HW
17/05/21

Light : Reflection & Refraction

Short Answer Type Questions.

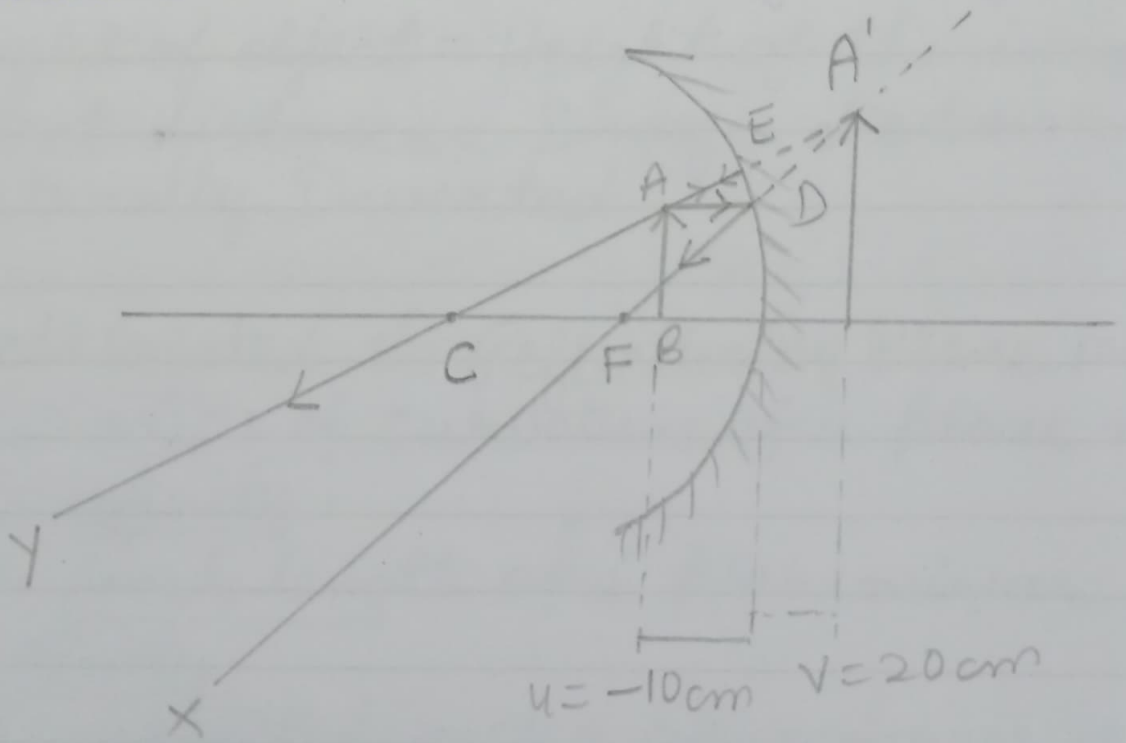
(From S. Chand Pg NO.-198 & 199)

11. Object distance (u) = -10 cm

Negative sign is taken according to sign convention as the object is in front of mirror and the object distance from mirror is in opposite direction of incident ray.

Focal length (f) = -20 cm (concave mirror)

a) As object is between pole and principal focus, the ray diagram will be as follows.



Concave mirror

b) From mirror formula,

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \Rightarrow \frac{1}{-20} = \frac{1}{v} + \frac{1}{-10}$$

$$\Rightarrow \frac{1}{v} = \frac{-1}{20} + \frac{1}{10} = \frac{1}{20} \Rightarrow v = 20 \text{ cm}.$$

c) The image formed by the concave mirror in the given case will be virtual, erect and enlarged. It will form behind the mirror.

12. $u = -36$ cm.

$f = -12$ cm (concave mirror)

using mirror formula:

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} + \frac{1}{-36} = \frac{-1}{12}.$$

$$\Rightarrow \frac{1}{v} = \frac{-1}{12} + \frac{1}{36} = \frac{-3+1}{36} = \frac{-2}{36} \frac{-1}{18}$$

$$\Rightarrow v = -18 \text{ cm}.$$

Magnification $= \frac{h_i}{h_o} = \frac{-v}{u}$

or $\frac{h_i}{10} = \frac{-(-18)}{-36} \Rightarrow h_i = -5$ cm.

