ws-9 → Basic → Mirrors, 9th foundation

①

Given distance of object $u = -10\,cm$

Focal length $f = 20\,cm$

∴ From mirror formula $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

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

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

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

$$\Rightarrow \frac{1}{v} = \frac{3}{20}$$

Image distance $\Rightarrow v = \frac{20}{3}\,cm$

②

Given size of image = 4.5 size of object → ①

Distance of object $u = -20\,cm$

From ① $h_I = -4.5\,h_o$ [image is real]

∴ Magnification $m = +\frac{h_I}{h_o}$ also $m = -\frac{v}{u}$

$$\therefore -\frac{v}{u} = +\frac{h_I}{h_o}$$

$$\Rightarrow +\frac{v}{+20} = -\frac{4.5\,h_o}{h_o}$$

$$\Rightarrow \frac{v}{20} = -4.5 \Rightarrow v = -4.5 \times 20$$

$$= -90\,cm$$

2nd continuation

we know that $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$\Rightarrow \frac{1}{f} = \frac{-1}{90} - \frac{1}{20}$

$\Rightarrow \frac{1}{f} = \frac{-2-9}{180}$

$\Rightarrow \frac{1}{f} = \frac{-11}{180}$

$\Rightarrow f = -\frac{180}{11}$ cm

(3)

Given size of image $h_I = \frac{1}{n} h_o$

Here object distance is $u = -u$.

$\therefore$ From Magnification $m = \frac{-v}{u} = \frac{h_I}{h_o}$

$\Rightarrow \frac{-v}{-u} = \frac{\frac{1}{n} h_o}{h_o}$

$\Rightarrow \frac{v}{u} = \frac{1}{n} \Rightarrow v = \frac{u}{n}$

$\therefore$ From mirror formula $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$\Rightarrow \frac{1}{f} = \frac{1}{\frac{u}{n}} + \frac{1}{(-u)}$

$\Rightarrow \frac{1}{f} = \frac{n}{u} - \frac{1}{u}$

$\Rightarrow \frac{1}{f} = \frac{(n-1)}{u}$

$\Rightarrow u = (n-1) f$

(4)

Given $R = -60$ cm

$\therefore f = \frac{R}{2} = -\frac{60}{2} = -30$ cm [For concave mirror f is -ve]

$v = -90$ cm.

By using mirror formula

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

$$\Rightarrow -\frac{1}{30} = -\frac{1}{90} + \frac{1}{u}$$

$$\Rightarrow \frac{1}{u} = -\frac{1}{30} + \frac{1}{90}$$

$$\Rightarrow \frac{1}{u} = \frac{-3+1}{90}$$

$$\Rightarrow \frac{1}{u} = \frac{-2}{90} \Rightarrow u = -\frac{90}{2} = -45 \text{ cm}$$

object distance is always Negative.

(5)

Given distance of object $u = 0.2$ m $= -20$ cm

Distance of image $v = 30$ cm

From mirror formula $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$$\Rightarrow \frac{1}{f} = \frac{1}{30} - \frac{1}{20}$$

$$\Rightarrow \frac{1}{f} = \frac{2-3}{60} = \frac{-1}{60}$$

$\Rightarrow f = -60$ cm Here focal length is Negative, so the nature of lens is concave.

(6)

If object distance is $u_1 = -25cm$

$\therefore$ Magnification is $m_1 = -\frac{v_1}{u_1}$

As the object is moved 15cm away from earlier position (i.e) the distance of object is $u_2 = -40cm$

Magnification is $m_2 = -\frac{v_2}{u_2}$

Given $\frac{m_1}{m_2} = 4 \Rightarrow \frac{-\frac{v_1}{u_1}}{-\frac{v_2}{u_2}} = 4$

$\Rightarrow \frac{v_1}{v_2} \times \frac{u_2}{u_1} = 4$

$\Rightarrow \frac{v_1}{v_2}\left(\frac{-40}{-25}\right) = 4$

$\Rightarrow \frac{v_1}{v_2} = \left[\frac{25}{40_{10_2}}\right] \times 4 = \frac{5}{2}$

