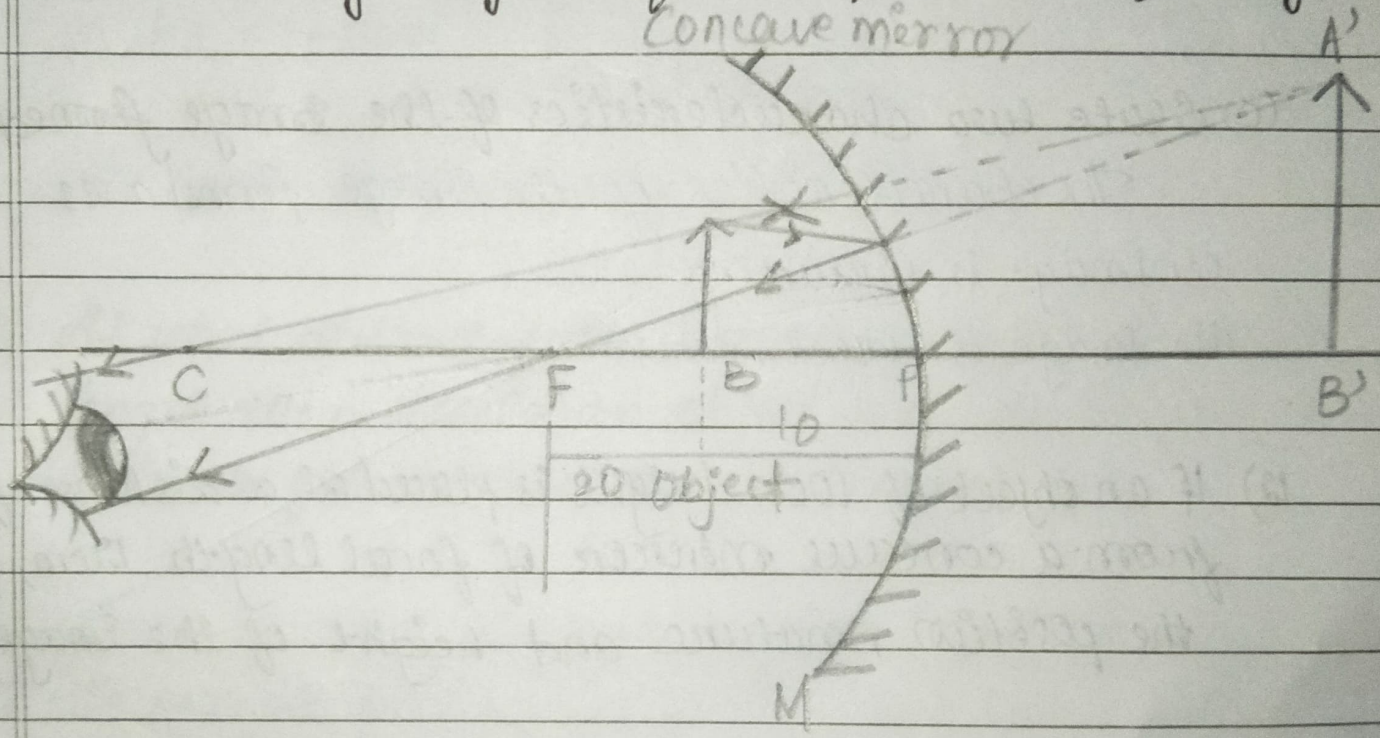
Short Answer Type Questions

11) An object is placed at a distance of 10cm from a concave mirror of focal ~~length~~ length 20cm.

(a) Draw a ray diagram for the formation of image.



formation of image by the concave mirror by the concave mirror when the object is placed between its pole and focus.

(b) Calculate the image distance.

$f = -20cm$, $u = -10cm$, $v = ?$

∵ we know that

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

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

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

$\Rightarrow v = 20cm$

$\therefore v = 20cm.$

(c) State two characteristics of the image formed.

The characteristics of the image formed are:

(i) Image is virtual

(ii) Image is erect.

12) If an object of 10cm height is placed at a distance of 36cm from a concave mirror of focal length 12cm, find the position, nature and height of the image.