Image formed is real and inverted.
So, Position of the image is 18cm infront of the mirror.
Height of the image $= -18$cm.
Nature of image formed is real and inverted.

13. $h_1 = 2$cm
$h_2 = 6$cm & $f = -10$ cm.
Erect image.
As we know, $m = \frac{h_2}{h_1} = \frac{6}{2} = 3$.
Also $m = \frac{-v}{u} = 3$
$\Rightarrow 3u = -v. \Rightarrow -3u = v$ ---- (i)
we have, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$\Rightarrow \frac{1}{(-3u)} + \frac{1}{u} = \frac{1}{(-10)} \Rightarrow \frac{1}{u} - \frac{1}{3u} = \frac{-1}{10}$

$\Rightarrow \frac{2}{3u} - \frac{1}{3u} = \frac{-1}{10} \Rightarrow u = \frac{-20}{3} = -6.66$ cm.

∴ The object must be placed at a distance of 6.66 cm on left side of mirror.

14. $u = -15$ cm (concave mirror)
$v = -10$ cm, $f = ?$
As we know, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$.

$\Rightarrow \frac{1}{(-10)} + \frac{1}{(-15)} = \frac{1}{f} \Rightarrow \frac{1}{f} = \frac{-1}{10} - \frac{1}{15}$

$= \frac{-3-2}{30} = \frac{-5}{30} = \frac{-1}{6}$.

$\Rightarrow f = -6$ cm.
∴ The focal length of the concave mirror is 6cm.

15. $u = -8$ cm, $h_o = 3$ cm, $h_i = 4.5$ cm.
$m = \frac{h_i}{h_o} = \frac{-v}{u} = \frac{4.5}{3} = \frac{-v}{u}$.

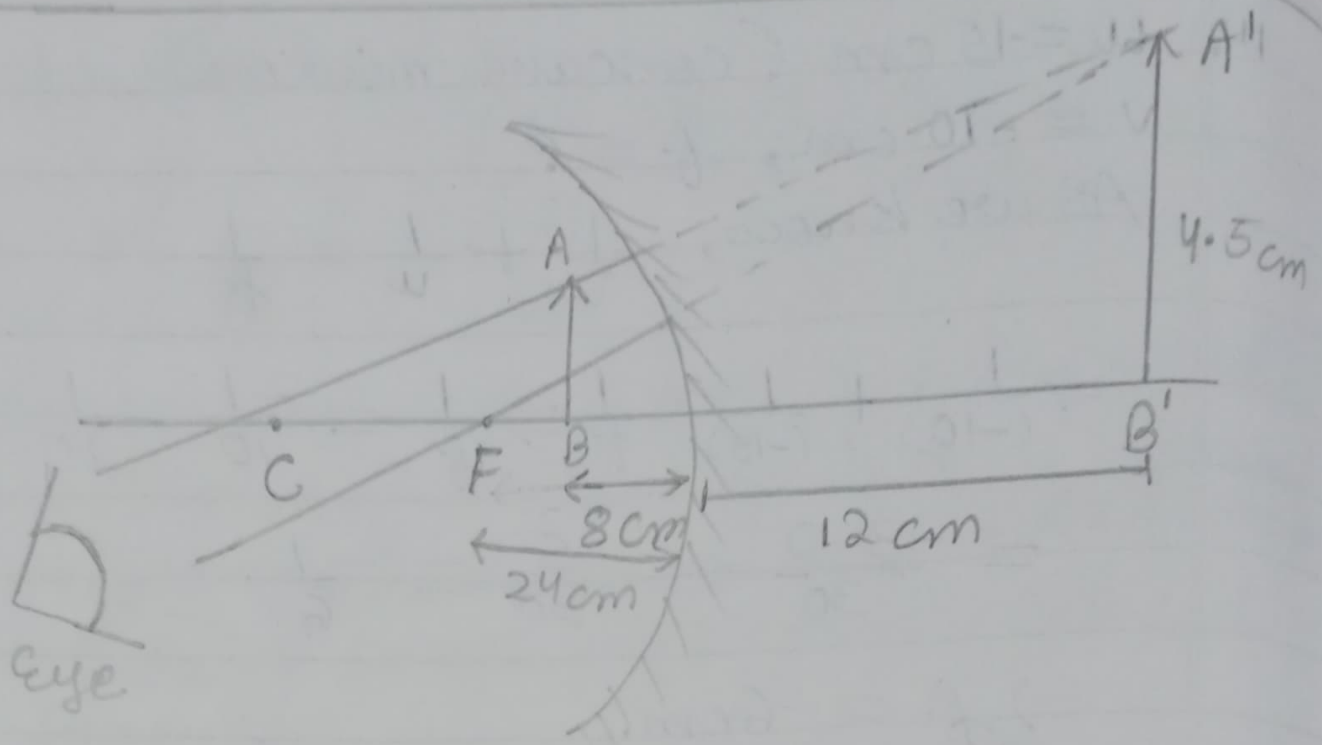
b) $v = 4.5 \times \frac{8}{3} = 12$ cm.