$\Rightarrow \frac{v_1}{v_2} = \frac{5}{2}$

From mirror formula $\frac{1}{f} = \frac{1}{v_0} + \frac{1}{u} \rightarrow (1)$

For $u_1 = -25cm \rightarrow \frac{1}{f} = \frac{1}{v_1} - \frac{1}{25} \rightarrow (2)$

For $u_2 = -40cm \rightarrow \frac{1}{f} = \frac{1}{v_2} - \frac{1}{40} \rightarrow (3)$

From (2) and (3) $\frac{1}{v_1} - \frac{1}{25} = \frac{1}{v_2} - \frac{1}{40}$

$\Rightarrow \frac{1}{40} - \frac{1}{25} = \frac{1}{v_2} - \frac{1}{v_1}$

6th continuation

$$\Rightarrow \frac{5-8}{200} = \frac{1}{v_1}\left[\frac{v_1}{v_2} - 1\right]$$

$$\Rightarrow -\frac{3}{200} = \frac{1}{v_1}\left[\frac{5}{2} - 1\right]$$

$$\Rightarrow -\frac{3}{200} = \frac{1}{v_1} \times \frac{3}{2}$$

$$\Rightarrow \frac{1}{v_1} = -\frac{1}{100} \Rightarrow v_1 = -100\,cm.$$

$\therefore$ From (2) $\quad \frac{1}{f} = \frac{1}{v_1} - \frac{1}{25}$

$$\Rightarrow \frac{1}{f} = -\frac{1}{100} - \frac{1}{25}$$

$$\Rightarrow \frac{1}{f} = \frac{-1-4}{100}$$

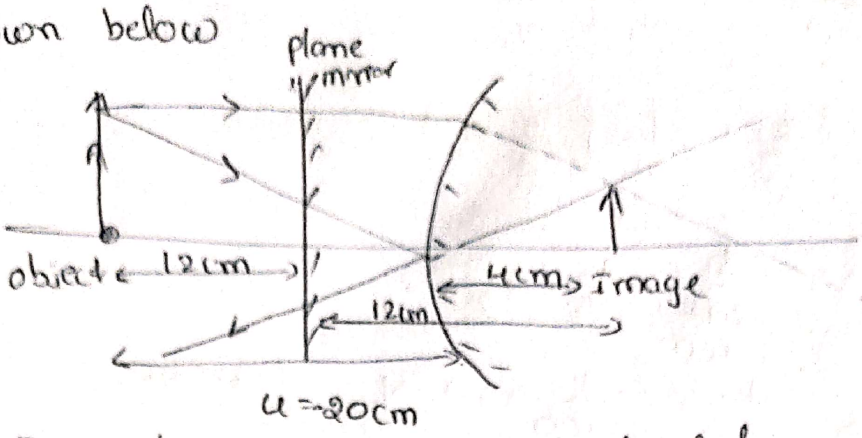
$$\Rightarrow \frac{1}{f} = \frac{-5}{100} \Rightarrow f = -\frac{100}{5} = -20cm$$

'-ve' sign shows the mirror is concave mirror

Distance of object $u = -20cm$

(F)

According to given data the ray diagram is shown below



For a plane mirror object distance = image distance

∴ From convex mirror image is at a distance

$$v = 4\,cm$$

∴ From mirror formula $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

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

$$\Rightarrow \frac{1}{f} = \frac{5-1}{20}$$

$$\Rightarrow \frac{1}{f} = \frac{4}{20} = \frac{1}{5}$$

$$\therefore f = 5\,cm$$

(G)

Given that size of image h_I = 2 size of object

$$h_I = 2h_o$$

∴ Magnification = $\frac{h_I}{h_o}$; From mirror formula

$$\Rightarrow -\frac{v}{u} = \frac{2h_o}{h_o}$$

$$\boxed{v = -2u}$$

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

$$\Rightarrow -\frac{1}{15} = -\frac{1}{2u} + \frac{1}{u}$$

$$\Rightarrow -\frac{1}{15} = \frac{1}{2u} \Rightarrow 2u = -15$$

$$\Rightarrow u = -7.5\,cm$$

(9)

