Ray Optics – 06

Mirror's Formula

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

$f \rightarrow$ focal length
$v \rightarrow$ image distance
$u \rightarrow$ object distance

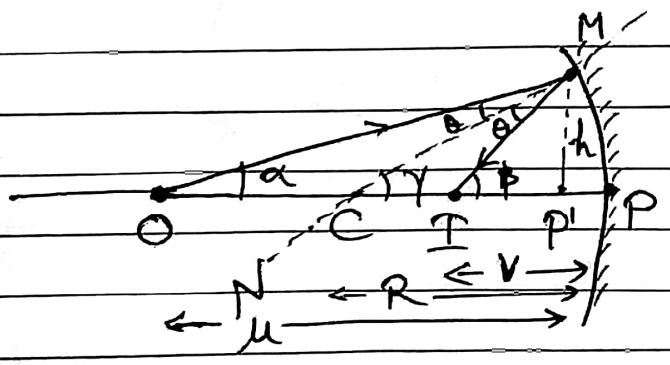
Sign Conventions:

1. All distances are measured from pole
2. Distances measured in direction of incident ray are +ve & opposite to it are -ve
3. Heights above principal axis are +ve & those below it are -ve

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

(1) Concave Mirror

for mirror of small aperture
$P' \rightarrow P$ & $f = \frac{R}{2}$



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

$$\tan\beta = \frac{h}{-v}$$

$$\tan\gamma = \frac{h}{-R}$$

$\Delta OMC \quad \gamma = \alpha + \theta$
$\Delta CMI \quad \beta = \gamma + \theta$
$\gamma - \beta = \alpha - \gamma$

$$2\gamma = \alpha + \beta$$

for small aperture mirror
α, β & γ are small
$\tan\alpha \approx \alpha \quad \tan\beta \approx \beta \quad \tan\gamma \approx \gamma$

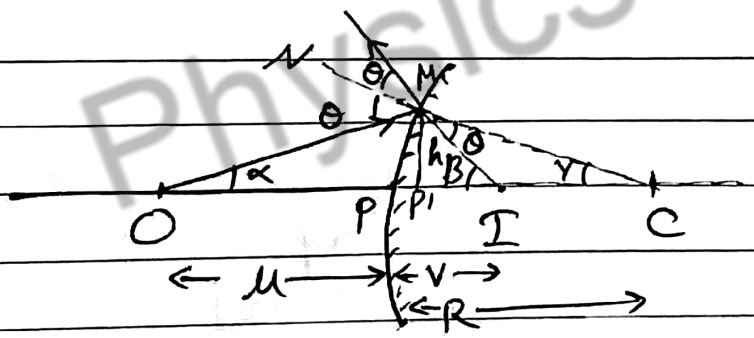
$$\frac{2h}{-R} = \frac{-h}{u} - \frac{h}{v}$$

$$\frac{1}{R/2} = \frac{1}{v} + \frac{1}{u}$$

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

② Convex Mirror

$P' \to P \quad f = \frac{R}{2}$



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

$$\tan\beta = \frac{h}{v}$$

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

$\Delta OMC \quad \theta = \alpha + \gamma \quad -(i)$

$\Delta CMI \quad \beta = \theta + \gamma \Rightarrow \theta = \beta - \gamma \quad -(ii)$

$$\Rightarrow \quad \alpha + \gamma = \beta - \gamma$$

$$2\gamma = \beta - \alpha$$

$\tan\alpha \approx \alpha \quad \tan\beta \approx \beta$
$\tan\gamma \approx \gamma$

$$\frac{2h}{R} = \frac{h}{V} - \frac{h}{-u}$$

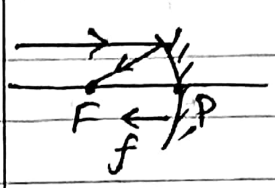
$$\frac{1}{R/2} = \frac{1}{V} + \frac{1}{u}$$

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

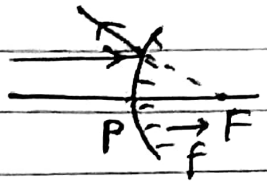
Note:

f = -ve for Concave mirror

f = +ve for Convex mirror



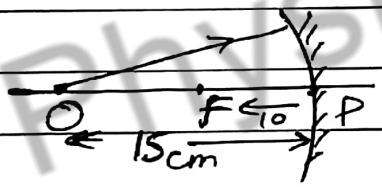
f = -ve
Concave mirror



f = +ve
Convex mirror

Q1) Find the position of image for

i) a Concave mirror of focal length 10cm when object is placed 15cm infront of it



$f = -10$
$u = -15$
$v = ?$

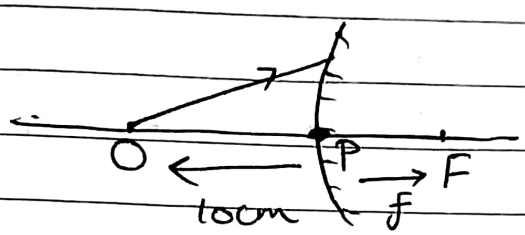
$$\frac{1}{f} = \frac{1}{V} + \frac{1}{u}$$

$$\frac{1}{-10} = \frac{1}{V} - \frac{1}{15} \Rightarrow \frac{1}{V} = \frac{1}{15} - \frac{1}{10}$$

$$\frac{1}{V} = \frac{2-3}{30} = \frac{-1}{30} \Rightarrow V = -30\,cm$$

image is formed at 30cm infront of it.

(ii) a convex mirror of focal length 20cm when object is placed at 10cm infront of it.



$f = +20cm$
$u = -10cm$

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

$$\frac{1}{20} = \frac{1}{v} - \frac{1}{10}$$

$$\frac{1}{v} = \frac{1}{10} + \frac{1}{20} = \frac{2+1}{20} = \frac{3}{20}$$

$$v = \frac{20}{3} = +6.66cm$$

(inside) behind the mirror at 6.66cm from it

You can use diredly

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

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

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