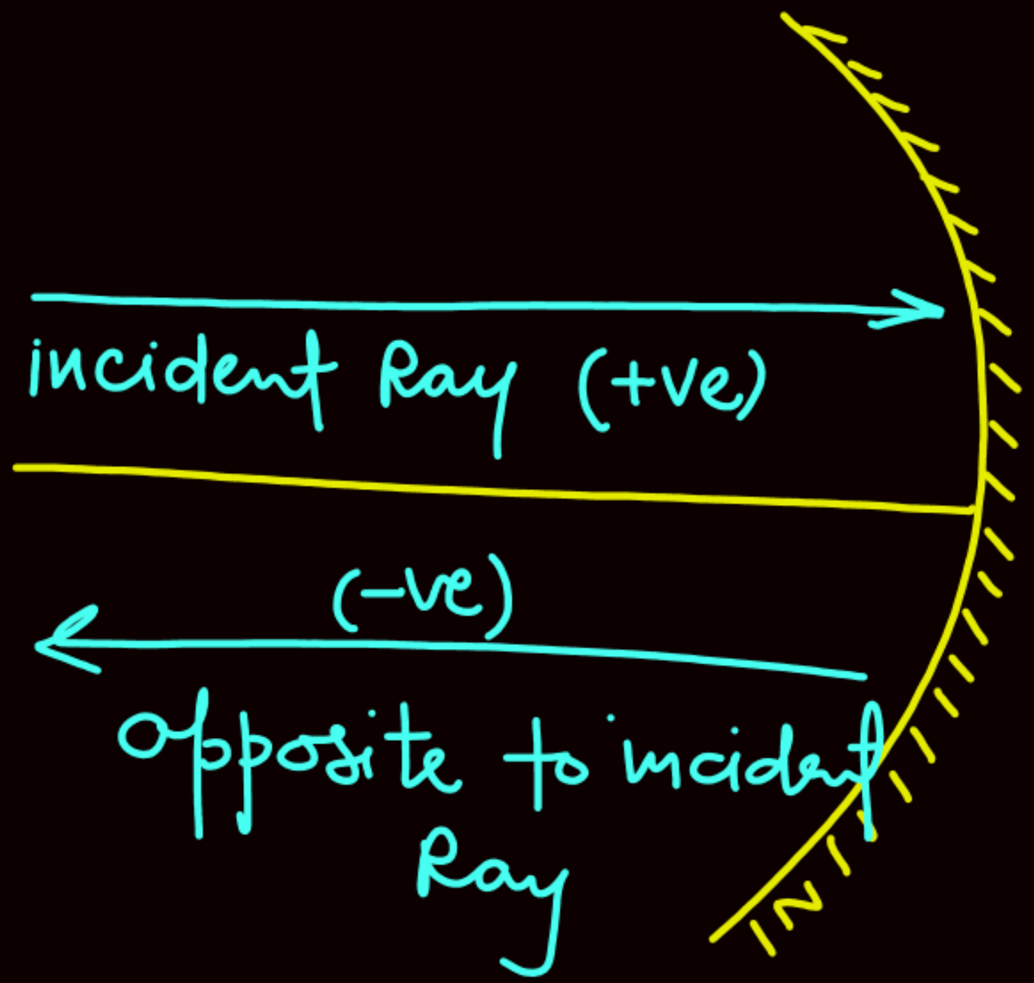
Sign convention

Above P. Axis = +ve

Below P. Axis = −ve

In the direction of incident light = +ve

opposite to the direction of incident light = −ve



Mirror formula and Rules

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

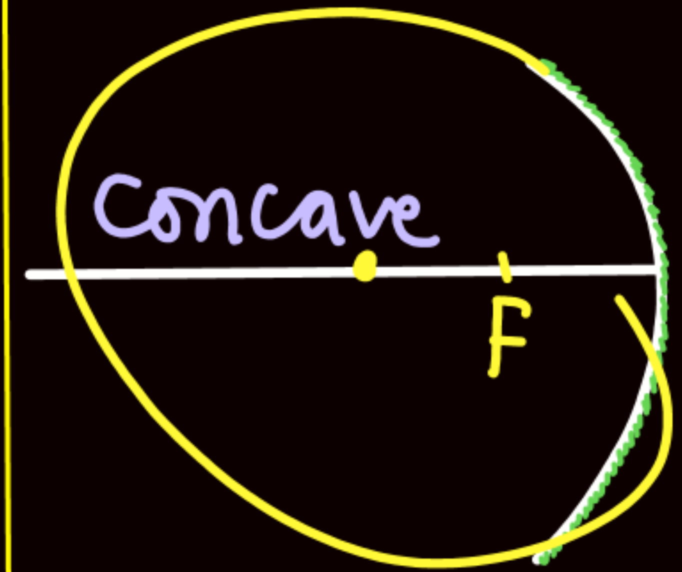
where,

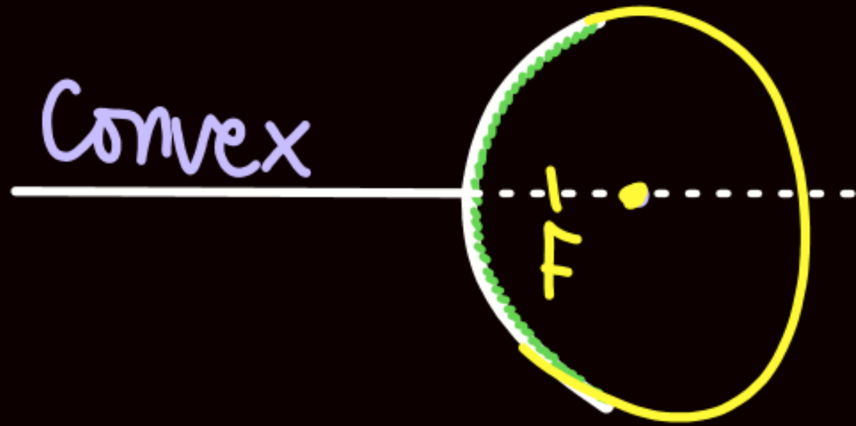
f is focal length of mirror

v Image distance from pole

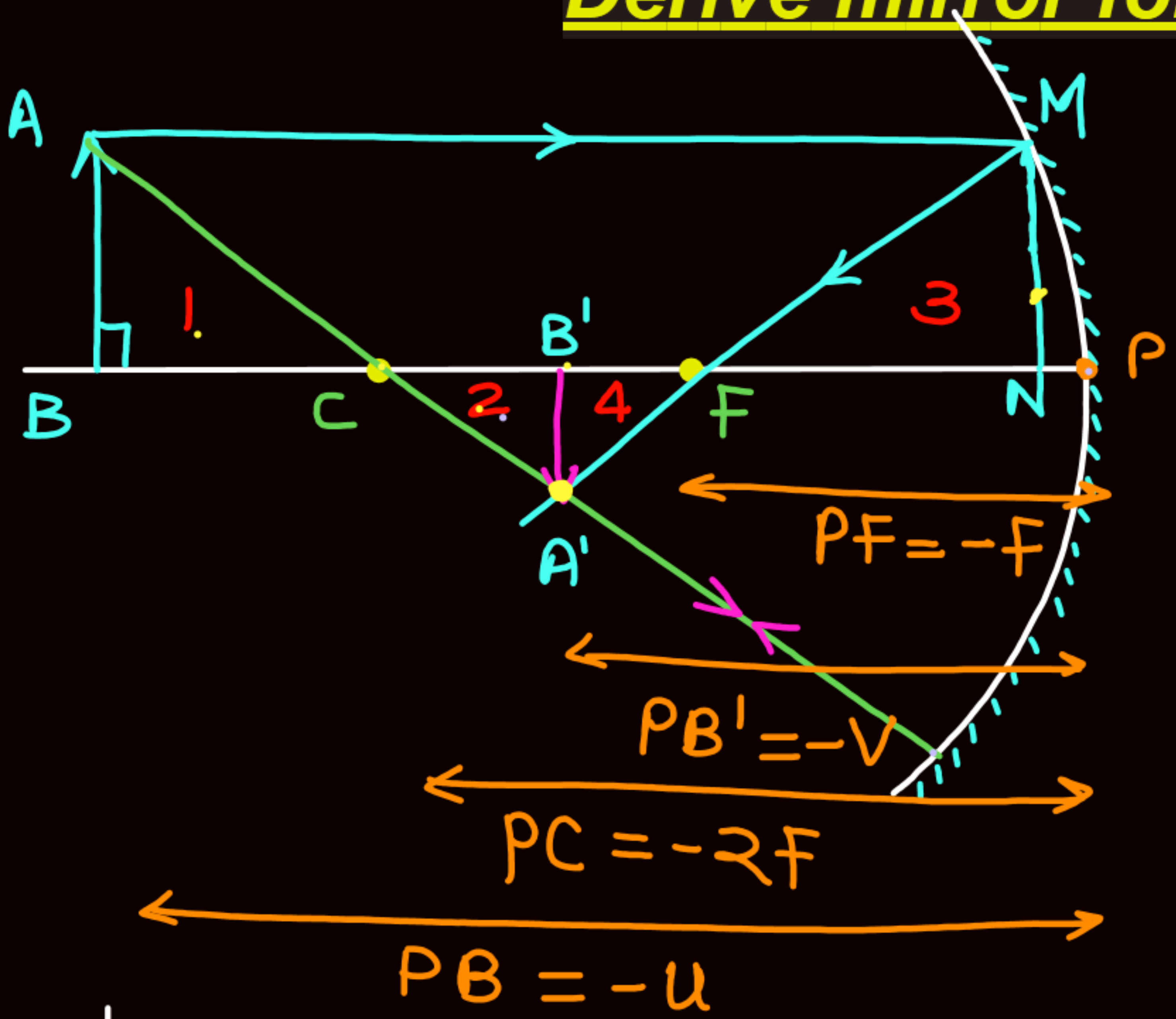
u object distance from pole

Concave	Convex
$u = -ve$	$u = -ve$
$v = -ve$ / $+ve$	$v = +ve$
$f = -ve$	$f = +ve$





Derive mirror formula for spherical mirror



here ΔABC and $A'B'C$

$\angle ABC = \angle A'B'C = 90°$

$\angle ACB = \angle A'CB'$ (opp angle)

In ΔABC and $A'B'C$ are similar triangle

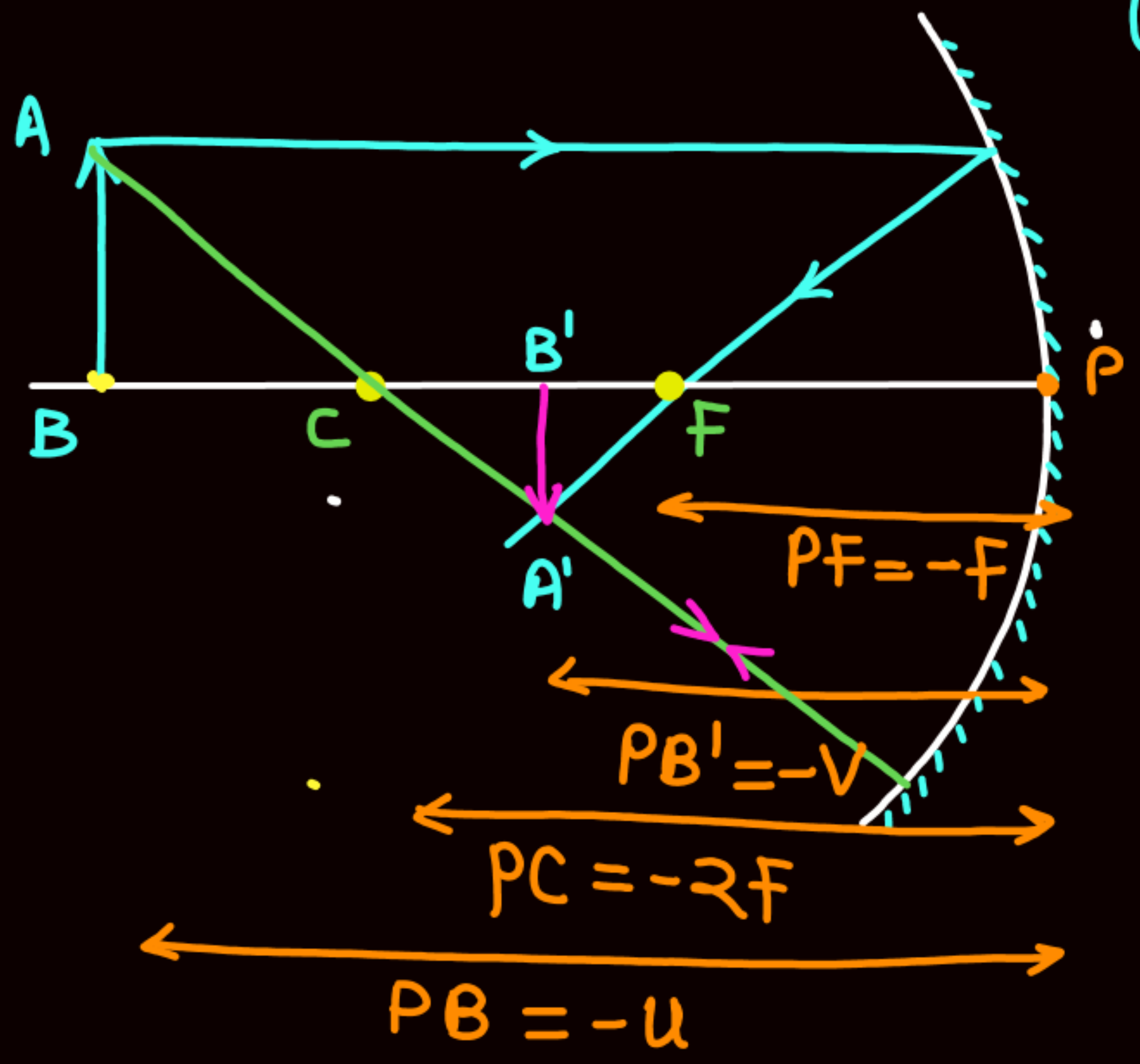
$$\left\{ \frac{AB}{A'B'} = \frac{BC}{B'C} \right\} \text{ --- } (1)$$

In ΔMNF and $A'B'F$ are similar triangle

$$\left\{ \frac{MN}{A'B'} = \frac{FN}{FB'} \right\}$$

here $\boxed{MN = AB}$ and $\boxed{FN \approx FP}$

$$\left\{ \frac{AB}{A'B'} = \frac{FP}{FB'} \right. \text{ --- } (2)$$



Comparing equation ① and ②

$$\left\{ \frac{BC}{B'C} = \frac{FP}{FB'} \right\}$$

putting values from Ray dia with sign convention.

$$\frac{(PB - PC)}{(PC - PB')} = \frac{FP}{PB' - FP}$$

$$\left\{ \frac{-u - (-2F)}{-2F - (-V)} \right\} = \left\{ \frac{-F}{-V - (-F)} \right\}$$

$$\frac{(-u + 2F)}{(-2F + V)} = \frac{-F}{(F - V)}$$

$$\frac{(-u+2f)}{(-2f+v)} = \frac{-f}{(f-v)}$$

$$(-u+2f)(f-v) = -f(-2f+v)$$

$$-uf + uv + \cancel{2f^2} - 2vf = \cancel{2f^2} - vf$$

$$-uf + uv = -vf + 2vf$$

$$-uf + uv = vf \quad \text{— } 3$$

Devide by $\underline{uvf}$ in both side

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

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

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

magnification for both convex and concave Mirror

$$m = \frac{\text{height of image}}{\text{height of Object}}$$

$$\boxed{m = \frac{h_i}{h_o}}$$

$$\frac{6cm}{2cm} = \boxed{3 = m}$$

or

$$\boxed{m = -\frac{v}{u}} \qquad \boxed{m = \frac{v}{u}}$$

for mirror   for lens

+ve → = Erect image

+1 → = Erect, same size

+2, +3, +4 - - - = Erect, magnified

-ve → = Inverted

-1 → = Inverted, same size

-2, -3, -4 - - - = Inverted-magnified.