a) $f = \frac{1}{f} = \frac{1}{v} + \frac{1}{u} \Rightarrow \frac{1}{f} = \frac{1}{12} + \frac{1}{-8}$

$\Rightarrow \frac{1}{f} = \frac{2-3}{24} = \frac{-1}{24} \Rightarrow f = -24$ cm

So, the focal length of the mirror is -24 cm.
And the position of the image is 12cm behind the mirror (on its right side)

c)



Concave mirror

16. (i) Magnification $(m) = \frac{-v}{u}$

$\Rightarrow -4 = \frac{-v}{-20} \Rightarrow v = -80\ cm$

(ii) From mirror formula,

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

$\Rightarrow \frac{1}{-80} + \frac{1}{-20} = \frac{1}{f} \Rightarrow \frac{1}{f} = \frac{1+4}{-80}$

$\Rightarrow \frac{1}{f} = \frac{-5}{80} = \frac{-1}{16} \Rightarrow f = -16\ cm.$

So, the image distance is 80 cm infront of the mirror.

The focal length of the mirror is 16 cm.

17. Given: $h_1 = 7cm$, $u = -27cm$, $f = -18cm$.

By applying the mirror formula,

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

$$\Rightarrow \frac{1}{(-18)} - \frac{1}{(-27)} = \frac{1}{v} \Rightarrow \frac{1}{v} = \frac{-1}{18} + \frac{1}{27}$$

$$= \frac{-3+2}{54} = \frac{-1}{54}$$

$$\Rightarrow \frac{1}{v} = \frac{-1}{54} \Rightarrow v = -54cm.$$

So, The screen should be placed infront of the concave mirror of 54cm.

$$m = \frac{-v}{u} = \frac{h_2}{h_1} \Rightarrow \frac{-(-54)}{-27} = \frac{h_2}{7}$$

$$\Rightarrow h_2 = -14cm.$$

So, the image size is 14cm and the nature of the image is real and inverted.

18. Given: $h_1 = 3cm$, $u = -10cm$, $f = -20cm$.
By applying mirror formula,

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

$$\Rightarrow \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{(-20)} - \frac{1}{-10}$$

$$= \frac{-1+2}{20} = \frac{1}{20} \Rightarrow \frac{1}{v} = \frac{1}{20}.$$

$$\Rightarrow v = 20cm$$

The image is formed at a distance of 20cm behind the converging mirror.

And $m = \frac{-v}{u} = \frac{h_2}{h_1}$

$$\Rightarrow \frac{-(20)}{-10} = \frac{h_2}{3} \Rightarrow \frac{h_2}{3} = 2.$$

$$\Rightarrow h_2 = 6\ cm.$$

So, the size of the image that formed is 6cm and nature of the image is virtual & erect.

19. Given: $h_2 = 2cm$, $u = -9cm$, $f = -4cm$
By applying mirror formula,

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{(-4)} - \frac{1}{(-9)}$$

$$\Rightarrow \frac{1}{v} = \frac{-1}{4} + \frac{1}{9} = \frac{-9+4}{36}$$

$$\Rightarrow \frac{1}{v} = \frac{-5}{36} \Rightarrow v = -7.2\,cm.$$

so, the image is formed at a distance 7.2 cm infront of concave mirror.