$h_1 = 10cm$, $u = -36cm$, $f = -12cm$

We know that

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

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

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

$\Rightarrow v = -18cm$

$\therefore$ The position of the image is 18cm infront of the mirror.

Magnification $(m) = \frac{h_2}{h_1} = \frac{-v}{u}$

$\Rightarrow \frac{h_2}{10} = \frac{-(-18)}{(-36)}$

$\Rightarrow h_2 = -5cm$

The image formed is real and inverted.

13) At what distance from a concave mirror of focal length 10cm should an object 2cm long be placed in order to get an erect image 6cm tall?

$f = -10cm$, $h_1 = 2cm$, $h_2 = 6cm$ (erect image)

$\therefore$ We know that

$m = \frac{h_2}{h_1} = \frac{6}{2} = 3$ and,

$m = -\frac{v}{u} = 3$

$\Rightarrow 3u = -v$

$\Rightarrow v = -3u$ ——— (i)

We have,

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

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

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

$\Rightarrow \frac{2}{3u} = \frac{-1}{10}$

$\Rightarrow u = -\frac{20}{3} = -6.66\,cm$

The object should be placed at a distance of 6.66cm on the ~~lef~~ left side of the mirror.

14) When an object is placed at a distance of 15cm from a concave mirror, its image is formed at 10cm in front of the mirror. Calculate the focal length of the mirror.

$u = -15cm, v = -10cm$

$\because$ We know that

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

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

$\Rightarrow \frac{1}{f} = -\frac{1}{10} - \frac{1}{15} = \frac{-3-2}{30} = -\frac{5}{30} = -\frac{1}{6}$

$\Rightarrow f = -6cm$

So, the focal length of the concave mirror is 6cm.

15) An object 3cm high is placed at a distance of 8cm from a concave mirror which produces a virtual image 4.5cm high:

(i) What is the focal length of the mirror?

$h_1 = 3cm, u = -8cm, h_2 = 4.5\,cm$ (virtual image).

(ii) $\because$ We know that

$m = \frac{h_2}{h_1} = \frac{4.5}{3} = 1.5$ and

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

$\Rightarrow 1.5 = \frac{-v}{(-8)}$

$\Rightarrow v = 1.5 \times 8 = 12cm$

We have

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

$\Rightarrow \frac{1}{12} + \frac{1}{(-8)} = \frac{1}{f}$

$\Rightarrow \frac{1}{f} = \frac{1}{12} - \frac{1}{8} = \frac{2-3}{24} = -\frac{1}{24}$

$\Rightarrow f = -24cm$

(iii) What is the position of image?

$v = 12cm$

$\therefore$ the image formed is 12cm behind the mirror.

16) A converging mirror forms a real image of height 4cm of an object of height 1cm placed 20cm away from the mirror:

$h_2 = -4\,cm$ (real ~~image~~ image)
$h_1 = 1\,cm$
$u = -20\,cm$

(i) Calculate the ~~image~~ image distance.

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

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

$\Rightarrow v = -80\,cm$

Image forms infront of the concave mirror.

(ii) ~~Also~~ what is the focal length of the mirror?

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

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

$= \frac{1}{f} = -\frac{1}{80} - \frac{1}{20} = \frac{-1-4}{80} = \frac{-5}{80}$

$\Rightarrow f = -16\,cm$

17) An object of size 7.0cm is placed at 27cm infront of a concave mirror of focal length 18cm. At what distance from the mirror should a screen be placed so that a sharp focussed image can be obtained? Find the size and nature of image.

Sol: $h_1 = 7\,cm$
$u = -27\,cm$
$f = -18\,cm$
} (Given)

∴ We know that

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

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

$= \frac{-1}{18} + \frac{1}{27} = \frac{-3+2}{54} = \frac{-1}{54}$

∴ $v = -54\,cm$

So, the screen should be placed at a distance of 54cm infront of the concave mirror.

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

$\Rightarrow \frac{(-54)}{(-27)} = \frac{h_2}{h_1}$

$\Rightarrow h_2 = -14\,cm$

So, the ~~inf~~ image formed is 14cm in size, real & inverted

18) An object 3cm high is placed at a distance of 10cm in front of a converging mirror of focal length 20cm. Find the position, nature and size of the image formed.