$m = +1.5$?

$m = -1.5$?

-0.5 = Invert smaller

Refractive index →

$\mu \propto \frac{1}{v}$

It is the ratio of speed of light in vacuum or air to the speed of light in medium.

Absolute Refractive index.

$$\mu = \frac{\text{speed of light in Vacuum}}{\text{speed of light in medium}}$$

$\boxed{\mu = 1.5}$

glass $= \frac{3\times10^8}{1.5} = 2\times10^8$ m/s

Relative Refractive index

1.33 ← water → glass

$$_1\mu_2 = \frac{\text{Velocity in } 1}{\text{Velocity in } 2}$$

$$_1\mu_2 = \boxed{\frac{\mu_2}{\mu_1} = \frac{v_1}{v_2}}$$

$$_w\mu_g = \frac{\mu_g}{\mu_w}$$

R.I of glass wrt water

from glass to water

$_{g}\mu_{w}$ R.I of water wrt glass

$$_{g}\mu_{w} = \frac{\mu_w}{\mu_g} = \frac{v_g}{v_w} = \frac{\lambda_g}{\lambda_w}$$

from paper to lens

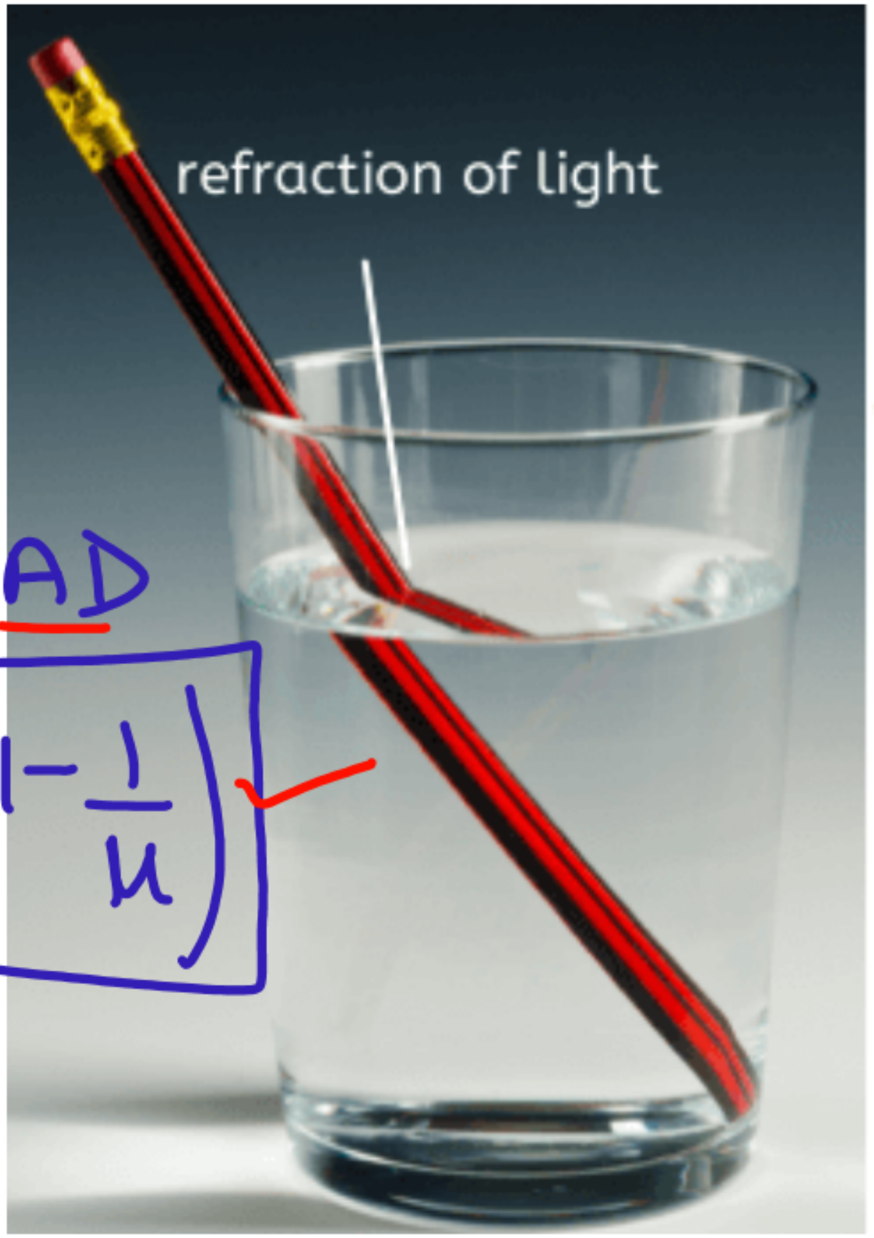
$$\boxed{_{P}\mu_{L} = \frac{\mu_L}{\mu_P} = \frac{v_P}{v_L} = \frac{\lambda_P}{\lambda_L}}$$

