WS-1 (Spherical mirrors)

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① Given $h_o = 6cm$

$u = -30cm$; $f = -20cm$.

From mirror formula

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

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

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

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

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

$$\Rightarrow \frac{h_I}{6} = \frac{+60}{-30}$$

$$\Rightarrow h_I = 12cm$$

② Given $h_o = 2cm$, $h_I = 1cm$

$u = -10cm$.

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

$$\Rightarrow \frac{1}{2} = \frac{-v}{-10}$$

$$\Rightarrow v = 5cm$$

From mirror formula

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

$$\Rightarrow \frac{1}{f} = -\frac{1}{10} + \frac{1}{5}$$

$$\Rightarrow f = 10cm$$

③ Given $h_o = 10cm$; $h_I = 5cm$

$u = -20cm$

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

$$\Rightarrow m = \frac{5}{10} = -\frac{v}{(-20)}$$

$$\Rightarrow v = 10cm$$

From mirror formula

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

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

$$\Rightarrow f = 20cm.$$

④ $h_o = 3cm$, $u = -30cm$

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

$$\Rightarrow \frac{h_I}{30} = \frac{30}{30} \Rightarrow h_I = 30cm$$

From mirror formula

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \quad [f = -15cm]$$

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

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

$$\Rightarrow v = -30\,cm.$$

⑤ Given $u = -30\,cm$

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

$v = 5u$

$f = \frac{R}{2}$ From mirror formula $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$$\Rightarrow \frac{1}{f} = \frac{1}{u} + \frac{1}{5u} = \frac{6}{5u}$$

$$\Rightarrow f = \frac{5}{6} \times u = \frac{5}{6} \times (-30)$$

$$f = -25\,cm$$

$$R = 2f = 2(-25)$$

$$= -50cm.$$

⑥ Given $h_I = n h_o$

Magnification $m = \frac{h_I}{h_o}$

$$m = \frac{n h_o}{h_o} = n.$$

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

From mirror formula

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

$$\Rightarrow \frac{1}{f} = \frac{1}{un} + \frac{1}{u}$$

$$\Rightarrow \frac{1}{f} = \frac{1+n}{nu}$$

$$\Rightarrow f = \frac{nu}{1+n}.$$

$$\Rightarrow nu = f(1+n)$$

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

⑦ Given $h_o = 8cm$

$f = 25cm$; $u = -25cm$

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

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

$$\Rightarrow \frac{1}{v} = \frac{1}{25} + \frac{1}{25} = \frac{2}{25}$$

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

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

$$\frac{h_I}{8} = \frac{+\frac{25}{2}}{-25}$$

$$\Rightarrow \frac{h_I}{8} = \frac{1}{2}$$

$$\Rightarrow h_I = 4\,cm$$

(8) Given $u=-10cm$; $R=30cm$

$f=\frac{R}{2}=\frac{30}{2}=15cm$

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

$\Rightarrow \frac{1}{15}=-\frac{1}{10}+\frac{1}{v}$

$\Rightarrow \frac{1}{15}+\frac{1}{10}=\frac{1}{v}$

$\Rightarrow v=6cm$

(9) Given $h_o=5cm$

$u=-30cm$; $f=-20cm$

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

$\Rightarrow -\frac{-60}{-30}=\frac{h_I}{h_o}$

$\Rightarrow 2=\frac{h_I}{5}\Rightarrow h_I=10cm$

From mirror formula

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

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

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

$\Rightarrow v=-60cm$

(10) Given $h_I=5h_o$

$f=-45cm$.

From def of magnification

$m=\frac{h_I}{h_o}=5$

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

$\Rightarrow v=5u$

From mirror formula

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

$\Rightarrow -\frac{1}{45}=\frac{1}{5u}+\frac{1}{u}$

$\Rightarrow -\frac{1}{45}=\frac{1+5}{5u}$

$\Rightarrow -\frac{1}{9}=\frac{6}{u}$

$\Rightarrow u=-54cm$

(15) $h_o=4cm$; $u=-20cm$

$f=16cm$

(i) $m=-\frac{v}{u}=\frac{h_I}{h_o}$

$=-\frac{80}{-20}=\frac{h_I}{4}$

$\Rightarrow h_I=16cm$.

(ii) From mirror formula

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

$\Rightarrow -\frac{1}{16}=\frac{1}{v}-\frac{1}{20}$

$\Rightarrow -\frac{1}{16}+\frac{1}{20}=\frac{1}{v}$

$\Rightarrow v=-80cm$.

(iii) Magnification $m=+\frac{v}{u}=\frac{-80}{-20}=4$.

(16) Given $h_o=7.5cm$

$R=25cm$; $u=-40cm$.