Given distance of object $u = -2f$

Focal length of the mirror $F = f$

∴ From mirror formula $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$$\Rightarrow \frac{1}{f} = \frac{1}{v} - \frac{1}{2f}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{2f} = \frac{3}{2f}$$

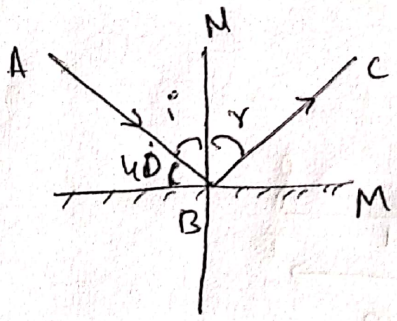
$$\Rightarrow v = \frac{2f}{3}$$

∴ Magnification $m = -\frac{v}{u}$

$$= -\frac{\frac{2f}{3}}{-2f}$$

$$m = \frac{1}{3}$$

(10)



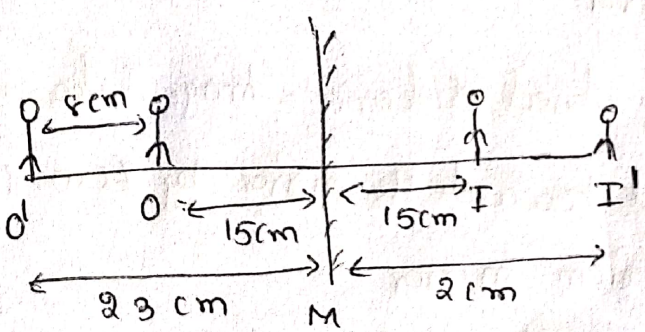
N is Normal makes an angle 90° with mirror.

Clearly $\angle i = 90 - 40 = 60°$

According to laws of reflection $\angle i = \angle r$

∴ Angle of reflection $\angle r = 60°$

(12)



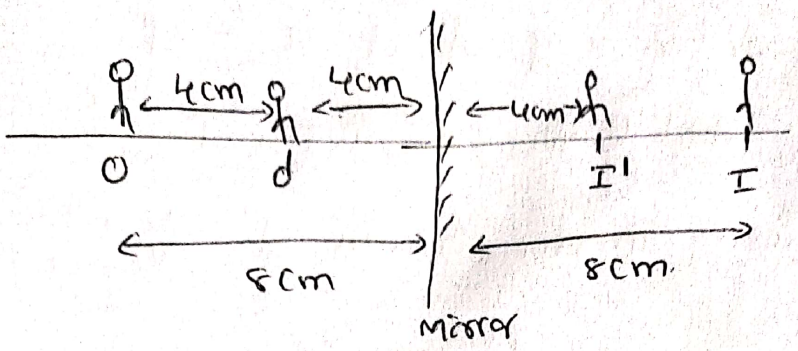
O, I are original positions of object and image. For plane mirrors object & image distances are equal.

As the object is moved 8cm away, it's new position is $O' = 23$cm

∴ The New Position of image is $I' = 23$ cm

Distance b/w O' & I' = 23cm + 23cm = 46cm

(13)



For a plane mirror object distance = image distance

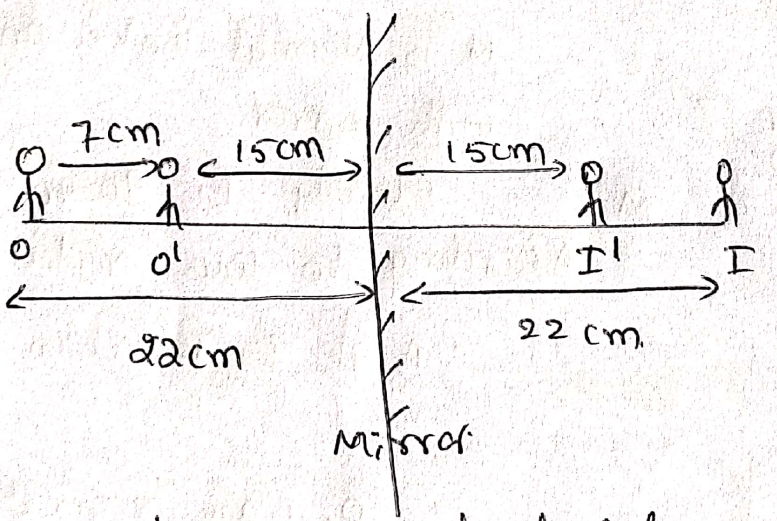
As the object is moved from O → d by 4cm, its new distance from mirror is 4cm.