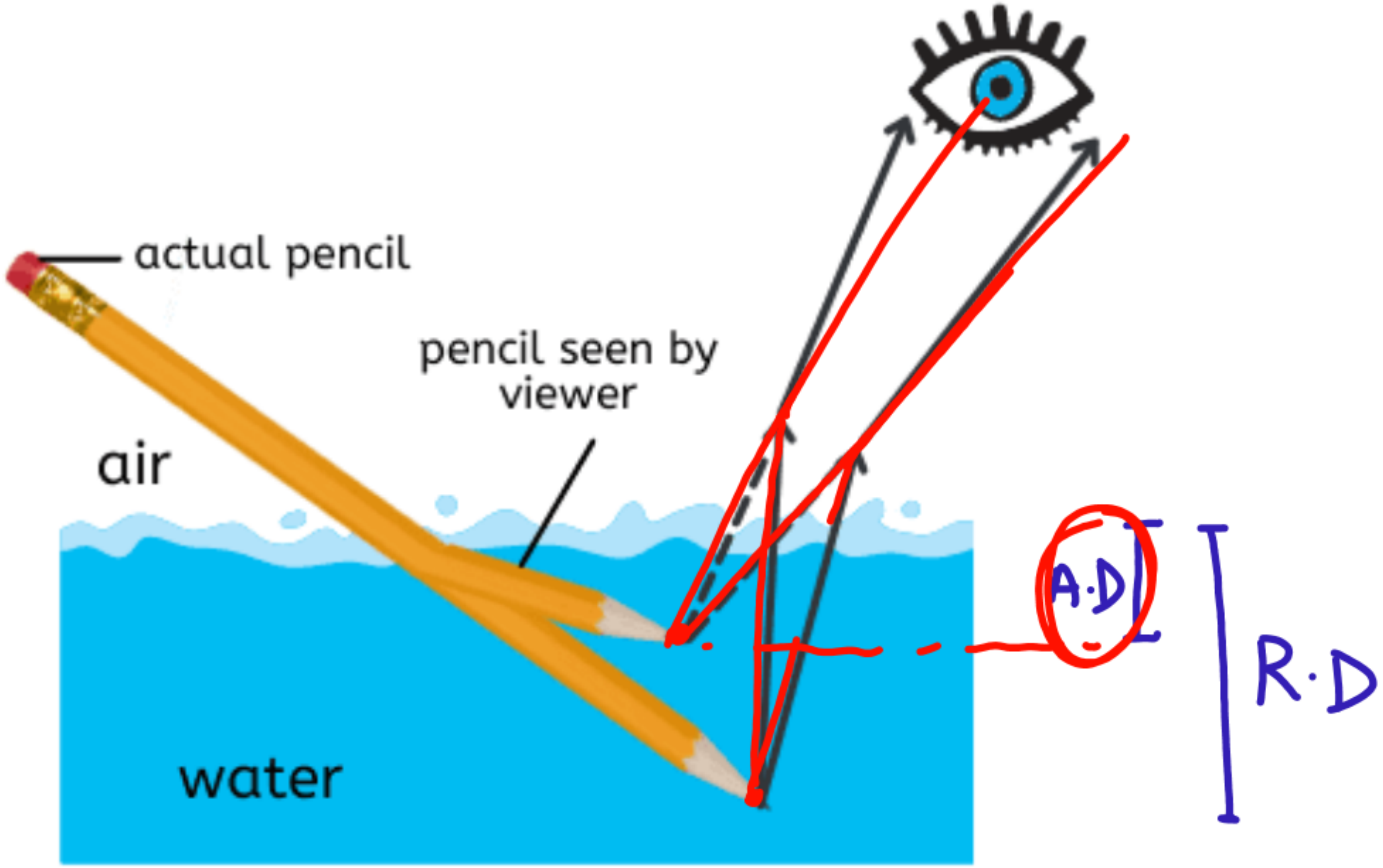
Example of Refraction of light

$$\boxed{\mu = \frac{R\cdot D}{A\cdot D}}$$

$$\text{Shift} = RD - AD$$

$$\boxed{\text{Shift} = R\cdot D\left(1-\frac{1}{\mu}\right)}$$

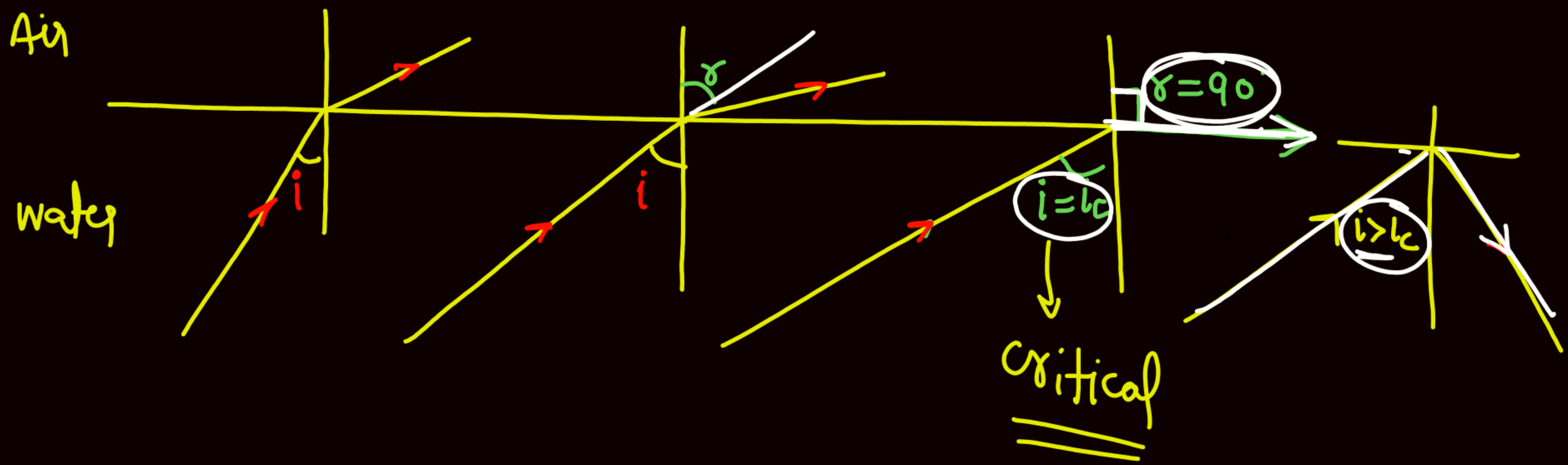




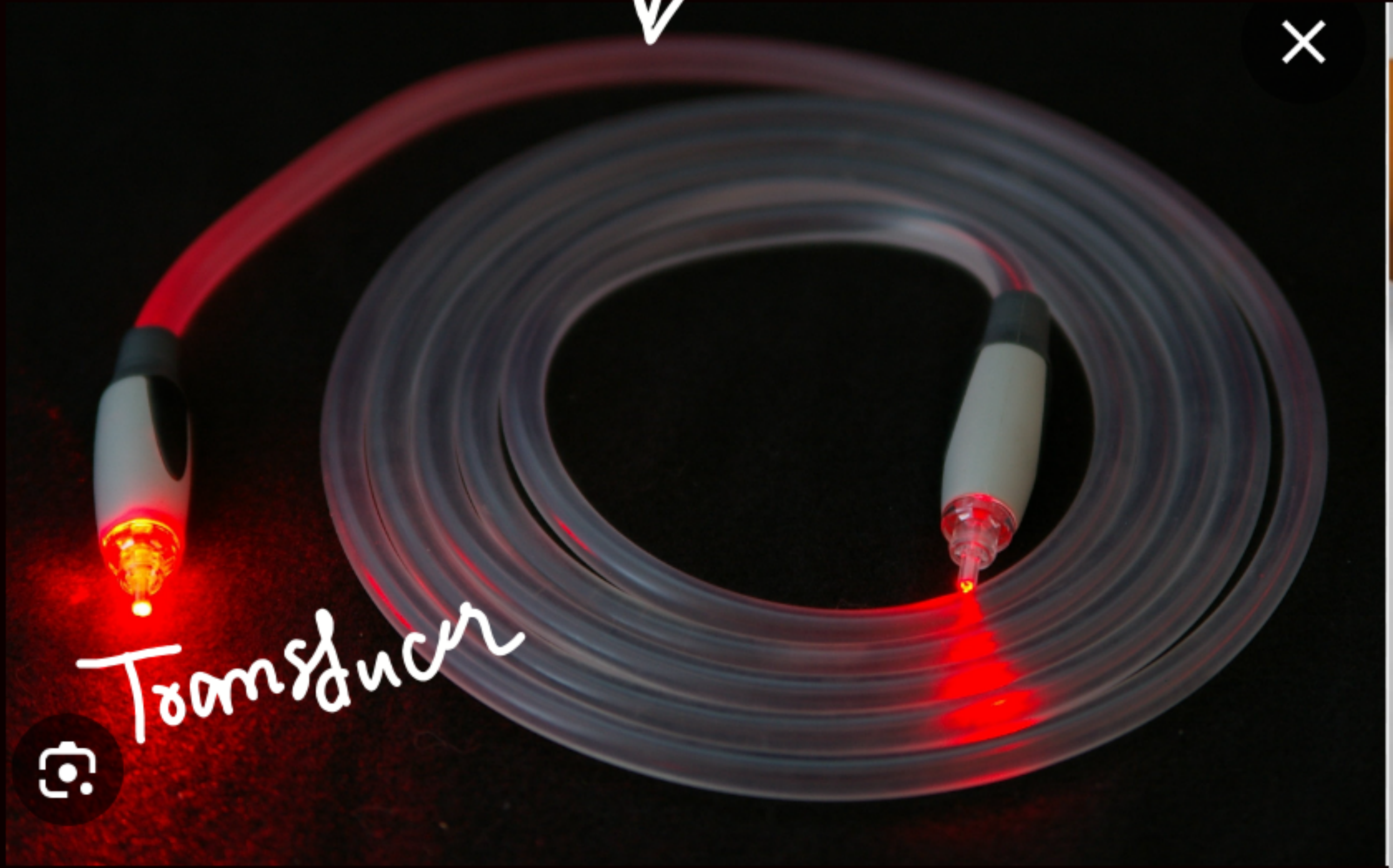
Total internal Reflections

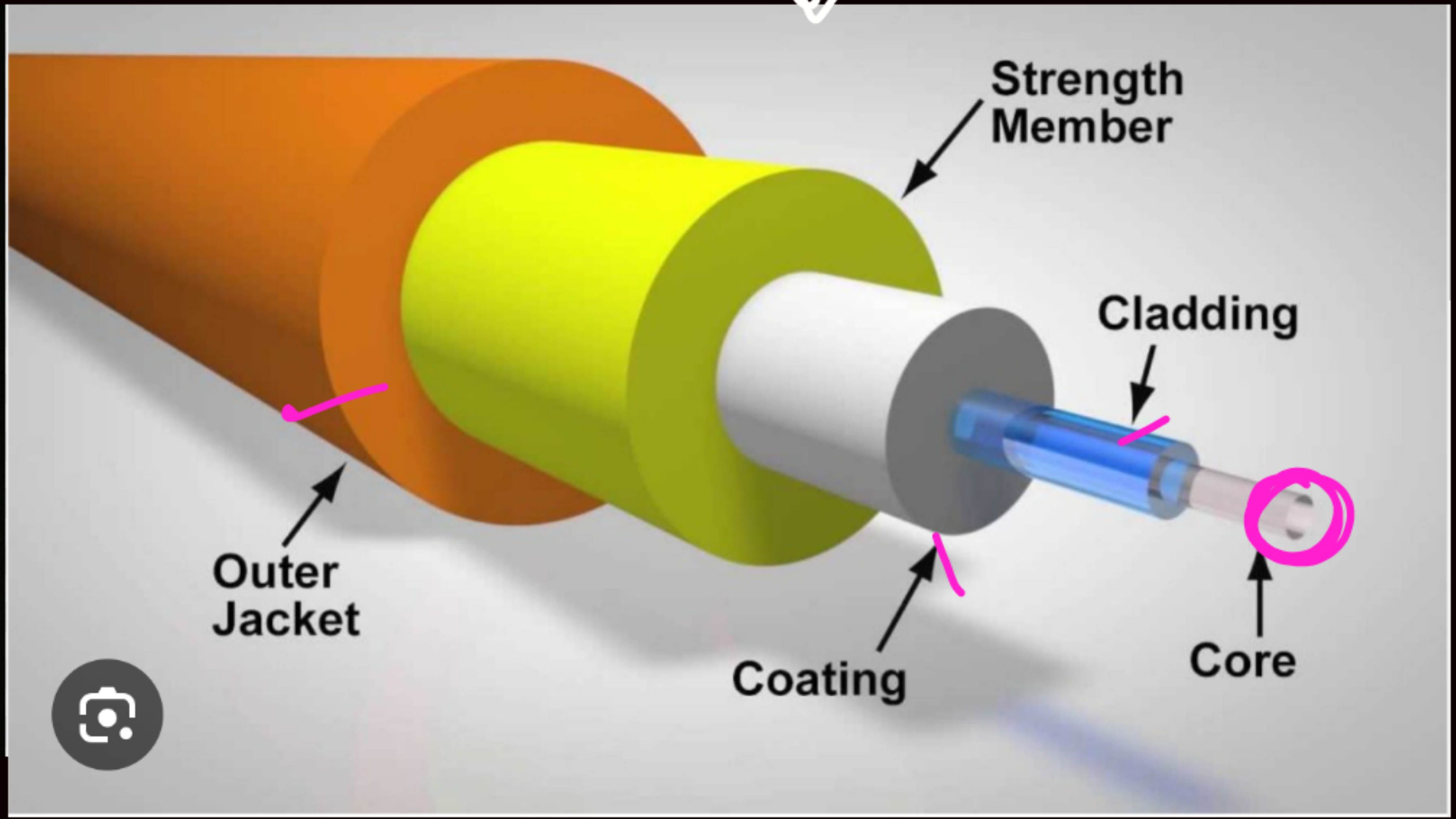
When a ray of light travels from denser to Rarer medium at an angle greater than critical angle they light reflects back in same medium. This phenomenon is called Total internal Reflection (T 1 R)

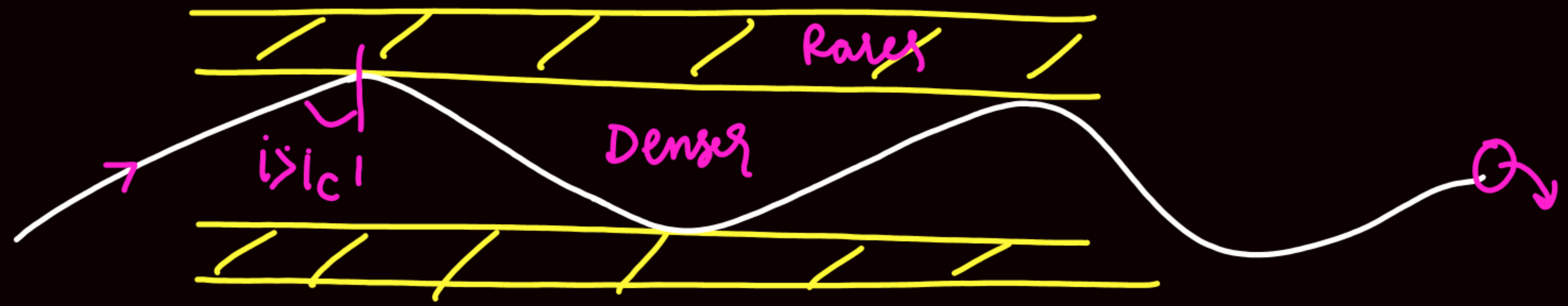
Denser → Rarer → Angle of incidence > i_c = TIR



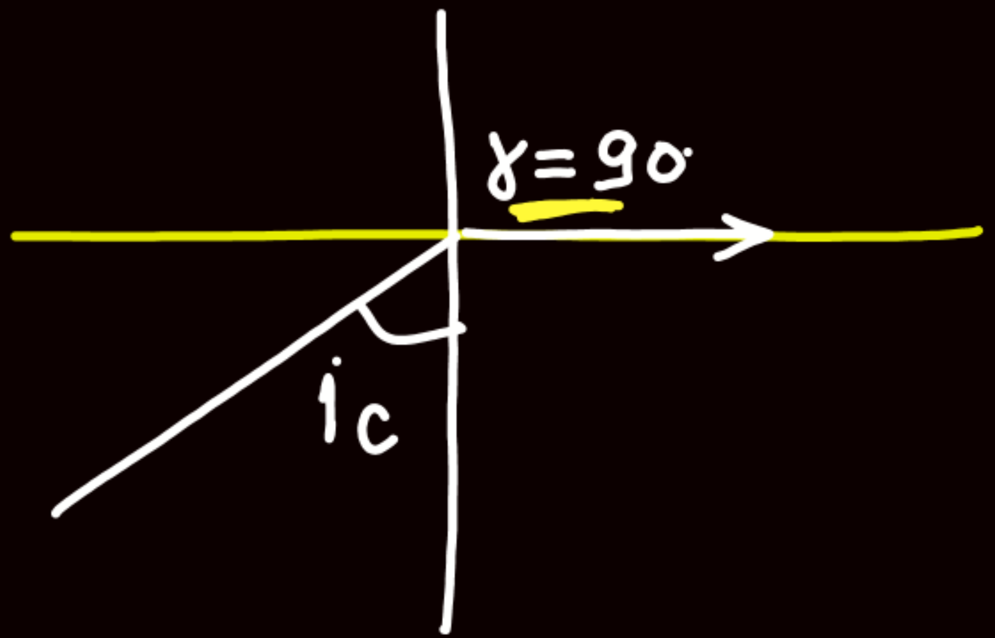
optical fiber






Rarer
Denser
i>ic

Relation b/w Critical angle and Refractive index



Rarer Air

Denser (water)

$$_w\mu_a = \frac{\sin i}{\sin r}$$

$$_w\mu_a = \frac{\sin i_c}{\sin 90}$$

$$\boxed{_w\mu_a = \sin i_c}$$

$$\frac{1}{_a\mu_w} = \sin i_c$$

$$\boxed{_a\mu_w = \frac{1}{\sin i_c}}$$

In general $\boxed{\mu = \frac{1}{\sin i_c}}$

Lens

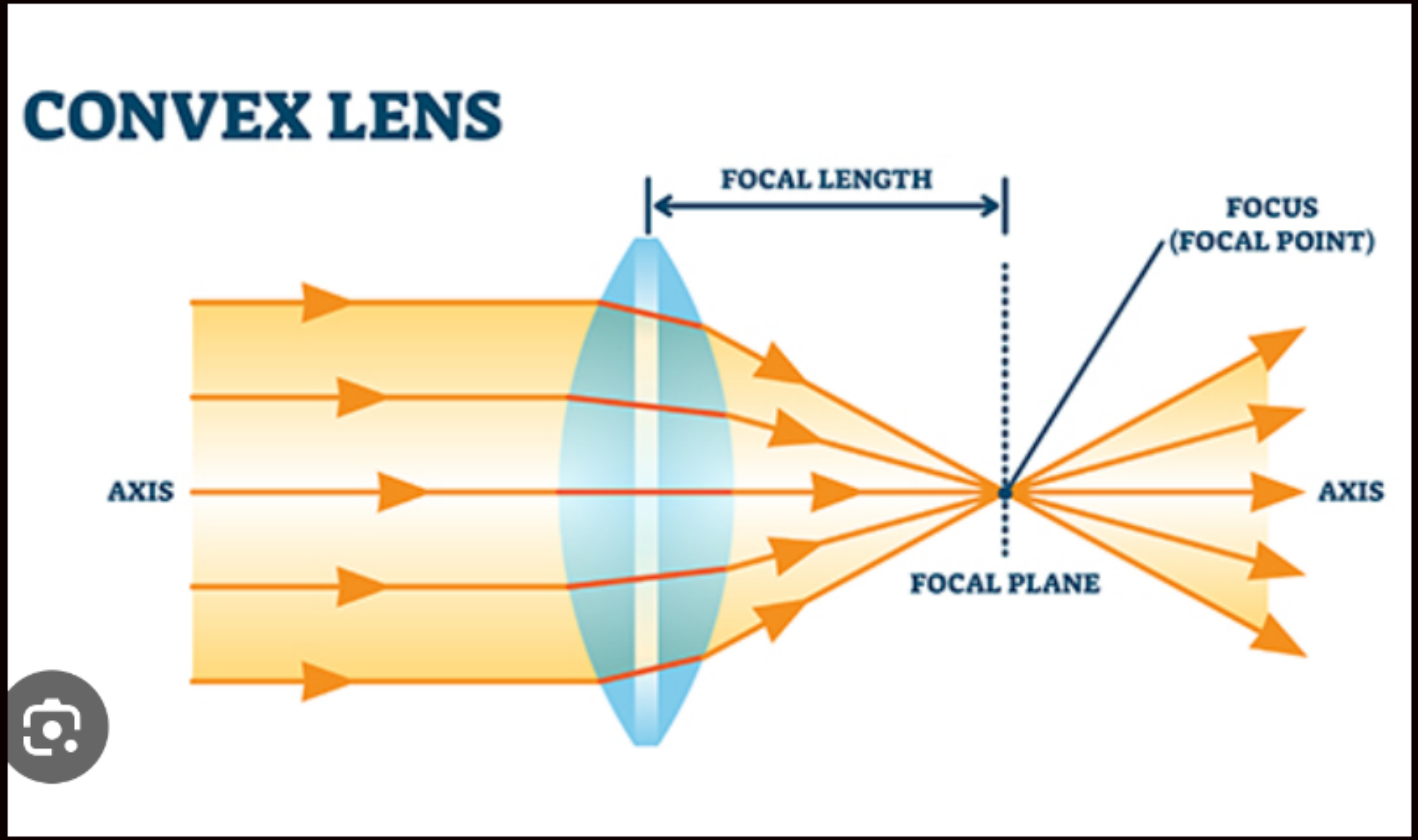
It is the combination of two transparent spherical surface used to converge or diverge light rays.

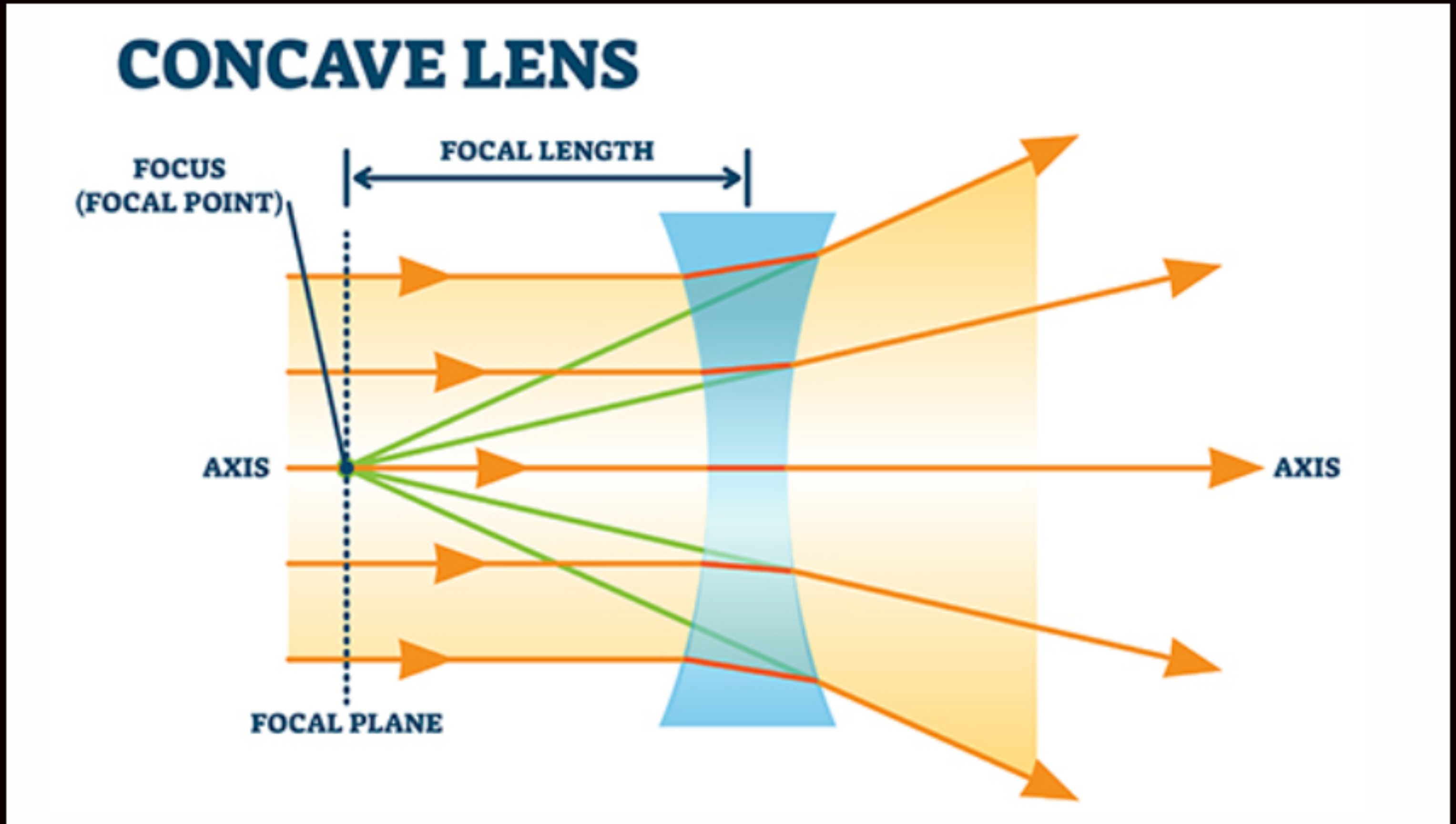
convex Lens.