Then, $m = \frac{-v}{u} = \frac{-(-7.2)}{-9} = -0.8$

$$m = \frac{h_2}{h_1} \Rightarrow -0.8 = \frac{h_2}{2} \Rightarrow h_2 = 1.6\,cm$$

so, the size of the image is 1.6 cm and the nature of the image is real & inverted.

20. Given: $u = -20\,cm$, $m = -3$ (real image)

(a) $m = \frac{-v}{u} \Rightarrow m = -3 = \frac{-v}{-20}$

$$\Rightarrow -3 \times 20 = v \Rightarrow v = -60\,cm$$

By applying mirror formula,

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{(-60)} + \frac{1}{(-20)} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{f} = \frac{-1}{60} - \frac{1}{20} = \frac{-1-3}{60} = \frac{-4}{60} = \frac{-1}{15}$$

$$\Rightarrow \frac{1}{f} = \frac{-1}{15} \Rightarrow f = -15\,cm.$$

(b) virtual image $m = 3$ & $f = -15cm$.

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

$$\Rightarrow 3 = \frac{-v}{u} \Rightarrow v = -3u.$$

Again by using the mirror formula,

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

$$\Rightarrow \frac{1}{-3u} + \frac{1}{u} = \frac{1}{-15} \Rightarrow \frac{-1+3}{3u} = \frac{-1}{15}$$

$$\Rightarrow u = \frac{-2 \times 15}{3} \Rightarrow u = -10cm.$$

So, the object must be placed 10cm from the concave mirror.

21. Given: $R = -3\,cm$ (concave mirror)
$m = 5$ (virtual)

$$\therefore f = \frac{R}{2} = \frac{-3}{2} = -1.5\,cm.$$

So, $m = \frac{-v}{u} \Rightarrow 5 = \frac{-v}{u} \Rightarrow v = -5u.$

By applying Mirror formula,

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

$$\Rightarrow \frac{1}{(-5u)} + \frac{1}{u} = \frac{1}{-1.5}$$

$$\Rightarrow \frac{4}{5u} = \frac{-1}{1.5} \Rightarrow u = \frac{-4 \times 1.5}{5} = -1.2\text{cm}$$

So, mirror should be placed 1.2cm away from the dental cavity.

22. Given: $R = -1.5\ m$ (concave mirror)

$u = -10\ m.$

$$f = \frac{R}{2} = \frac{-1.5}{2} = -0.75\ m.$$

By applying mirror formula,

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} + \frac{1}{(-10)} = \frac{1}{(-0.75)}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{10} - \frac{100}{75} = \frac{1}{10} - \frac{4}{3}$$

$$\Rightarrow \frac{1}{v} = \frac{3 - 40}{30} = \frac{-37}{30}$$

$$\Rightarrow v = \frac{-30}{37} = -0.81\ m.$$

∴ The person's image will be 0.81m infront of concave mirror.

23. Given: $h_1 = 5.0\ cm$, $u = -20\ cm$ & $f = -15\ cm.$

By applying mirror formula,

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f} \Rightarrow \frac{1}{v}+\frac{1}{(-20)}=\frac{1}{(-15)}$$

$$\Rightarrow \frac{1}{v}=\frac{1}{20}-\frac{1}{15} \Rightarrow \frac{1}{v}=\frac{-5}{300}.$$

$$\Rightarrow v=-60\,cm.$$

∴ The screen should be placed 60 cm in front of the mirror.

$$m=\frac{h_2}{h_1}=\frac{-v}{u} \Rightarrow \frac{h_2}{5}=\frac{-(-60)}{-20}$$

$$\Rightarrow \frac{h_2}{5}=-3 \Rightarrow h_2=-15\,cm.$$

So, the height of the image is 15cm.

24. Given: $m=3$ (virtual)

$u=-10\,cm.$

$$\therefore m=\frac{-v}{u} \Rightarrow 3=\frac{-v}{-10} \Rightarrow v=30\,cm.$$

By applying mirror formula,

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f} \Rightarrow \frac{1}{30}+\frac{1}{-10}=\frac{1}{f}.$$

$$\Rightarrow \frac{10+(-30)}{300}=\frac{1}{f} \Rightarrow \frac{-20}{300}=\frac{1}{f}$$

$\Rightarrow f = -15\ cm.$

Radius of curvature $= R = 2f$

$= 2 \times (-15) = -30\ cm.$

$\therefore$ The radius of curvature is 30 cm.