$h_1 = 3cm$
$u = -10cm$
$f = -20cm$
} Given

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

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

$= -\frac{1}{20} + \frac{1}{10} = \frac{-1+2}{20} = \frac{1}{20}$

$\Rightarrow v = 20cm$

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

And,

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

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

$\Rightarrow h_2 = 6cm$

So, the image is 6cm in size, virtual and erect.

19) A concave mirror has a focal length of 10cm and an object 2cm tall is placed 9cm away from it. Find the nature, position and size of the image formed.

$h_1 = 2cm, u = -9cm, f = -10cm$

∵ We know that

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

$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{(-10)} - \frac{1}{(-9)}$

$= -\frac{1}{10} + \frac{1}{9} = \frac{-9+10}{90} = \frac{1}{90}$

$\Rightarrow v = -7.2cm$

The image is formed at a distance 7.2cm in front of the mirror.

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

$m = \frac{h_2}{h_1}$

$\Rightarrow -0.8 = \frac{h_2}{2}$

$\Rightarrow h_2 = -1.6cm$

∴ The image is 1.6cm in size, real and inverted.

20) When an object is placed 20 cm from a concave mirror, a real image magnified three times is formed. Find:

$u = -20$cm

$m = -3$, for the real image } Given

a) the focal length of the mirror

∵ We know that

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

$$\therefore m = -3 = \frac{-v}{(-20)}$$

$$\Rightarrow v = 60\text{cm}.$$

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

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

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

$$\Rightarrow f = -15\text{cm}$$

b) Where must the object be placed to give a virtual image three times the height of the object?

Sol: For virtual image, $m = 3$, $f = 15$cm

∵ We know that,

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

$$\therefore m = 3 = \frac{-v}{u}$$

$$\Rightarrow v = -3u$$

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

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

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

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

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

21) A dentist's mirror has a radius of curvature of 3cm. How far must it be placed from a small dental cavity to give a virtual image of the cavity that is magnified five times?

$R = -3$cm (concave mirror)

$m = 5$ (virtual image)

$$f = \frac{R}{2} = \frac{-3\text{cm}}{2} = -1.5\text{cm}$$ and,

$$m = 5 = \frac{-v}{u}$$

$$\Rightarrow v = -5u$$

We have,

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

$$\Rightarrow \frac{1}{(5u)}+\frac{1}{u}=\frac{1}{(15)}$$

$$\Rightarrow \frac{4}{5u}=\frac{-1}{1.5}$$

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

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

22) A large concave mirror has a radius of curvature curvature of 1.5m. A person stands 10m in front of the mirror. Where is the person's image?

$R=-1.5m$ (Concave mirror)

$u=-10m$

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

We know that,

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

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

$$\Rightarrow \frac{1}{v}+\frac{1}{10}-\frac{1}{0.75}=\frac{1}{10}-\frac{100}{75}$$

$$\Rightarrow \frac{1}{10}-\frac{4}{3}=\frac{3-40}{30}=-\frac{37}{30}$$

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

So, the person's image will be 0.81m ~~in~~ in front of the concave mirror.

23) An object of 5cm size is placed at a ~~distance~~ distance of 20cm ~~of~~ from a converging mirror of focal length 15cm. At what distance from the mirror should a screen be ~~pla~~ placed to get a sharp image? Also calculate the size of the image.

$h_1=5cm$
$u=-20cm$ } Given
$f=-15cm$

We know that

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

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

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

$$\Rightarrow \frac{1}{v}=\frac{-5}{300} \Rightarrow v=-60cm$$

So, the ~~sch~~ screen ~~should~~ should be placed 60cm infront of the mirror.

and,

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

$$\frac{h_2}{5} = \frac{(-60)}{(-20)}$$

$h_2 = -15cm$

height of image = 15cm

24) A concave mirror produces three times enlarged virtual image of an object placed at 10cm in front of it. Calculate the radius of curvature of the mirror.

$m = 3$ (virtual image) } Given
$u = -10cm$

We know that

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

$$= 3 = \frac{-v}{(-10)}$$

$\Rightarrow v = 30cm$ and,

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \qquad \Rightarrow \frac{-20}{300} = \frac{1}{f}$$

$$= \frac{1}{30} + \frac{1}{(-10)} = \frac{1}{f} \qquad \Rightarrow f = -15cm$$

$\therefore R = 2f = 2(15cm) = -30cm.$

25) A bright object 50mm high stands on the axis of a concave mirror of focal length 100mm and at a distance of 300mm from the concave mirror. How big will the image be?