converge light rays

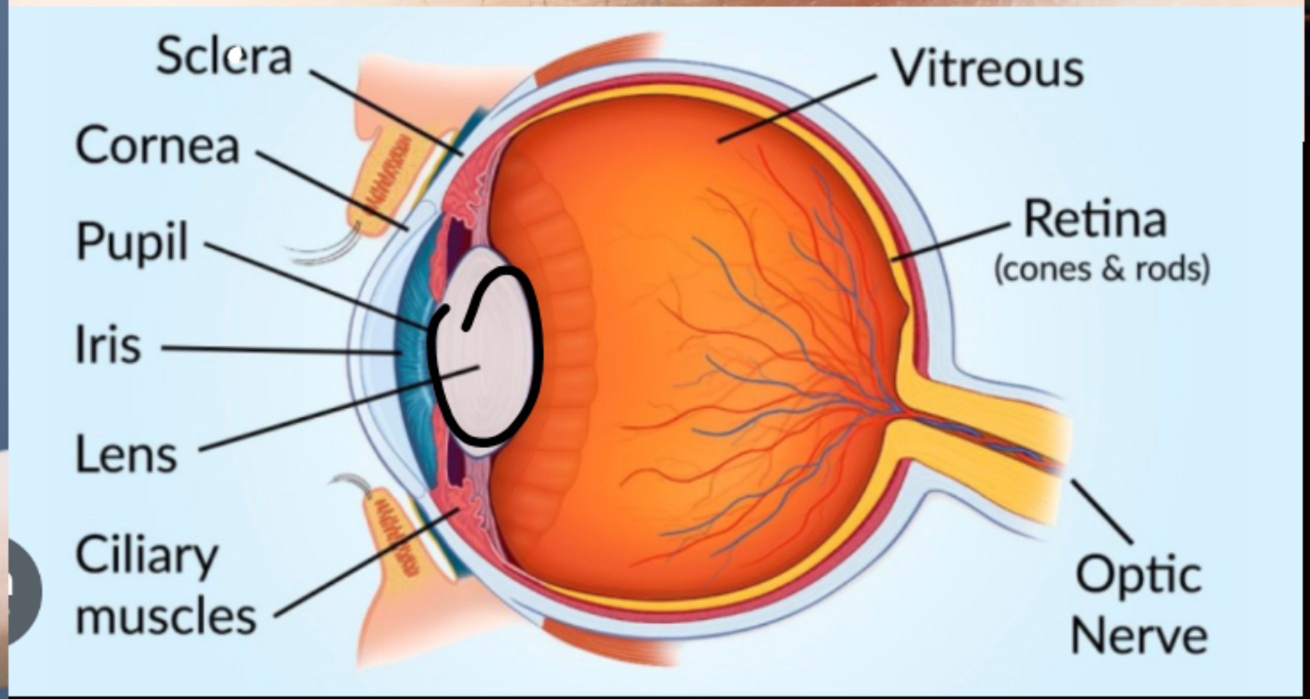
concave Lens.

Diverge light ray





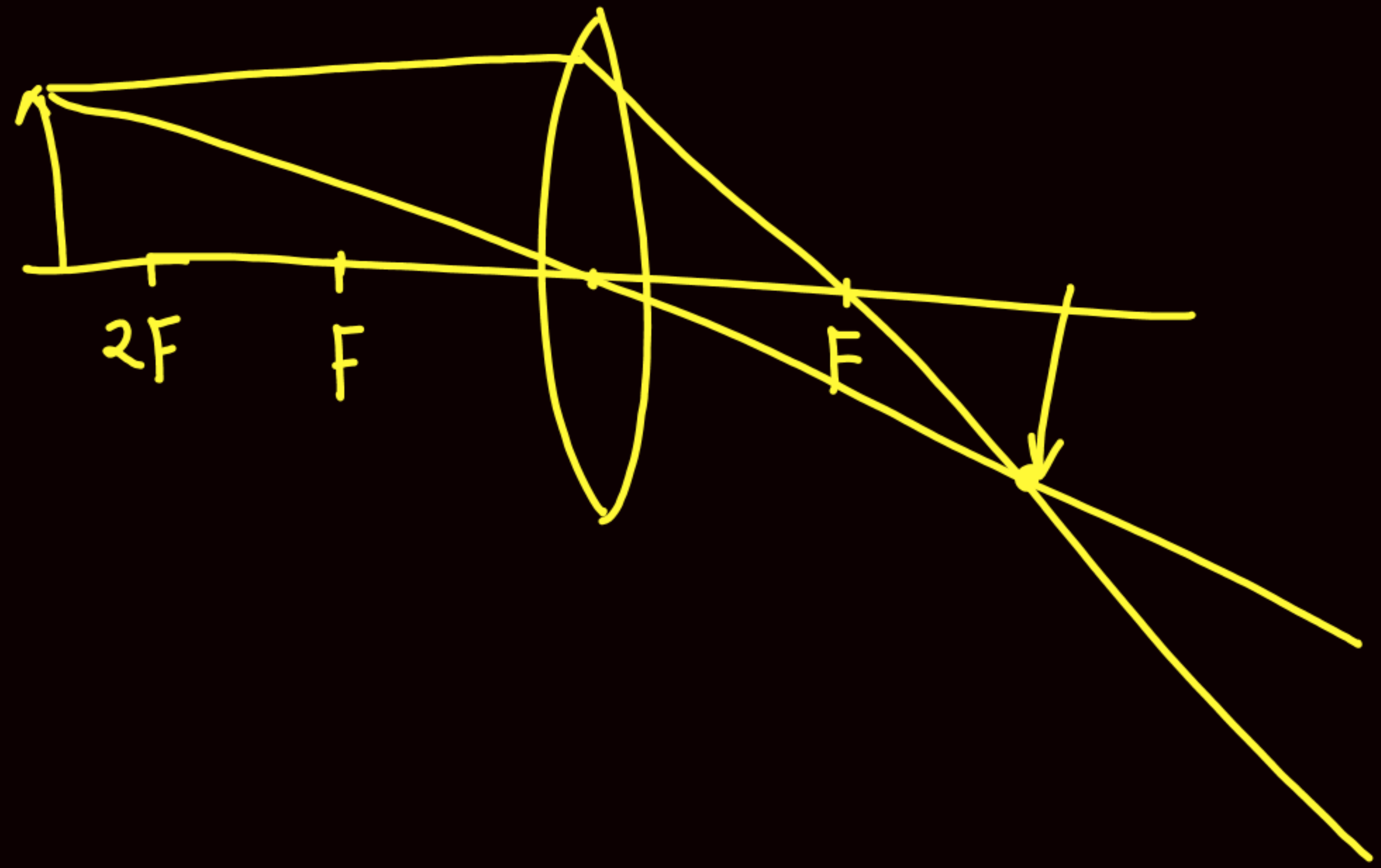
Uses of Convex lens



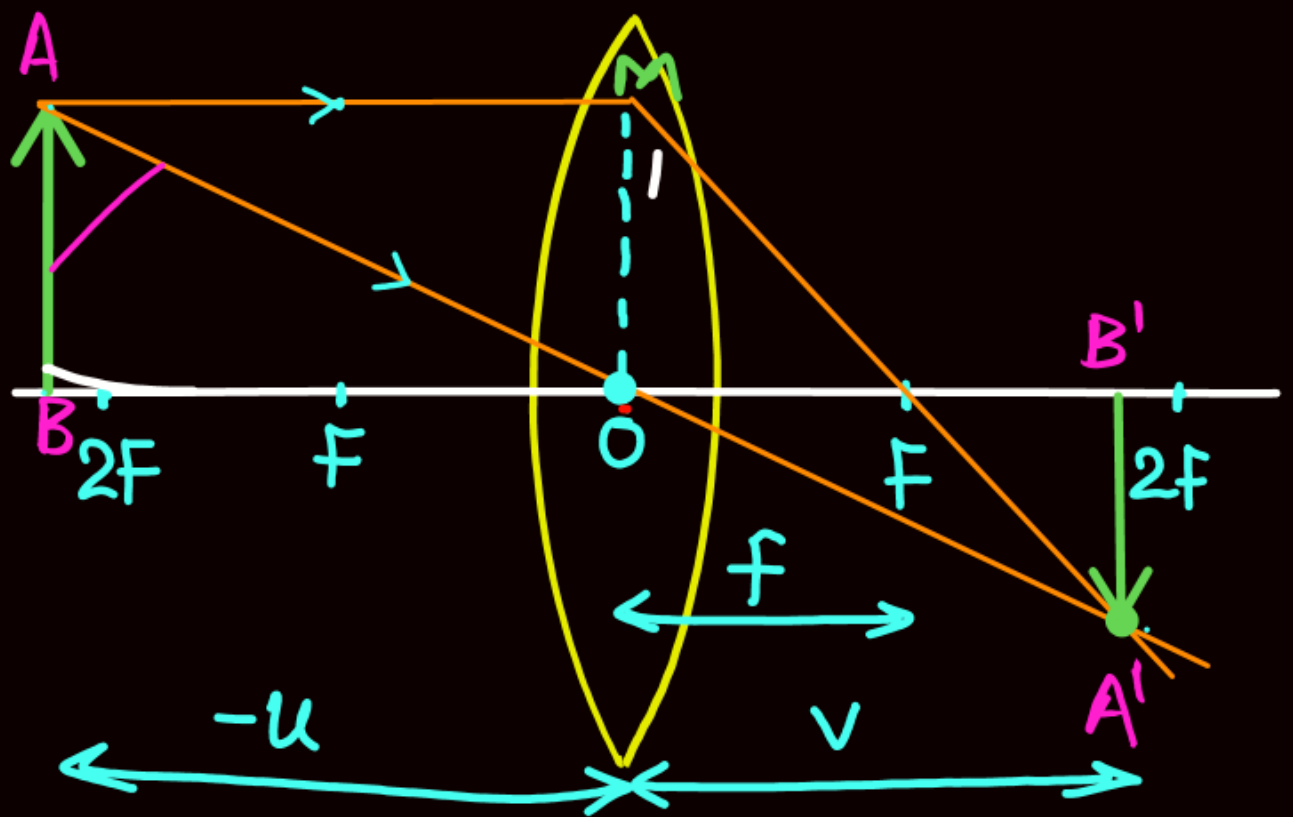
Concave

Galieam T.

Lens Basics	convex	Concave
Lens formula	$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$	$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$
focal length	+ve	-ve
Magnification	Image size keeps on ↑ing as we move toward Lens.	Always Diminished
Nature of Image formed	Real, when object is outside / on the focus. / Virtual inside focus.	Always Virtual.


2F
F
F

Lens formula



Here ΔABO and $A'B'O$

$\angle ABO = \angle A'B'O = 90^\circ$

$\angle AOB = \angle A'OB' =$ opposite angle

Thus ΔABO and $A'B'O$ are similar Triangle.

In ΔABO and $\Delta A'B'O$

$$\frac{AB}{A'B'} = \frac{BO}{B'O} \quad \text{—} \ (1)$$

In ΔMOF and $A'B'F$

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

$\boxed{MO = AB}$

$$\frac{AB}{A'B'} = \frac{OF}{B'F} \quad \text{—} \ (2)$$

Comparing (1) and (2)

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

$$\frac{-u}{v} = \frac{f}{(v-f)}$$

$$-uv + uf = vf \quad \text{—} \ (3)$$

Devide eq (3) by uvf

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

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

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

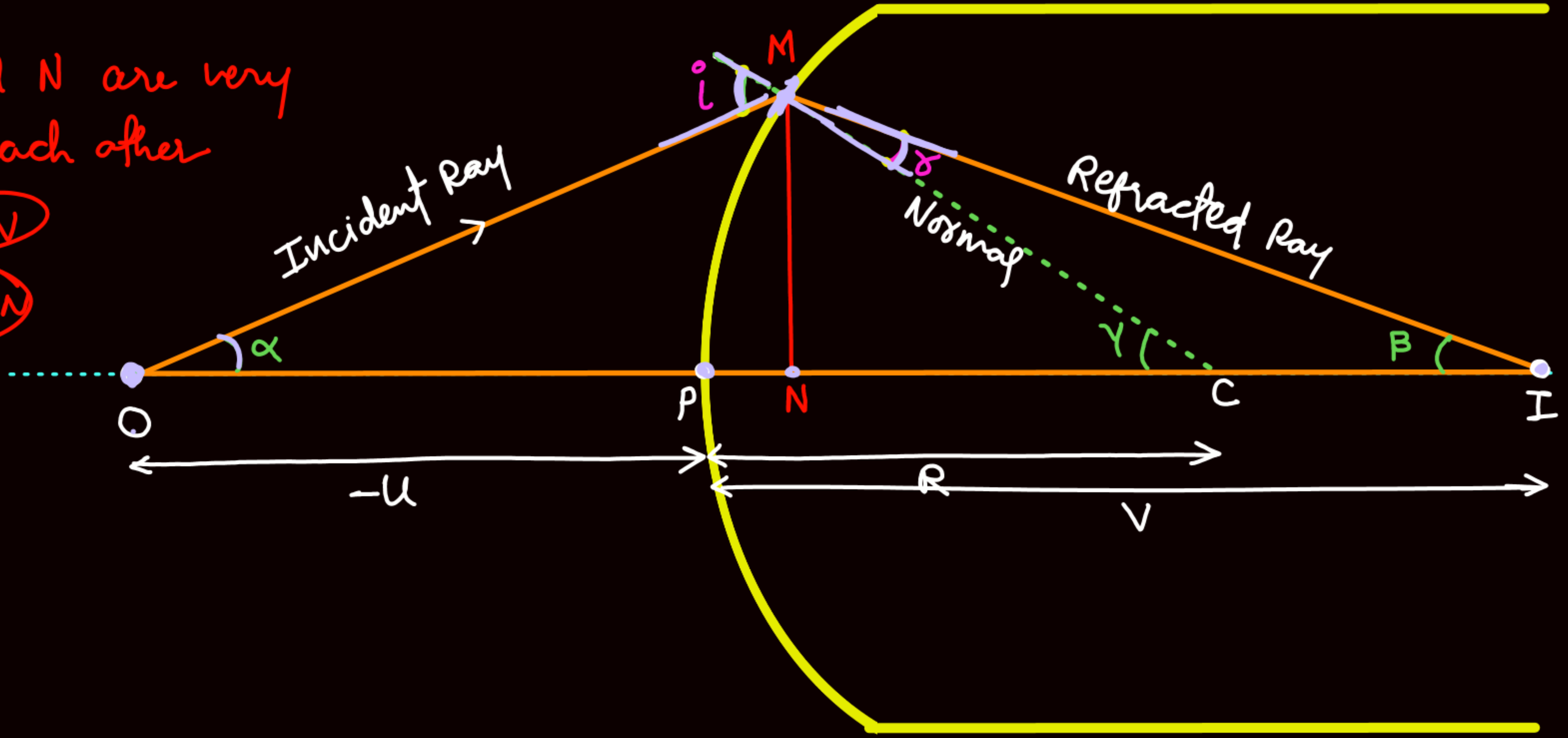
Refraction at spherical spherical surface (convex)