∴ Now the position of image I' is also 4cm from mirror.

∴ The distance between object and image is

$$d'I' = 4cm + 4cm$$
$$= 8cm$$

(14)



For a plane mirror object distance = image distance = 22cm

As object is moved towards the mirror by 7cm, its new position is 15cm from mirror

So the image is at a distance of 15 cm from mirror.

(10)

focal length $f = -12$ cm

let 'u' be the object distance, v be the image distance

using mirror formula

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

$$\Rightarrow -\frac{1}{12} = \frac{1}{u} + \frac{1}{v} \rightarrow (1)$$

Given image is 10cm more left than the object.

image distance $v = u - 10 \rightarrow (2)$

$$\therefore \Rightarrow -\frac{1}{12} = \frac{1}{u} + \frac{1}{u-10}$$

$$\Rightarrow -\frac{1}{12} = \frac{u-10+u}{u(u-10)}$$

$$\Rightarrow -\frac{1}{12} = \frac{2u-10}{u^2-10u} \Rightarrow -(u^2-10u) = 12(2u-10)$$

$$\Rightarrow -u^2+10u = 24u-120$$

$$\Rightarrow -u^2-14u+120 = 0$$

$$\Rightarrow u^2+14u-120 = 0$$

$$\Rightarrow u^2+20u-6u-120 = 0$$

$$\Rightarrow u(u+20)-6(u+20) = 0$$

$$\Rightarrow (u+20)(u-6) = 0$$

$$\therefore u+20 = 0 \quad (or) \quad u-6 = 0$$

$$\Rightarrow u = -20\text{cm} \qquad u = 6\text{cm}$$

16th continuation

object distance can not be positive

$u = -20$ cm

image distance $v = u - 10$

$= -20 - 10$

$v = -30$ cm

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

$\Rightarrow m = \frac{-(-30)}{-20} = -1.5$

For concave mirror magnification is Negative.

(16)

Focal length $f = -7.5$ cm (For concave mirror)

object distance $u = -15$ cm.

∴ From mirror formula $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$\Rightarrow \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{-1}{7.5} + \frac{1}{15}$

$\Rightarrow \frac{1}{v} = \frac{-2+1}{15} = \frac{-1}{15}$

$\Rightarrow v = -15$ cm

Image is real, it can be caught on screen.

-ve value of 'v' indicates that image is formed infront of the mirror.

(21)

Given size of image = $\frac{1}{3}$ size of object

$$h_I = \frac{1}{3} h_o$$

Focal length of concave mirror $f = -40$ cm

(22)

Given size of image = size of object

$$h_I = h_o$$

and image is real so magnification = -ve

$$m = -\frac{v}{u} \quad \left[m = \frac{h_I}{h_o} = 1\right]$$

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

Focal length $f = -40$ cm

From mirror $\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \rightarrow (1)$

$$\Rightarrow -\frac{1}{40} = \frac{1}{u} + \frac{1}{u} \Rightarrow -\frac{1}{40} = \frac{2}{u} \Rightarrow u = -80\text{ cm}$$

v also -80 cm

As the object moved towards mirror by 10cm, then it's

Position $u' = 70$ cm

From (1) $$-\frac{1}{40} = \frac{1}{v'} - \frac{1}{70} \Rightarrow \frac{1}{v'} = -\frac{1}{40} + \frac{1}{70} = \frac{-7+4}{280}$$

$$\Rightarrow \frac{1}{v'} = \frac{-3}{280} \Rightarrow v' = -\frac{280}{3}$$

$$= -93.33\text{cm}$$

∴ The image is moving from -80 cm to -93.33 cm

∴ It moves 13.33 cm away from the mirror.