$h_1 = 50mm$, $f = -100mm$, $u = -300mm$.

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

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

$$\Rightarrow \frac{1}{v} = \frac{1}{300} - \frac{1}{100} \Rightarrow \frac{1}{v} = \frac{-200}{30000} \Rightarrow \frac{1}{v} = -\frac{2}{300} \Rightarrow v = -150mm.$$

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

$$= \frac{-150}{-300} = \frac{h_2}{50} \Rightarrow h_2 = 25mm$$

So, the image will be 25mm high.

26) How far should an object be placed from the pole of a converging mirror of focal length 20cm to form a real image of the size exactly 1/4 th the size of the object

$f = -20cm$, $m = -1/4$ (real image)

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

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

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

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

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

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

$\therefore u = 4v = 4(-25) = -100\ cm.$

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

27) When an object is placed at a distance of 50 cm from a concave spherical mirror, the magnification produced is $-\frac{1}{2}$. Where should the object be placed to get a magnification of $-\frac{1}{5}$?

Sol: Case I:

$u = -50cm$

$m = -1/2$

$m = -v/u$

$\therefore -\frac{1}{2} = \frac{-v}{-50} \Rightarrow v = -25cm$

We know that,

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

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

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

$\Rightarrow f = -50/3\ cm.$

Case II:

$m = -1/5$

$f = -50/3\ cm$

$m = -1/5 = -v/u$

$\Rightarrow v = u/5$

Now, $\frac{1}{v} + \frac{1}{u} = 1/f = 5/u + 1/u = -3/50 \Rightarrow 6/u = -3/50$

$u = \frac{600}{-3} = -100\ cm$

28) An object is placed at 20 cm (b) 4 cm, in front of a concave mirror of focal length 12 cm. Find the nature and position of the image formed in each case.

Sol: a) $u = -20\ cm, f = -12cm$

$1/v + 1/u = 1/f = 1/v + 1/-20 = 1/-12$

$\Rightarrow 1/v = -1/12 + 1/20 = -20+12/240 = -8/240 \Rightarrow v = -30cm$

$\therefore$ The image formed is at a distance of 30 cm in front of the mirror and it is real and inverted.

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

$\frac{1}{v} + \frac{1}{u} = 1/f = \frac{1}{v} + \frac{1}{-4} = \frac{1}{-12} \Rightarrow \frac{1}{v} = \frac{-1}{12} + \frac{1}{4} = \frac{-1+3}{12} = \frac{2}{12} = \frac{1}{6}$

$\Rightarrow v = 6\,cm$

∴ The image formed is at a distance of 6 cm behind the mirror and is virtual and erect.

29) A concave mirror produces a real image 1 cm tall of an object 2.5 mm tall placed 5 cm from the mirror. Find the position of the image and the focal length of the mirror.

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

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

We know that

$m = -v/u$

$\Rightarrow -4 = \frac{-v}{(-50)} \Rightarrow v = -200\,mm = -20\,cm$

∴ The image formed is 20 cm in front of the mirror.

$1/v + 1/u = 1/f$

$= 1/(-20) - 1/-5 = 1/f$

$\Rightarrow 1/f = -25/100 = -1/4$

$\Rightarrow f = -4\,cm$

30) A man holds a ~~spher~~ spherical shaving mirror of radius of curvature 60 cm, and focal length 30 cm, at a distance of 15 cm, from his nose. Find the position of image, and calculate the magnification.

$R = -60\,cm$ (concave mirror)
$f = -30\,cm$,
$u = -15\,cm$

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

$= 1/v + 1/-15 = 1/-30$

$\Rightarrow 1/v = 1/15 + 1/-30 \Rightarrow 1/v = 1/30 \Rightarrow v = 30\,cm$

$m = -v/u$

$= m = \frac{30}{-15}$

$\Rightarrow m = 2$

So, the image is formed 3 cm behind the mirror and its magnification is +2.