Assumption

here P and N are very close to each other

OP = ON

PC = PN



Refraction at convex spherical Surface...." object in Rarer and Image in Denser

In ΔCMO

$$\boxed{i = \alpha + \gamma}$$

In ΔCMI

$$\gamma = r + \beta$$

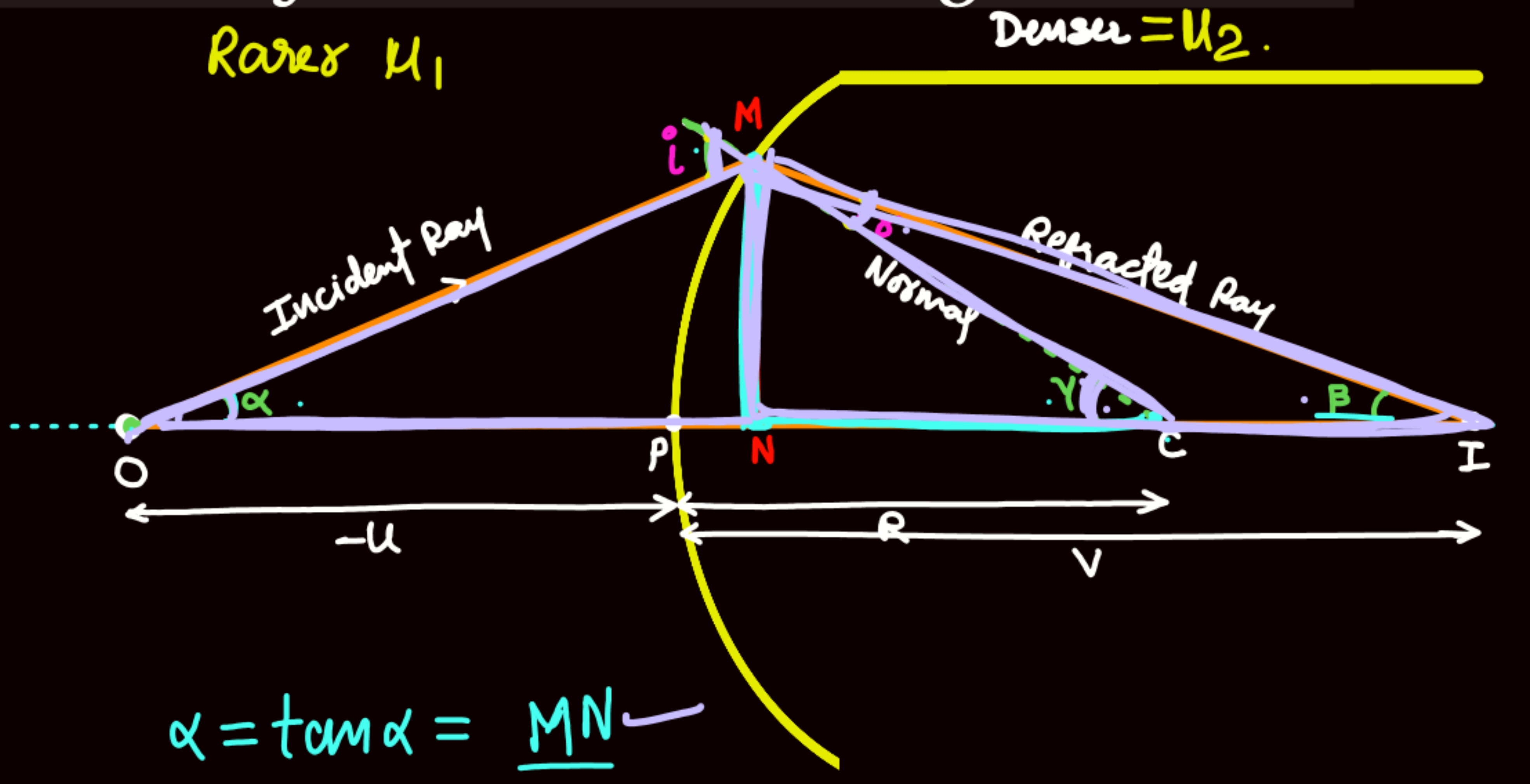
$$\boxed{r = \gamma - \beta}$$

Since angles very very small so we consider

$$\tan\alpha \approx \alpha$$

$$\tan\beta \approx \beta$$

$$\tan\gamma \approx \gamma$$



$$\alpha = \tan\alpha = \frac{MN}{-u}$$

$$\beta = \tan\beta = \frac{MN}{V}$$

$$\gamma = \tan\gamma = \frac{MN}{R}$$

Now by snell's law

$$ {}_1\mu_2 = \frac{\sin i}{\sin r} $$

For very small angle

$\sin i \approx i$, $\sin r \approx r$.

$$ \frac{\mu_2}{\mu_1} = \frac{i}{r} $$

$$ \mu_2 r = \mu_1 i $$

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

$$ \mu_2\left(\frac{MN}{R} - \frac{MN}{V}\right) = \mu_1\left(\frac{MN}{-u} + \frac{MN}{R}\right) $$

$$ \mu_2 \cdot \cancel{MN}\left(\frac{1}{R} - \frac{1}{V}\right) = \mu_1 \cancel{MN} \cdot \left(-\frac{1}{u} + \frac{1}{R}\right) $$

$$ \frac{\mu_2}{R} - \frac{\mu_2}{V} = -\frac{\mu_1}{u} + \frac{\mu_1}{R} $$

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

$$ \boxed{\frac{\mu_2}{V} - \frac{\mu_1}{u} = \left(\frac{\mu_2 - \mu_1}{R}\right)} $$

If Rarer medium is air, $\mu_1 = 1$ and if $\mu_2 = \mu$

$$ \boxed{\frac{\mu}{V} - \frac{1}{u} = \frac{\mu - 1}{R}} $$

formula

* $\dfrac{\mu_2}{v} - \dfrac{\mu_1}{u} = \dfrac{(\mu_2 - \mu_1)}{R}$ [Rarer to Denser]

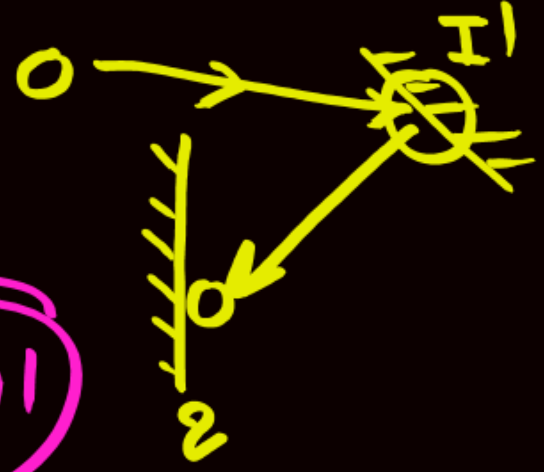
$\dfrac{\mu}{v} - \dfrac{1}{u} = \dfrac{\mu - 1}{R}$

$\dfrac{\mu_2}{\text{Image distance}} - \dfrac{\mu_1}{\text{object distance}} = \dfrac{\mu_2 - \mu_1}{\text{Radius}}$

* $\dfrac{\mu_1}{v} - \dfrac{\mu_2}{u} = \dfrac{\mu_1 - \mu_2}{R}$ [Denser to Rarer]

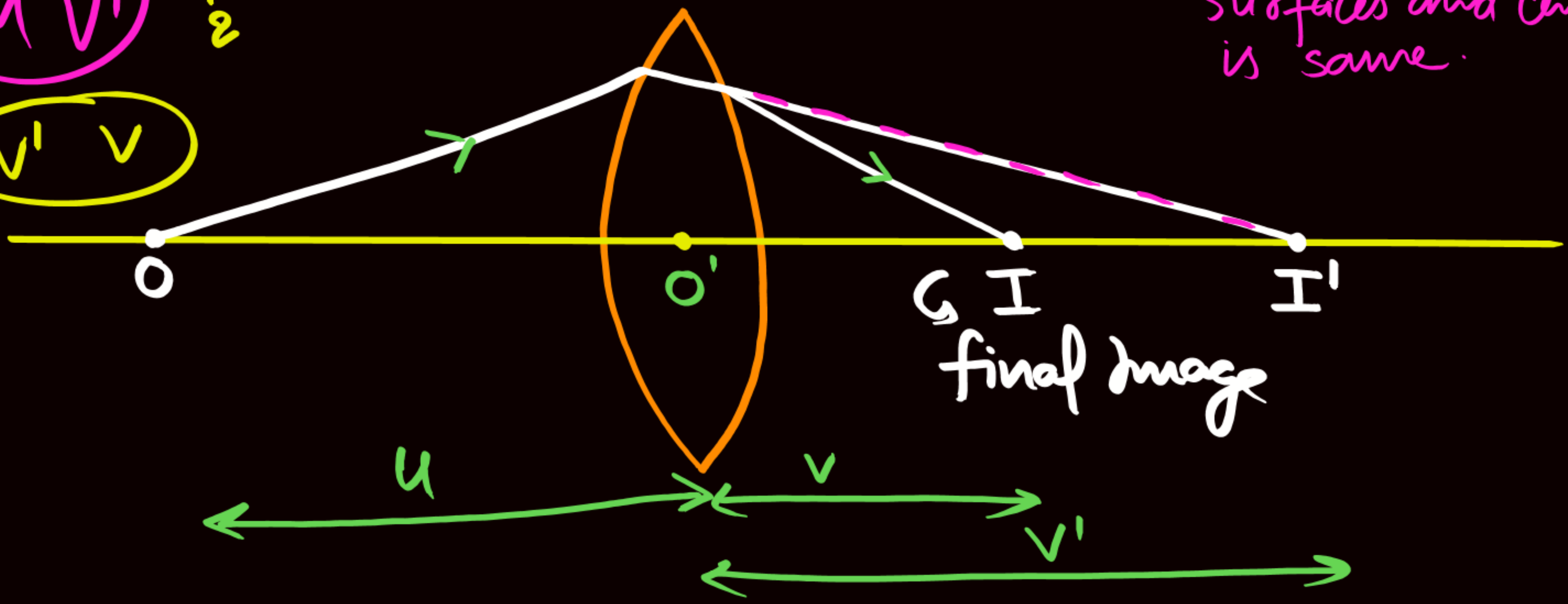
Lens maker formula

Assumption → Lens is very thin so distance from both surfaces and center of lens is same.



u v'

v' v



Lens maker formula

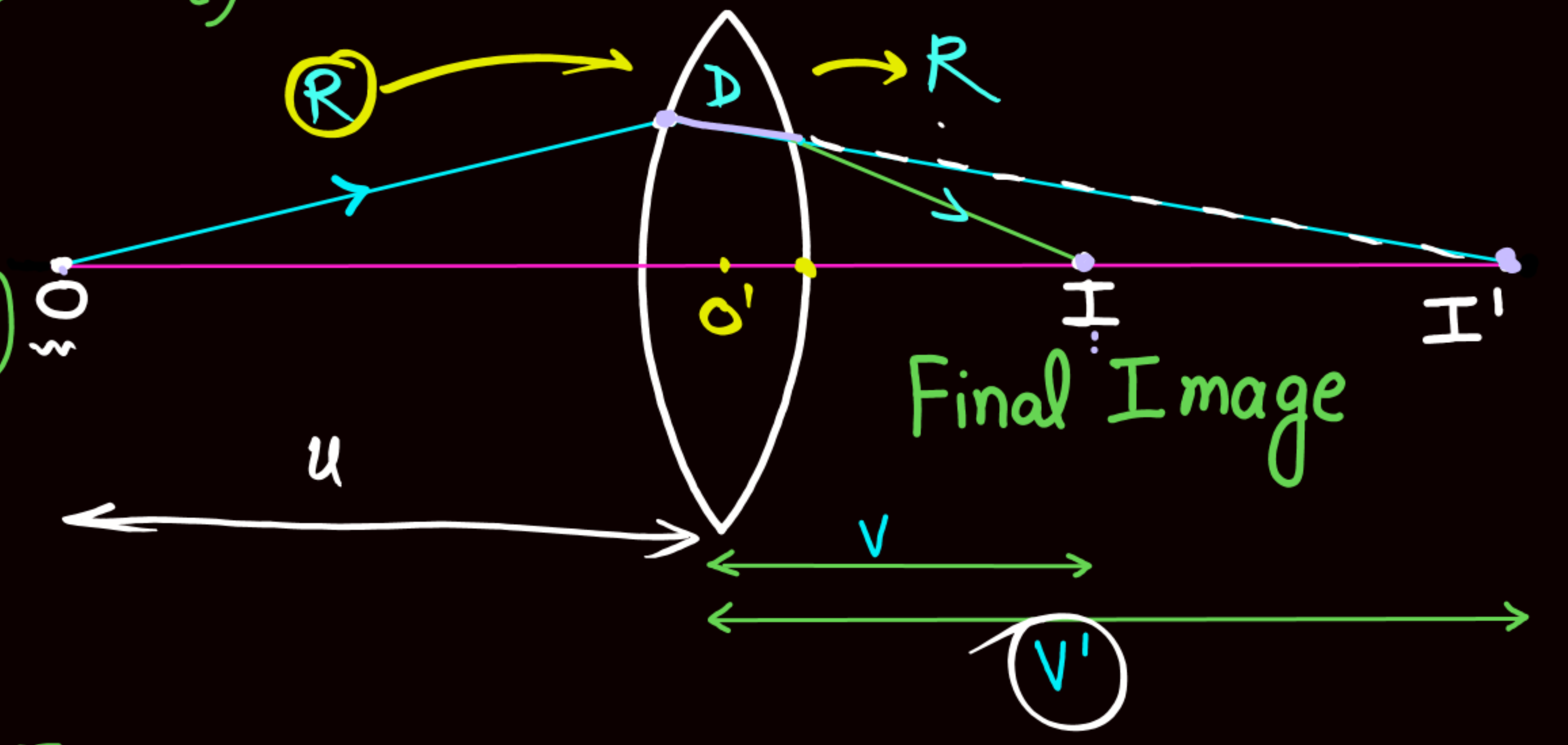
For Surface 1 (Rarer to Denser)

$$\frac{\mu_2}{v'} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R_1} \quad \text{--- } (1)$$

For Surface 2 (Denser to Rarer)

$$\frac{\mu_1}{v} - \frac{\mu_2}{v'} = \frac{\mu_1 - \mu_2}{R_2}$$

$$\frac{\mu_1}{v} - \frac{\mu_2}{v'} = -\frac{(\mu_2 - \mu_1)}{R_2} \quad \text{--- } (2)$$



Adding equation ① and ②

$$\cancel{\frac{\mu_2}{v'}} - \frac{\mu_1}{u} + \frac{\mu_1}{v} - \cancel{\frac{\mu_2}{v'}} = \left(\frac{\mu_2 - \mu_1}{R_1}\right) - \left(\frac{\mu_2 - \mu_1}{R_2}\right)$$

$$\frac{\mu_1}{v} - \frac{\mu_1}{u} = (\mu_2 - \mu_1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\mu_1\left[\frac{1}{v} - \frac{1}{u}\right] = (\mu_2 - \mu_1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\boxed{\frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]}$$

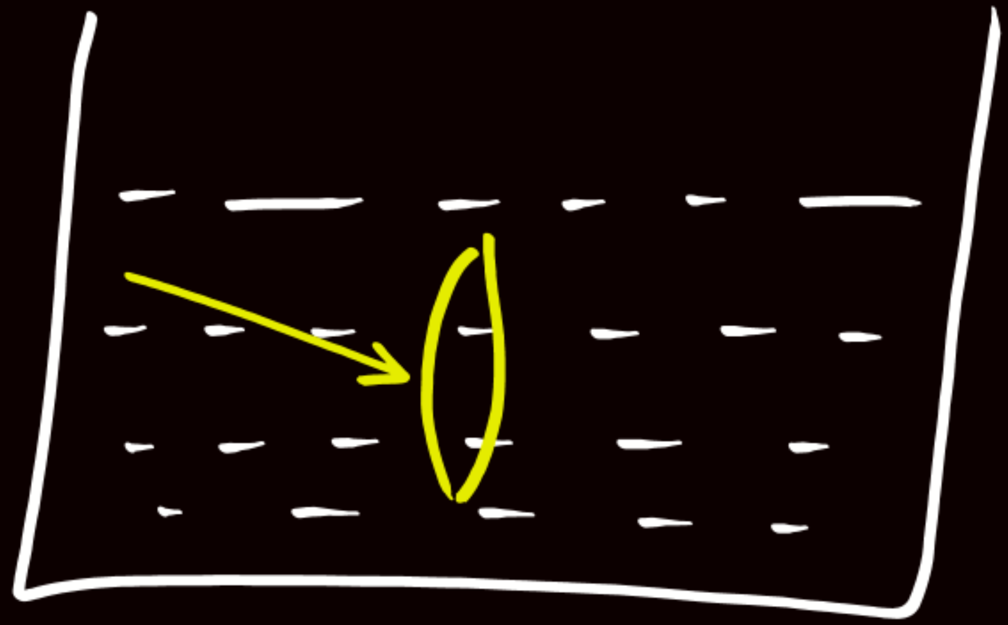
If $\boxed{\mu_2 = \mu}$, $\boxed{\mu_1 = 1}$ then