LTask CUQ's

(10)

Focal length of concave mirror $f = -15\,cm$

$$h_I = 2h_O$$

$\therefore$ magnification $m = \frac{h_I}{h_O} = 2$

$$\Rightarrow -\frac{V}{u} = 2 \Rightarrow V = -2u$$

From mirror formula $\frac{1}{f} = \frac{1}{V} + \frac{1}{u}$

$$\Rightarrow -\frac{1}{15} = \frac{-1}{2u} + \frac{1}{u}$$

$$\Rightarrow -\frac{1}{15} = \frac{-1+2}{2u} = \frac{1}{2u}$$

$$\Rightarrow 2u = -15 \Rightarrow u = -\frac{15}{2} = -7.5\,cm.$$

LTask Jee mains level

(11)

Focal length of convex mirror $f = 20\,cm$

Size of image $= \frac{1}{2}$ size of the object.

$$h_I = \frac{1}{2} h_O$$

$\therefore$ magnification $m = \frac{h_I}{h_O} = \frac{1}{2}$

$$\Rightarrow -\frac{V}{u} = \frac{1}{2} \Rightarrow V = -\frac{u}{2}.$$

From mirror formula $\frac{1}{f} = \frac{1}{V} + \frac{1}{u}$

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

$$\Rightarrow \frac{1}{20} = -\frac{1}{u}$$

$$\Rightarrow u = -20\,cm$$

object distance is always Negative.

(12)

focal length $f = -20$ cm

Size of image = 2 Size of object

image is real means magnification is -ve

$\therefore$ magnification $= -\frac{h_I}{h_O} = -\frac{2h_O}{h_O}$ [Also $m = -\frac{V}{u}$]

$+\frac{V}{u} = +2 \Rightarrow \frac{V}{u} = 2 \Rightarrow V = 2u$

From mirror formula

$$\frac{1}{f} = \frac{1}{V} + \frac{1}{2u}$$

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

$$\Rightarrow -\frac{1}{20} = \frac{3}{2u} \Rightarrow u = -30\text{cm}$$

object distance is always Negative.

(13)

Focal length of mirror $f = -16$ mm

distance of cavity = Distance of object $u = -8$ mm

To see real images A dentist use concave mirror

$\therefore$ From mirror formula $\frac{1}{f} = \frac{1}{V} + \frac{1}{U}$

$$\Rightarrow -\frac{1}{16} = \frac{1}{V} - \frac{1}{8m}$$

$$\Rightarrow \frac{1}{V} = -\frac{1}{16} + \frac{1}{8} = \frac{-1+2}{16}$$

$$\Rightarrow \frac{1}{V} = \frac{1}{16} \Rightarrow V = 16\text{mm}$$

$\therefore$ magnification $m = \frac{V}{u} = \frac{16}{8} = 2.$

(14)

magnification $m = \frac{1}{3}$; focal length $f = 18\,cm$

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

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

From mirror formula $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$$= \frac{1}{18} = -\frac{3}{u} + \frac{1}{u}$$

$$\Rightarrow \frac{1}{18} = \frac{-3+1}{u} = -\frac{2}{u}$$

$\Rightarrow u = -36\,cm$ object distance is always Negative.

(15)

Focal length of convex lens $f = 30cm$

Size of image $h_I = \frac{1}{4}$ Size of object (h_O)

$\therefore$ magnification $m = \frac{h_I}{h_O}$

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

$\therefore$ From concave mirror $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$$\Rightarrow \frac{1}{30} = -\frac{4}{u} + \frac{1}{u}$$

$$\Rightarrow \frac{1}{30} = \frac{-4+1}{u}$$

$$\Rightarrow \frac{1}{30} = \frac{-3}{u}$$

$$\Rightarrow u = -30 \times 3 = -90\,cm$$

Object distance is always $-ve$.