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

$=\frac{200}{\frac{21}{40}}=\frac{h_I}{7.5}$

$\Rightarrow \frac{5}{21}=\frac{h_I}{7.5}$

$\Rightarrow h_I=1.78cm$

(17) Given $f=-12cm$; $h_o=4cm$; $h_I=1cm$

$m=\frac{v}{u}=\frac{h_I}{h_o}$

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

$f=\frac{R}{2}$.

From mirror formula

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

$\Rightarrow \frac{2}{R}=-\frac{1}{40}+\frac{1}{v}$

$\Rightarrow \frac{2}{25}+\frac{1}{40}=\frac{1}{v}$

$v=\frac{200}{21}cm$

∴ from mirror formula

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

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

$\Rightarrow -\frac{1}{12}=\frac{5}{u}$

$\Rightarrow u=-60cm$

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(11) $h_o = 5cm$

$h_I = 10cm$

magnification $m = \frac{h_I}{h_o} = \frac{v}{u}$

$\Rightarrow \frac{v}{u} = \frac{50}{15} = \frac{2}{1}$

$\Rightarrow v = 2u$

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

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

$\Rightarrow \frac{1}{f} = \frac{3}{2u}$

$f = \frac{2u}{3} = -\frac{40}{3} cm$

(13) $h_I = 2h_o$; $u_1 = -15cm$

$m = \frac{h_I}{h_o} = 2$

$\Rightarrow \frac{v}{u_1} = 2$

$\Rightarrow v = 2u_1$

From $\frac{1}{f} = \frac{1}{u_1} + \frac{1}{v_1}$

$\Rightarrow \frac{1}{f} = \frac{1}{u_1} + \frac{1}{2u_1}$

$\Rightarrow f = \frac{2u_1}{3}$

also $m' = \frac{h_I'}{h_o} = 4 = \frac{v_2}{u_2}$

$\Rightarrow v_2 = 4u_2$

From $\frac{1}{f} = \frac{1}{u_2} + \frac{1}{v_2}$

$\Rightarrow \frac{3}{2u_1} = \frac{1}{u_2} + \frac{1}{4u_2}$

$\Rightarrow \frac{3}{2u_1} = \frac{5}{4u_2}$

$\Rightarrow \frac{3}{u_1} = \frac{5}{2u_2}$

$u_2 = \frac{5u_1}{6}$

$= \frac{5}{6} \times (-15)$

$= 1.25cm$

(14) Given

$h_o = 5cm$

$h_I = 10cm$

$u = -20cm$

$m = \frac{h_I}{h_o} = \frac{10}{5} = 2$

$\frac{v}{u} = 2$

$\Rightarrow v = 2u = 2 \times 20$

$\Rightarrow v = -40cm.$

From mirror formula

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

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

$\Rightarrow f = \frac{2u}{3} = \frac{2}{3}(-20)$

$\Rightarrow f = -\frac{40}{3} cm$

(15) $u = -40cm$ $h_I = \frac{1}{2} h_o$

magnification $m = \frac{h_I}{h_o}$

$m = \frac{\frac{1}{2} h_o}{h_o} = \frac{1}{2}$

$\Rightarrow \frac{v}{u} = \frac{1}{2} \Rightarrow v = \frac{u}{2}$

$\Rightarrow v = 20cm.$

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

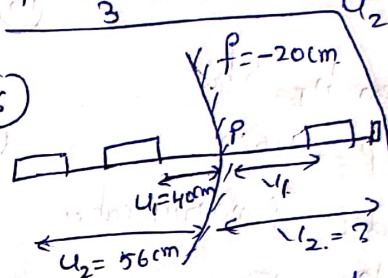
$\Rightarrow \frac{1}{f} = \frac{1}{u} - \frac{2}{u}$

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

$\Rightarrow f = -u$

$= -40cm$

(16)



From mirror formula also

$\frac{1}{f} = \frac{1}{u_1} + \frac{1}{v_1}$

$\Rightarrow -\frac{1}{20} = -\frac{1}{40} + \frac{1}{v_1}$

$\Rightarrow -\frac{1}{20} + \frac{1}{40} = \frac{1}{v_1}$

$\Rightarrow v_1 = -40 cm$

$\frac{1}{f} = \frac{1}{u_2} + \frac{1}{v_2}$

$\Rightarrow -\frac{1}{20} = \frac{1}{-56} + \frac{1}{v_2}$

$\Rightarrow -\frac{1}{20} + \frac{1}{56} = \frac{1}{v_2}$

$v_2 = -\frac{20 \times 14}{9}$

$L = v_1 \sim v_2.$

$= -\frac{20 \times 14}{9} - 40 = 14.15 cm$

(17) Given $m = \frac{1}{2} \Rightarrow -\frac{v_1}{u_1} = \frac{1}{2}$ also $m = \frac{h_I}{h_o} = \frac{1}{4}$