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

This is Lens Maker's formula.

water to glass

$$\frac{1}{f} = \left(\frac{\mu_g}{\mu_w} - 1\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$



water to glass

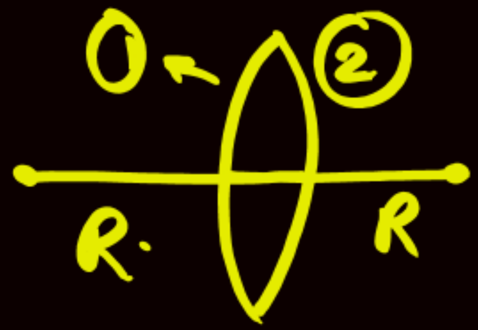
$$_{w}\mu_{g} = \left(\frac{\mu_g}{\mu_w}\right)$$

से

$$\frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\frac{1}{f} = \left(\frac{\mu_g}{\mu_w} - 1\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

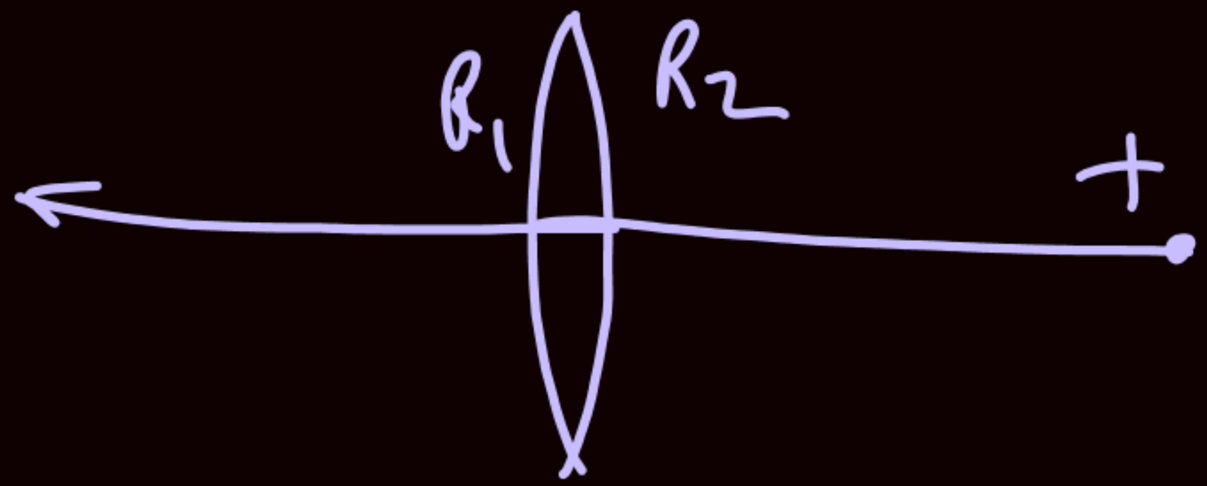
Same Radius of Curvature / Biconvex lens



$R_1 = +R$

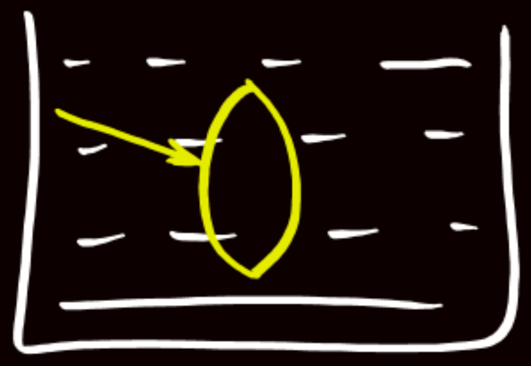
$R_2 = -R$

(Numerical)



$$\boxed{\frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]}$$

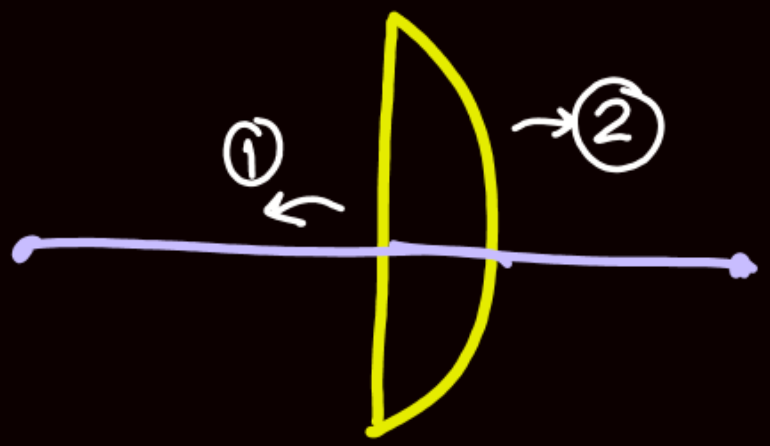
$$\frac{1}{f} = \left(\frac{\mu_g}{\mu_w} - 1\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$



$\mu_1 = \mu_w$

$\mu_2 = \mu_g$

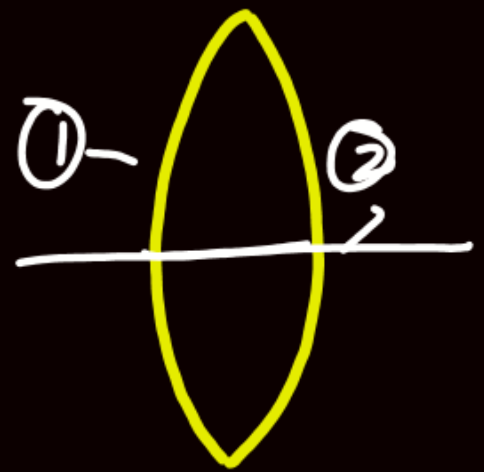
Lens maker formula



Plano convex

$R_1 = \infty$

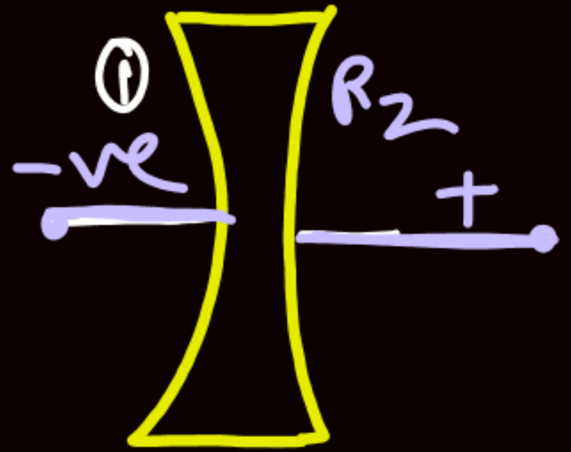
$R_2 = -R$



Biconvex

$R_1 = +R$

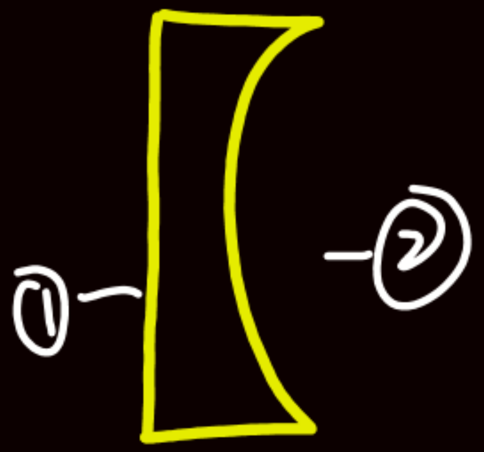
$R_2 = -R$



Biconcave

$R_1 = -ve$

$R_2 = +ve$



plano concave

$R_1 = \infty$

$R_2 = +ve$

$P = -ve$ Concave lens ✓

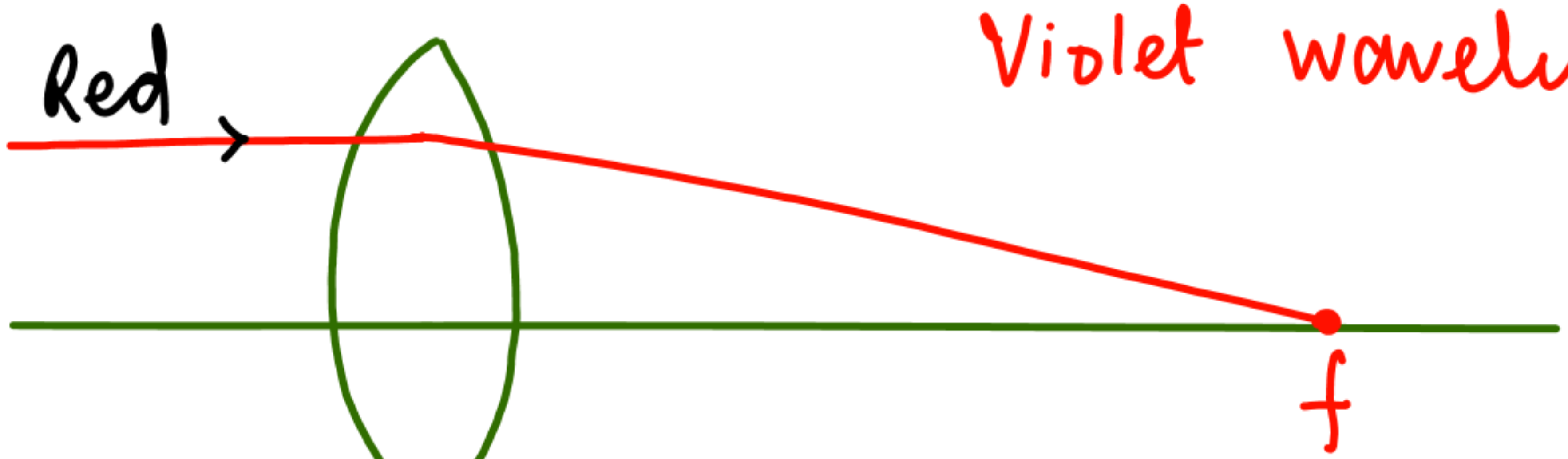
$P = +ve$ Convex lens ✓

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

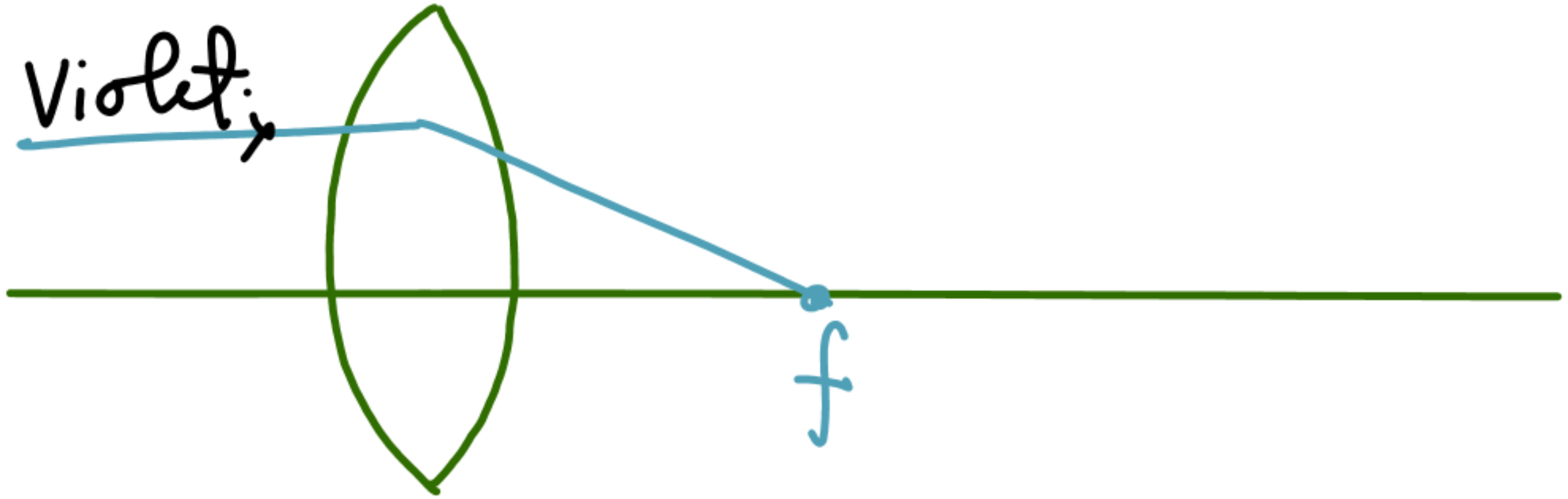
How does the focal length of a lens changes when a red light incident on it and replaced by violet light. Give reason

Red , wavelength highest / velocity highest

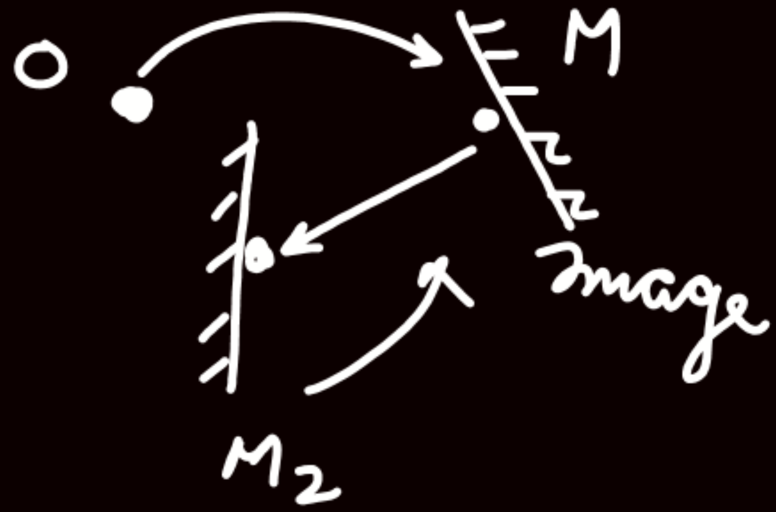
Violet wavelength least / least velocity