(16)

Focal length of convex mirror $F = f$

object distance $u = -\frac{f}{2}$

$\therefore$ From mirror formula $\frac{1}{F} = \frac{1}{v} + \frac{1}{u}$

$$\Rightarrow \frac{1}{f} = \frac{1}{v} - \frac{2}{f}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{2}{f} = \frac{3}{f}$$

$$\Rightarrow v = \frac{f}{3}$$

(17)

object distance $u = -40\ cm$

Radius of curvature $R = 20\ cm$

$\therefore$ focal length $f = \frac{R}{2} = 10\ cm$

From mirror formula $\frac{1}{F} = \frac{1}{v} + \frac{1}{u}$

$$\Rightarrow \frac{1}{10} = \frac{1}{v} - \frac{1}{40}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{10} + \frac{1}{40}$$

$$\Rightarrow \frac{1}{v} = \frac{4+1}{40} = \frac{5}{40_8}$$

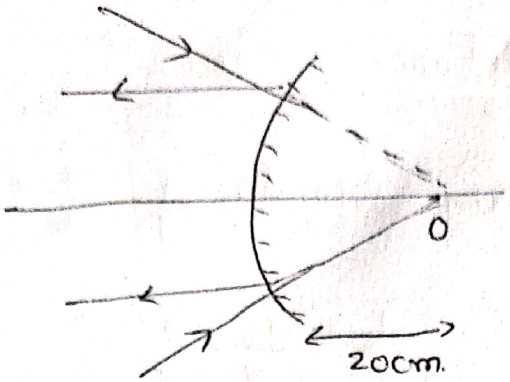
$$\Rightarrow \frac{1}{v} = \frac{1}{8}$$

$$\Rightarrow v = 8\ cm \quad \text{virtual}$$

v is positive means image is ~~real~~ and is formed behind the mirror

(18)

Given focal length $f = 20\ cm$



Here we have virtual object so u is positive

$u = 20\ cm$

From mirror formula $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

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

$\Rightarrow \frac{1}{v} = \frac{1}{20} - \frac{1}{20} = 0$

$\Rightarrow v = \frac{1}{0} = \infty$ = infinity

(19)

Focal length $f = -20\ cm$

Size of image (h_I) = 2 Size of object (h_O)

$\therefore$ magnification $m = \frac{h_I}{h_O} = \frac{2h_O}{h_O} = 2$

For virtual image formed by a concave mirror 'm' is +Ve

$\therefore \quad m = -\frac{v}{u} \Rightarrow 2 = -\frac{v}{u} \Rightarrow v = -2u$

From mirror formula $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

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

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

$\Rightarrow -\frac{1}{20} = \frac{1}{2u} \Rightarrow 2u = -20$

$\Rightarrow u = -10\ cm$

object distance is always Negative

(20)

Given magnification $m = 3$

If it is concave mirror focal length $f = -24$ cm

For real image $m = -3$

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

$$\Rightarrow v = 3u$$

From mirror formula $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$$\Rightarrow -\frac{1}{24} = \frac{1}{3u} + \frac{1}{u}$$

$$\Rightarrow -\frac{1}{24} = \frac{4}{3u}$$

$$\Rightarrow u = -8 \times 4 = -32 \text{ cm}$$

(or)

For virtual image $m = 3$

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

$$\Rightarrow v = -3u$$

$\therefore$ From mirror formula $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$$\Rightarrow -\frac{1}{24} = -\frac{1}{3u} + \frac{1}{u}$$

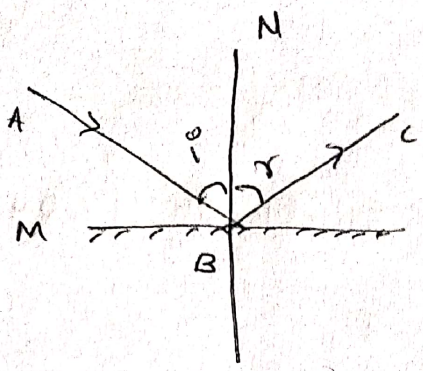
$$\Rightarrow -\frac{1}{24} = \frac{-1+3}{3u}$$

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

$$\Rightarrow u = -8 \times 2 = -16 \text{ cm}$$

$\because$ bject distance is always '-ve'.