25. Given: $h_1 = 50\ mm$, $f = -100\ mm$,

$u = -300\ mm.$

By applying mirror formula,

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} + \frac{1}{(-300)} = \frac{1}{-100}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{300} - \frac{1}{100}$$

$$\Rightarrow \frac{1}{v} = \frac{1-3}{300} = \frac{-2}{300} \Rightarrow v = -150\ mm$$

$$m = \frac{-v}{u} = \frac{h_2}{h_1} \Rightarrow \frac{-(-150)}{-300} = \frac{h_2}{50}$$

$$\Rightarrow \frac{-1}{2} = \frac{h_2}{50} \Rightarrow h_2 = -25\ mm.$$

$\therefore$ The image will be 25 mm high.

26. Given: $f = -20\ cm$, $m = \frac{-1}{4}$ (real image)

$$m = \frac{-v}{u} \Rightarrow \frac{-1}{4} = \frac{-v}{u}$$

$$\Rightarrow -u = -4v \Rightarrow u = 4v$$

By applying mirror formula,

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f} \Rightarrow \frac{1}{v}+\frac{1}{4v}=\frac{1}{(-20)}$$

$$\Rightarrow \frac{4+1}{4v}=\frac{-1}{20} \Rightarrow \frac{5}{4v}=\frac{-1}{20}$$

$$\Rightarrow -4v=100$$

$$\Rightarrow v=\frac{-100}{4}=-25\,cm.$$

$$u=4v$$

$$\Rightarrow u=4\times(-25) \Rightarrow u=-100\,cm.$$

$\therefore$ The object should be placed 100 cm to the left of the mirror.

27. Case-1

Given: $u=-50\,cm$, $m=\frac{-1}{2}$

$$m=\frac{-v}{u} \Rightarrow \frac{-1}{2}=\frac{-v}{-50}$$

$$\Rightarrow 50=-2v \Rightarrow v=\frac{-50}{2}=-25\,cm.$$

By applying mirror formula,

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f} \Rightarrow \frac{1}{-25}+\frac{1}{-50}=\frac{1}{f}$$

$$\Rightarrow \frac{-3}{50}=\frac{1}{f} \Rightarrow f=\frac{-50}{3}\,cm.$$

case-2

Given: $m = \frac{-1}{5}$, $f = \frac{-50}{3}$ cm.

$$m = \frac{-1}{5} = \frac{-V}{u}$$

$$V = \frac{u}{5}$$

By applying mirror formula,

$$\frac{5}{u} + \frac{1}{u} = \frac{-3}{50} \Rightarrow \frac{6}{u} = \frac{-3}{50}$$

$$\Rightarrow u = \frac{-300}{3} = -100 \text{ cm.}$$

$\Rightarrow u = -100$ cm.

∴ The object should be placed 100 cm to the left of the mirror.

28. (a) Given: $u = -20$ cm, $f = -12$ cm

By applying mirror formula,

$$\frac{1}{V} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{V} + \frac{1}{-20} = \frac{1}{-12}$$

$$\Rightarrow \frac{1}{V} = \frac{-1}{12} + \frac{1}{20} = \frac{-20+12}{240} = \frac{-8}{240}$$

$\Rightarrow V = -30$ cm.

so, the image is formed at a distance of 30cm infront of the mirror (on its left side). The image is real and inverted.

(b) Given- $u = -4cm$, $f = -12cm$.

By applying mirror formula,

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

$$\Rightarrow \frac{1}{v} + \frac{1}{-4} = \frac{1}{-12} \Rightarrow \frac{1}{v} = \frac{-1}{12} + \frac{1}{4}$$

~~$\frac{-20+12}{240} = \frac{-8}{240} \Rightarrow v =$~~

$$= \frac{-1+3}{12} = \frac{2}{12_6} = \frac{1}{6} \Rightarrow v = 6cm.$$

so, the image is formed at a distance of 6 cm behind the mirror (on its right side).