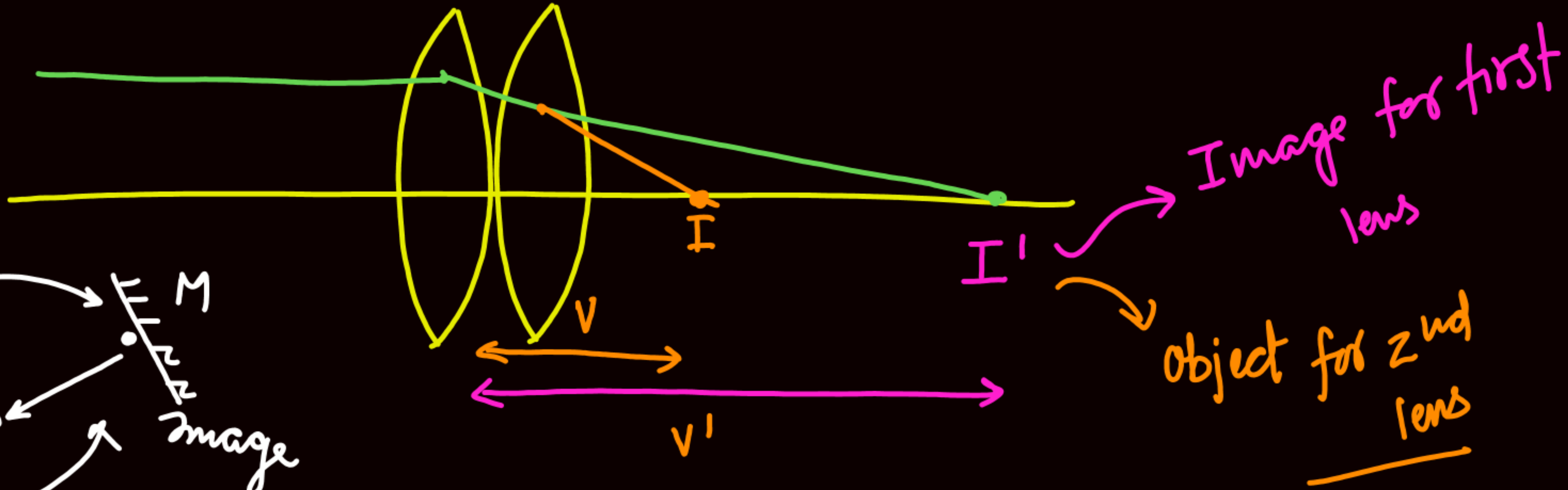


focal. length ↑ , power ↓



focal length ↓ , power ↑


O
M
Image
M_2

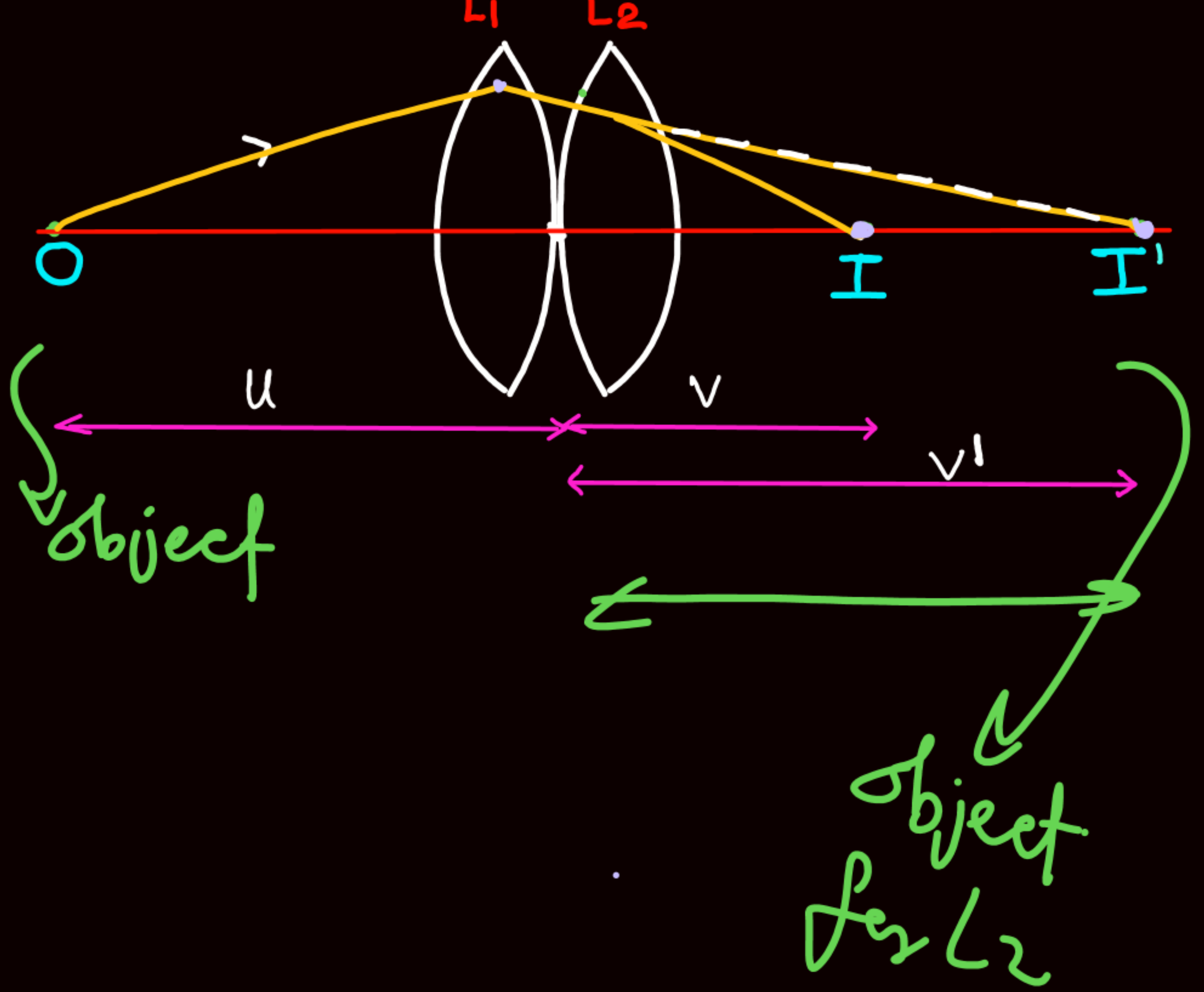

I
I'
V
V'
Image for first lens
Object for 2nd lens

Combination of lens

→ Assumptions lens are very thin ✓ so distance from center and both lenses will be same.

formula used

$$\frac{1}{f} = \frac{1}{\text{image dist}} - \frac{1}{\text{object distance}}$$



For lens 1

$$\frac{1}{f_1} = \cancel{\frac{1}{v'}} - \frac{1}{u} \quad -①$$

For lens 2

$$\frac{1}{f_2} = \frac{1}{v} - \cancel{\frac{1}{v'}} \quad -②$$

$$\frac{1}{f_1}+\frac{1}{f_2} = \cancel{\frac{1}{v_1}} - \frac{1}{u} + \frac{1}{v} - \cancel{\frac{1}{v_1}}$$

Also

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

$$\frac{1}{f_1}+\frac{1}{f_2} = \frac{1}{v}-\frac{1}{u}$$

$$\boxed{\frac{1}{f_1}+\frac{1}{f_2} = \frac{1}{f}}$$

F is combined focal length

$f_1 = +ve$, $f_2 = +ve$

$f_1 = -ve$, $f_2 = -ve$

$f_1 = +ve$ $f_2 = -ve$

L1 = Convex Concave = L2

$$\frac{1}{f_1}-\frac{1}{f_2} = \frac{1}{f}$$

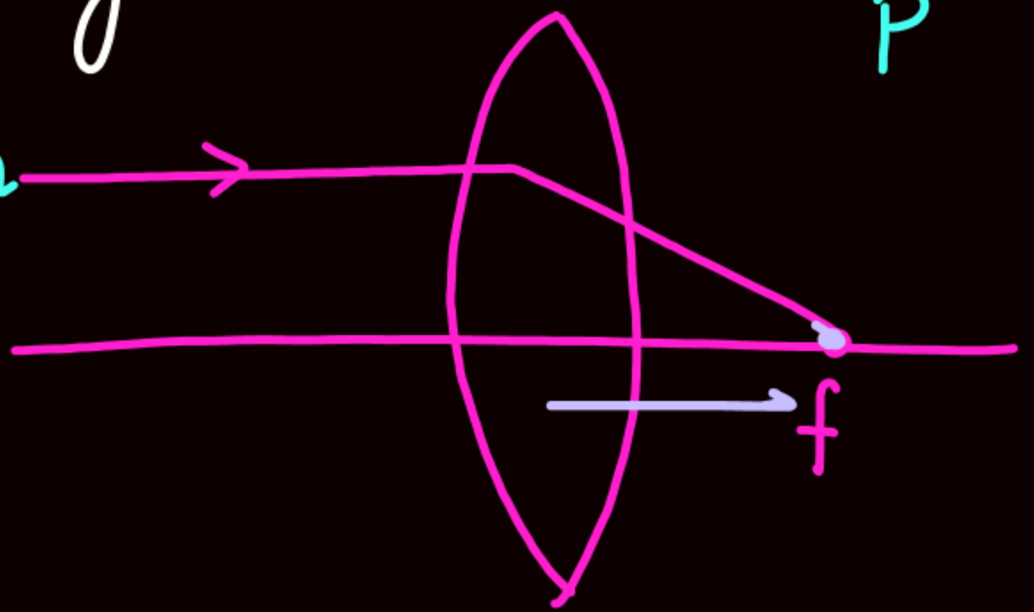
Power of lens

→ The ability of a lens to converge or diverge light ray is called power of lens. It is reciprocal of focal length.