(21)



AB → incident ray

$\angle ABN = \angle i$ = Angle of incidence = 30°

BC → Reflected ray

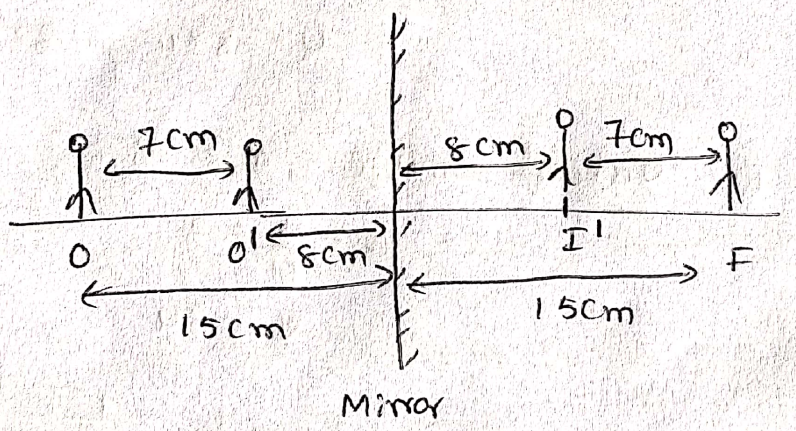
$\angle NBC = \angle r$ = Angle of reflection.

According to laws of reflection $\angle i = \angle r$

$\therefore \angle r = 30°$

From fig angle between incident ray and reflected ray = $\angle i + \angle r = 30° + 30° = 60°$

(22)

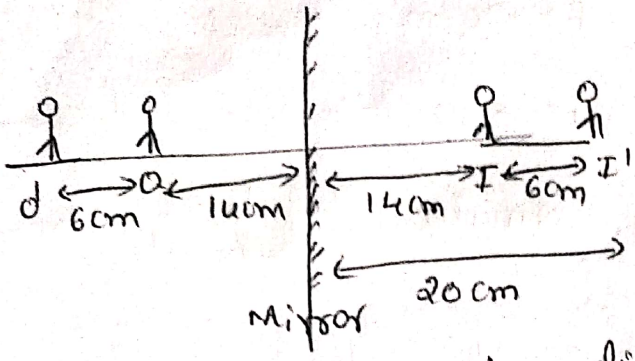


For a plane mirror object distance = image distance

As the object moved towards mirror by 7cm, it's new distance from mirror becomes 15cm - 7cm = 8cm

$\therefore$ the image will be formed at a distance 8cm from mirror

(23)



For a plane mirror

object distance = image distance

Given image is at a distance 14cm from mirror means object is at a distance 14cm from mirror.

If the object is moved 6cm away from mirror

so it's position from mirror is 14cm + 6cm = 20cm

∴ The distance of image from mirror = 20cm

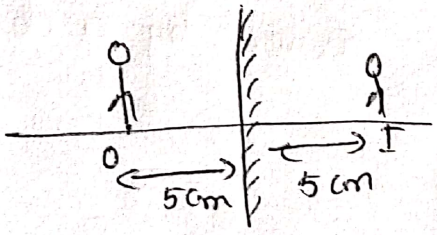
Advanced level

(7th) Take solution from 20th & jee mains level

(9)

For a plane mirror

Distance of object (face) = distance of image



As the person moves 5cm away from the mirror so the image also moved 5cm. Thus the distance between the image formed by the mirror and object is 10cm

(8) Given focal length $f = -20\,cm$

object distance $u = -30\,cm$

From mirror formula $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$$\Rightarrow -\frac{1}{20} = \frac{1}{v} - \frac{1}{30}$$

$$\Rightarrow \frac{1}{v} = -\frac{1}{20} + \frac{1}{30} = \frac{-3+2}{60}$$

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

As the object moved 5cm towards mirror

Then the object distance $u' = -25\,cm$

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

$$\Rightarrow -\frac{1}{20} = \frac{1}{v'} + \frac{1}{25}$$

$$\Rightarrow \frac{1}{v'} = -\frac{1}{20} + \frac{1}{25} = \frac{-5+4}{100}$$

$$\Rightarrow v' = -100\,cm$$

$\therefore$ The image moved by a distance $= v' - v$

$= -100 - (-60)$

$= -40\,cm.$