29. Given: $h_2 = 1cm = 10mm$ (real image), $h_1 = 2.5\ mm$, $u = -5cm = -50mm$.

$$m = \frac{-h_2}{h_1} \Rightarrow m = \frac{-10}{2.5} \Rightarrow m = -4$$

and we know that

$$m = \frac{-v}{u} \Rightarrow -4 = \frac{-v}{(-50)}$$

$\Rightarrow v = -200\ mm$

$\Rightarrow v = -20\ cm$

So, the image is formed 20cm infront of the mirror.

Then, by applying mirror formula,

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

$\Rightarrow \frac{-1}{20} + \left(\frac{-1}{5}\right) = \frac{1}{f} \Rightarrow \frac{1}{f} = \frac{-25}{100}$

$\Rightarrow f = -4cm.$

So, the focal length of the mirror is 4cm.

30. Given: $R = -60cm$ (concave mirror), $f = -30cm$, $u = -15cm$.

By applying mirror formula,

$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} = \frac{1}{15} + \frac{1}{-30}$

$\Rightarrow \frac{1}{v} = \frac{1}{30} \Rightarrow v = 30\ cm$

$m = \frac{-v}{u} \Rightarrow m = \frac{-30}{-15} \Rightarrow m = +2.$

so, the image is formed 30cm behind the mirror and the magnification is +2.

Long Answer Type Question

31. Given: $u = -24$ cm, $v = -16$ cm

For finding the focal length we use mirror formula.

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \Rightarrow \frac{1}{f} = \frac{1}{-16} + \frac{1}{-24}$$

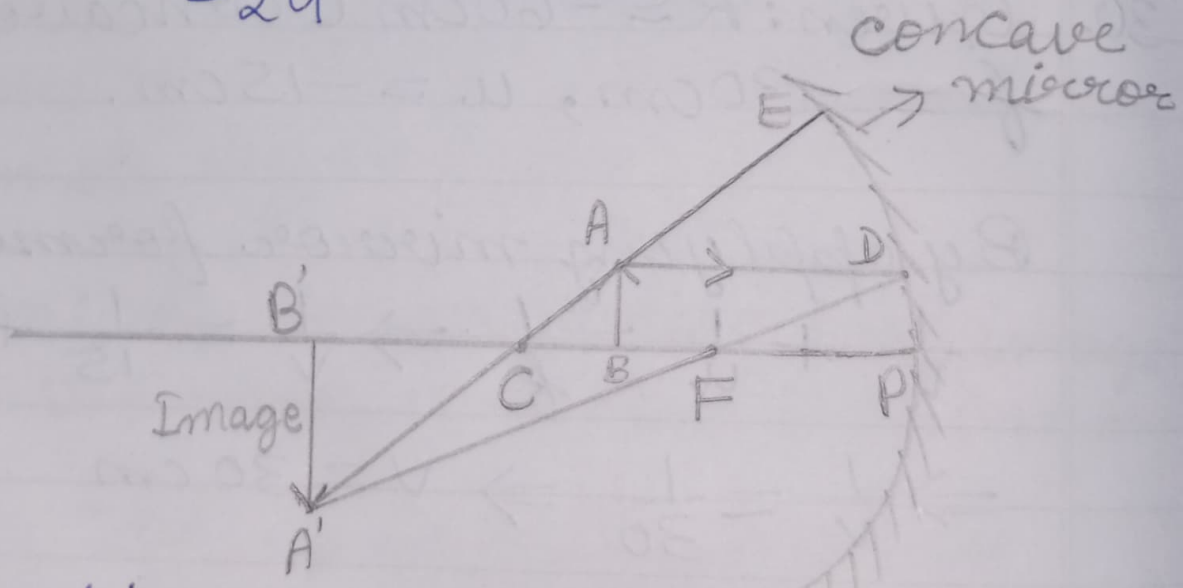
$$\Rightarrow f = -9.6 \text{ cm}.$$

$$R = 2f = 2 \times (-9.8) = -19.2 \text{ cm}.$$

Magnification is given by, $m = \frac{-v}{u}$

$$= \frac{-(-16)}{-24} = -0.66.$$

(a)



The position of image is beyond C, the size of the image is enlarged and nature of the image is real and inverted.

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