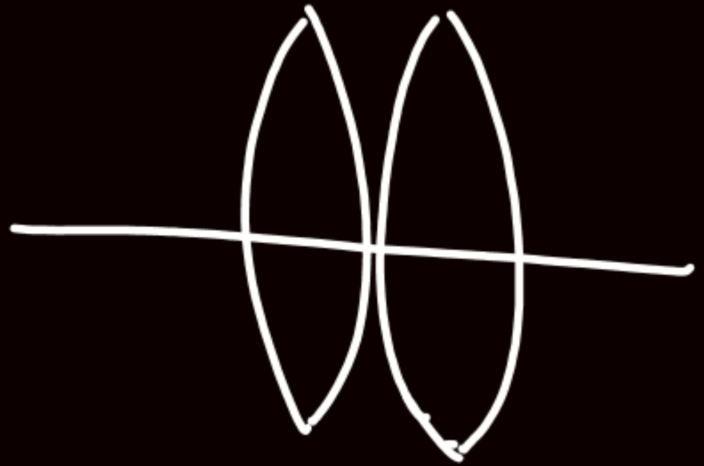
$$P = \frac{1}{f\,(m)}$$

→ SI unit Diopter

P

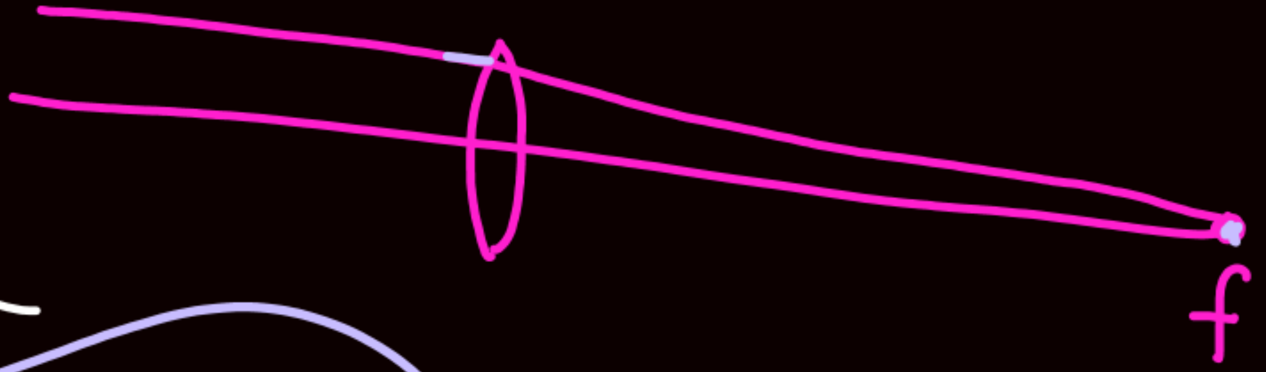


for combination of lens



$$P = \frac{1}{f_1} + \frac{1}{f_2} + \cdots$$

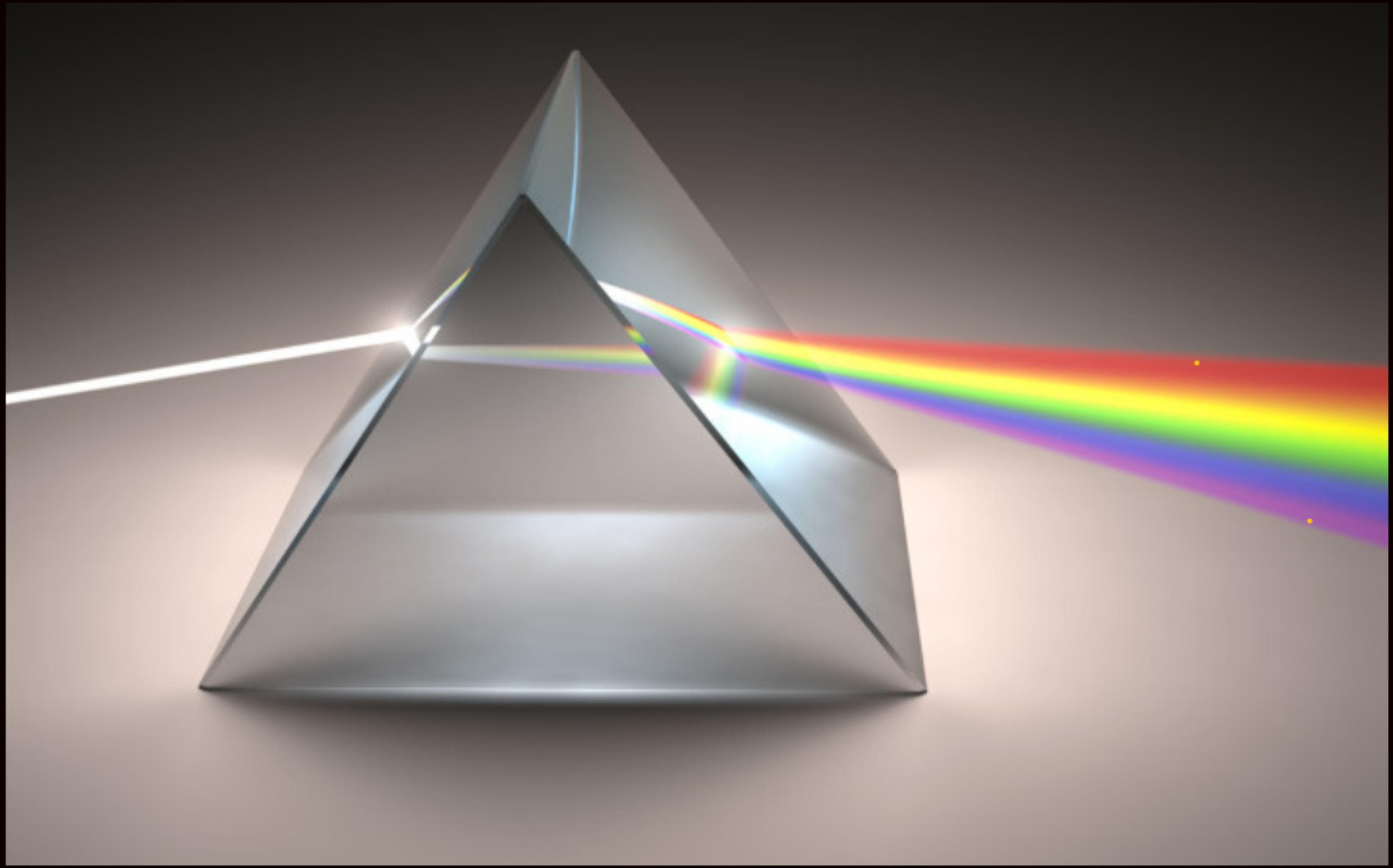
$$P = P_1 + P_2$$



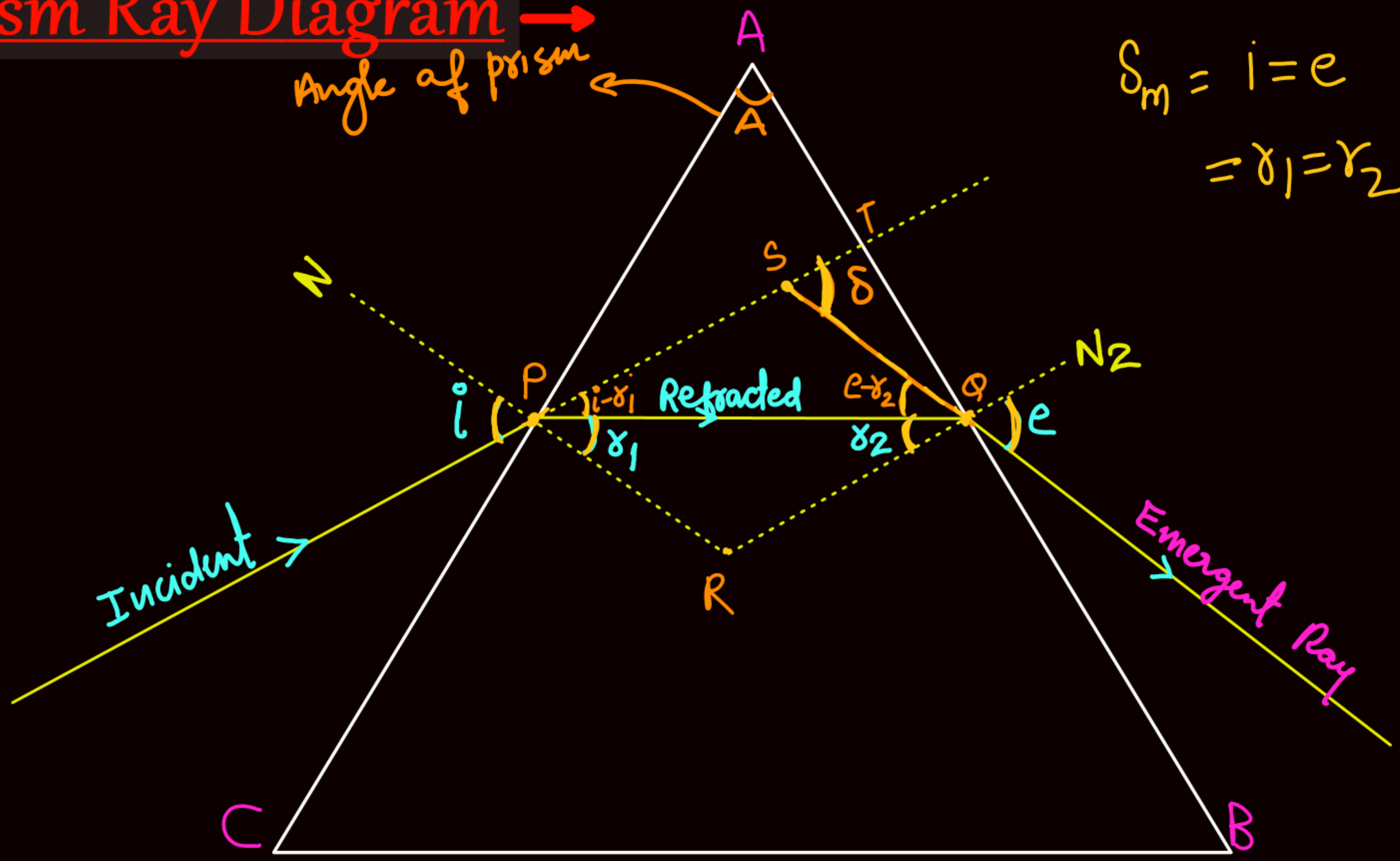
Prism → It is a transparent optical component having flat refracting surfaces at acute angle to each other.

It disperses light in its constituent colours.

Cause → Different speed of light in medium.



Prism Ray Diagram



$$\delta_m = i = e$$

$$= \gamma_1 = \gamma_2 = \gamma$$

Refractive index of prism material → Most Important

In ΔPSQ

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

$$\delta = (i+e) - (r_1+r_2) \quad \text{—— (1)}$$

In ΔPRQ

$$r_1+r_2+\angle PRQ = 180^\circ$$

$$\angle PRQ = 180-(r_1+r_2) \quad \text{—— (2)}$$

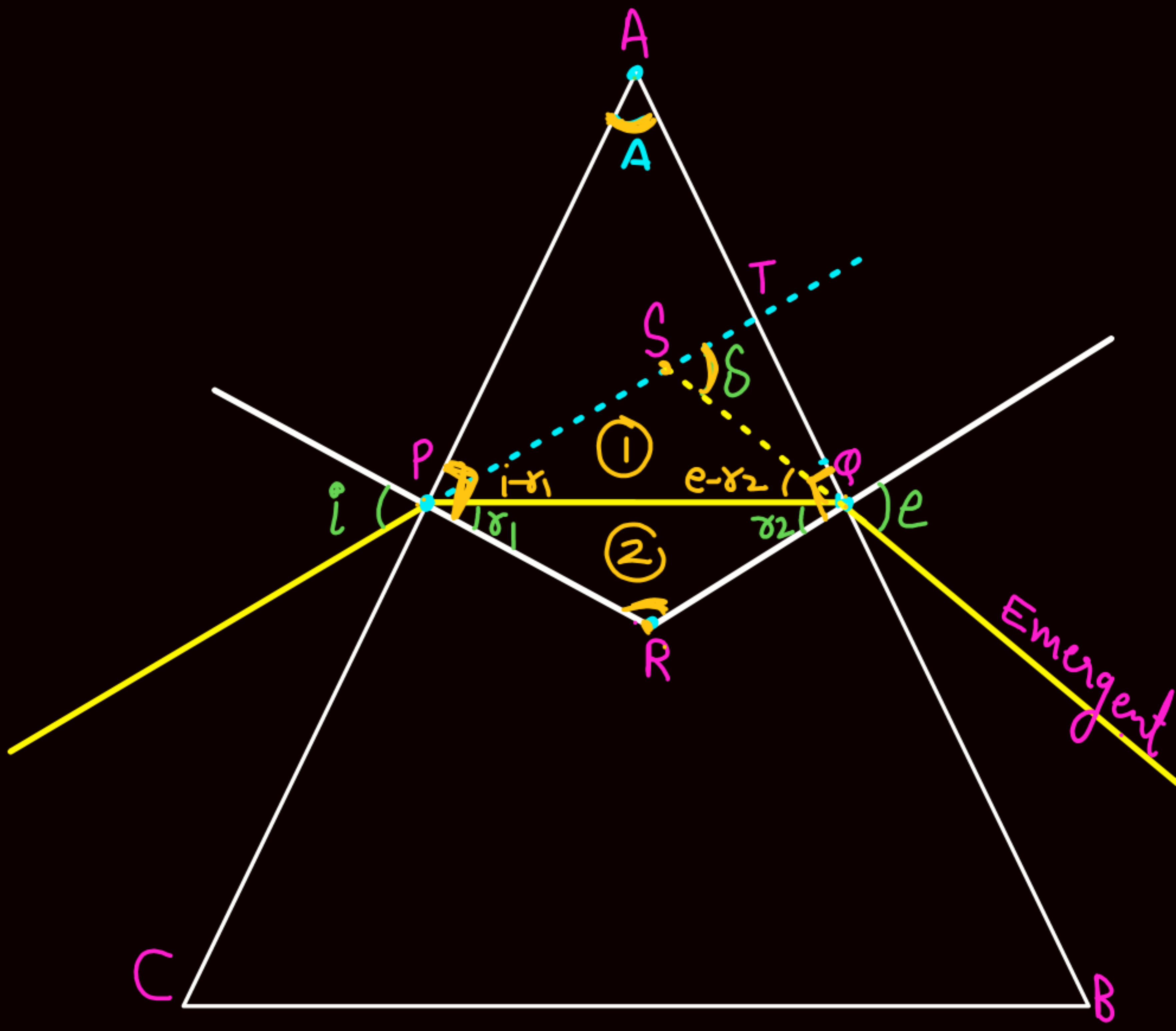
In Quad. APRQ.

$$A+90+\angle PRQ+90 = 360^\circ$$

$$A+\cancel{90}+1\cancel{8}0-(r_1+r_2)+\cancel{90} = 3\cancel{6}0^\circ$$

$$A-(r_1+r_2) = 0$$

$$\boxed{A = (r_1+r_2)} \quad \text{—— (3)}$$



For minimum deviation

$$r_1 = r_2 = r$$

and $i_1 = e$

So

$$\boxed{A = r + r}$$

$$\boxed{A = 2r}$$

or

$$\boxed{r = \frac{A}{2}}$$

Now from eq ①

$$\delta_{min} = (i + i) - (r + r)$$

$$\delta_{min} = 2i - 2r$$

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

$$\delta_{min} + A = 2i$$

$$\boxed{i = \frac{\delta_{min} + A}{2}}$$

Now refractive index of prism

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

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

Angular Dispersion

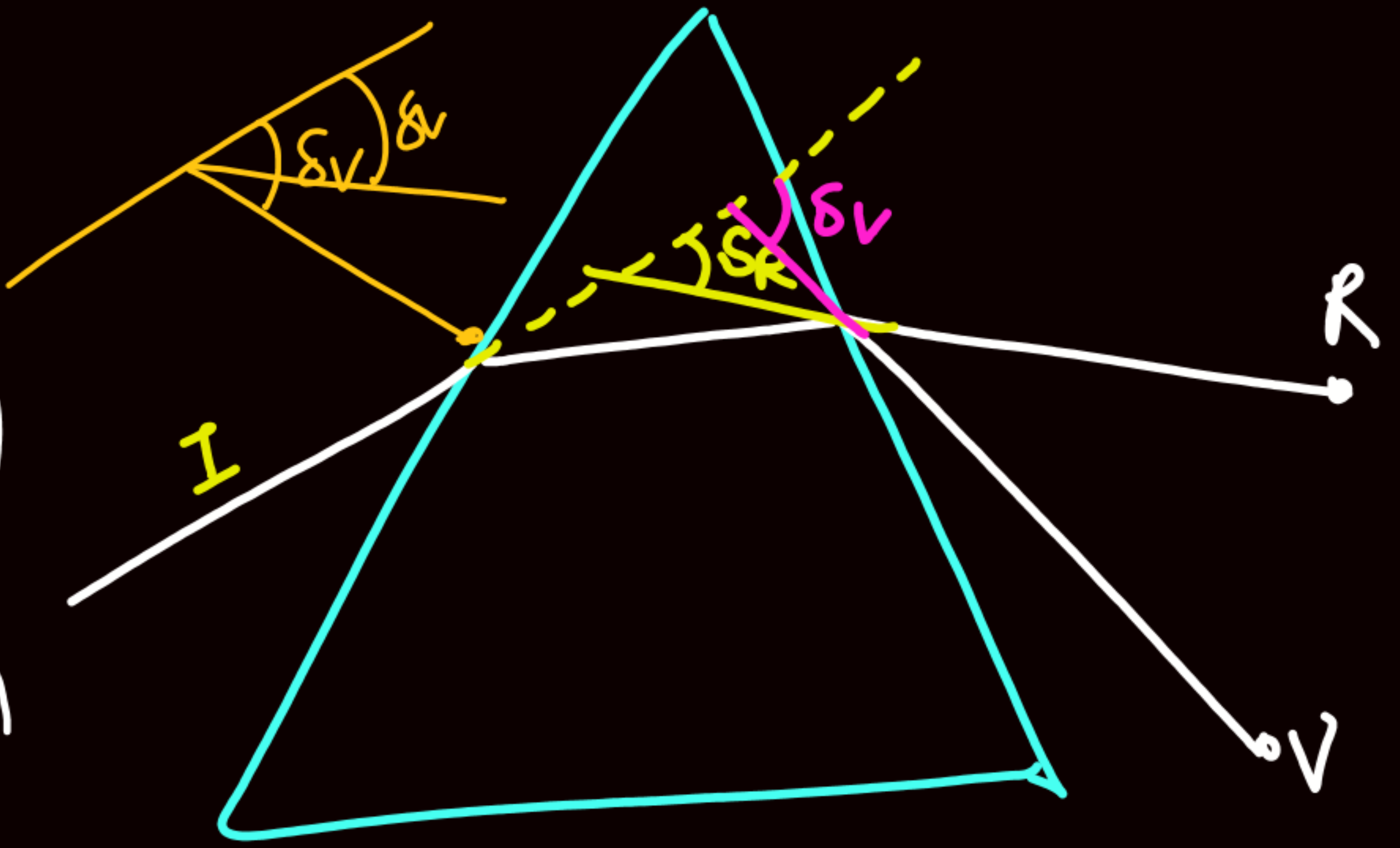
→ The angular seperation between two extreme colours (Violet and Red) in spectrum is called Angular dispersion.

$$\text{Ang. dispersion} = \delta_V - \delta_R$$

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

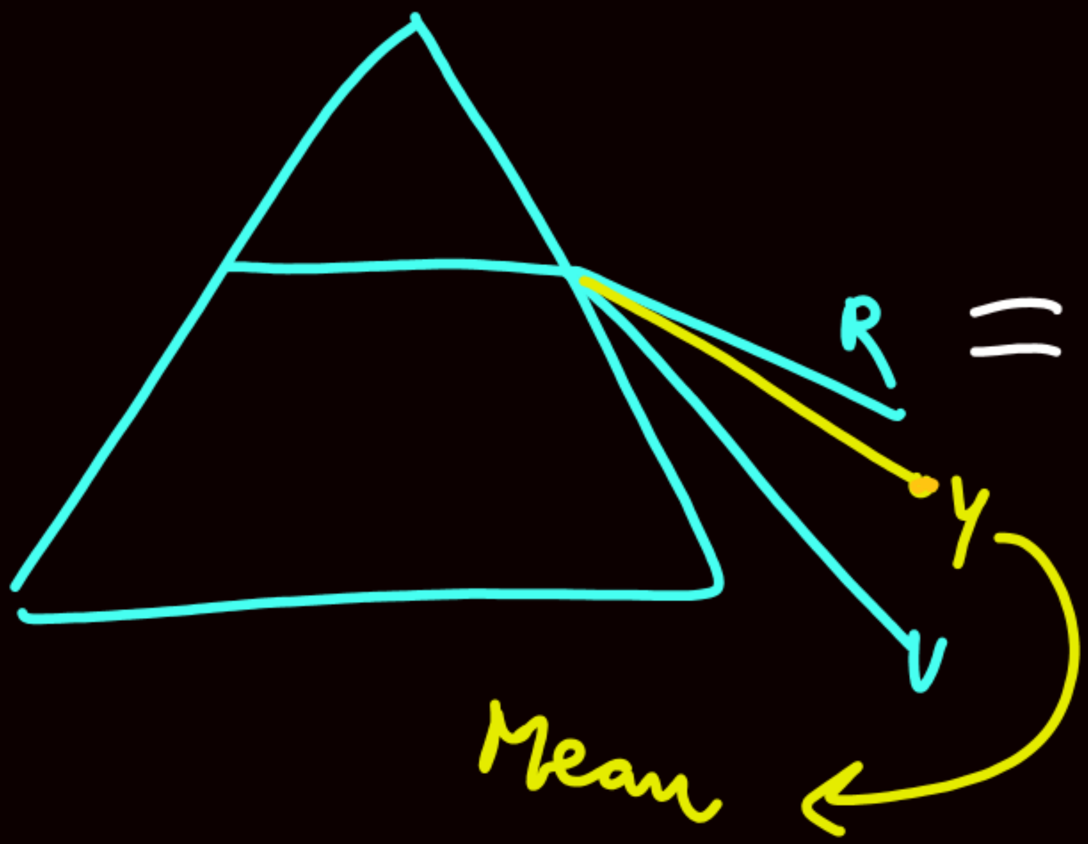
$$= \mu_V \cdot A - A - \mu_R \cdot A + A$$

$$\text{Ang. dispersion} = (\mu_V - \mu_R) \cdot A$$



Dispersive power → It is the ability of prism to cause dispersion. It is the ratio of angular dispersion to the mean deviation.

$$\textbf{Dispersive power} = \frac{\text{Angular dispersion}}{\text{mean deviation}} = \frac{(\delta_V - \delta_R)}{(\delta)}$$



$$= \frac{(\mu_V - \mu_R)A}{(\mu - 1)A} \Rightarrow \boxed{\frac{\mu_V - \mu_R}{\delta}}$$

Search optical Instrument Revision by Abhishek Sahu sir