$u_1 = -40cm$ $\Rightarrow v_1 = -\frac{u_1}{2}$ $\Rightarrow -\frac{v_2}{u_2} = \frac{1}{4}$

From mirror formula $\Rightarrow v_2 = -\frac{1}{4} u_2$

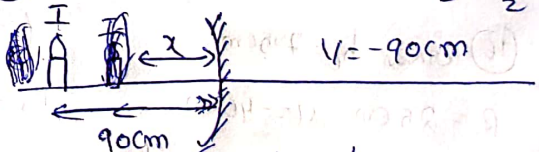
$\frac{1}{f} = \frac{1}{u_1} + \frac{1}{v_1}$ and $\frac{1}{f} = \frac{1}{u_2} + \frac{1}{v_2}$

$\therefore \frac{1}{u_1} + \frac{1}{v_1} = \frac{1}{u_2} + \frac{1}{v_2}$

$\Rightarrow \frac{1}{u_1} - \frac{2}{u_1} = \frac{1}{u_2} - \frac{4}{u_2}$

$\Rightarrow \frac{1}{u_1} = -\frac{3}{u_2} \Rightarrow u_2 = -3u_1 = 120cm$

(18) We know that $f = \frac{R}{2} = \frac{60}{2} = 30cm$



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

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

$\Rightarrow \frac{1}{u} = -\frac{1}{30} + \frac{1}{90} \Rightarrow \frac{1}{u} = -\frac{2}{90}$

$u = -45cm$

The flame must be placed 45cm before concave mirror.

(19) Given $v = -30\,cm$

$u = 0.2\,m = 20\,cm$

$u = -20\,cm.$

From mirror formula

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

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

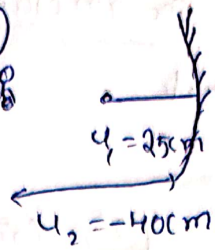
$\Rightarrow \frac{1}{f} = -\frac{2-3}{60}$

$\Rightarrow \frac{1}{f} = -\frac{5}{60}$

$f = -12\,cm$

(or) $-120\,mm$

(20)



Given $\frac{m_1}{m_2} = 4$

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

$\Rightarrow \frac{8 v_1}{5 v_2} = 4$

$\Rightarrow \frac{2 v_1}{5 v_2} = 4$

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

From mirror formula

$\frac{1}{f} = \frac{1}{u_1} + \frac{1}{v_1}$ and also $\frac{1}{f} = \frac{1}{u_2} + \frac{1}{v_2}$

$\Rightarrow \frac{1}{u_1} + \frac{1}{v_1} = \frac{1}{u_2} + \frac{1}{v_2}$

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

$\Rightarrow -\frac{1}{25} + \frac{2}{5v_2} = -\frac{1}{40} + \frac{1}{v_2}$

$\Rightarrow -\frac{1}{25} + \frac{1}{40} = \frac{1}{v_2} - \frac{2}{5v_2}$

$\Rightarrow \frac{-5+8}{200} = \frac{3}{5v_2}$

$\Rightarrow \frac{3}{200} = \frac{3}{5v_2}$

$v_2 = -\frac{200}{5} = -40(\text{cm})$

(27) Given $m = 2$

$h_I = 2h_0$; $u = -20\,cm.$

(i) $m = \frac{h_I}{h_0} = \frac{2h_0}{h_0} = 2$

(ii) $\frac{v}{u} = 2 \Rightarrow v = 2u$

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

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

$\Rightarrow \frac{1}{f} = \frac{3}{2u}$

$\Rightarrow f = \frac{2u}{3} = \frac{2}{3}(-20)$

$f = -\frac{40}{3}\,cm.$

(iii) $h_I = 3h_0$

$m = \frac{h_I}{h_0} = 3$

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

$\Rightarrow v = 3u.$

From mirror formula

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

$\Rightarrow \frac{1}{f} = \frac{1}{u} + \frac{1}{3u} = \frac{4}{3u}$

$\Rightarrow f = \frac{3u}{4}$

$\Rightarrow -\frac{40}{3} = \frac{3u}{4}$

$\Rightarrow u = -\frac{160}{9}\,cm$

(28) Given $u = -90\,cm$; $f = -30\,cm$

From mirror formula

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

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

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

$\Rightarrow \frac{1}{v} = -\frac{2}{90} = -\frac{1}{45}$

$\Rightarrow v = -45\,cm$

(29) Given $h_0 = 1.5cm$; $u = -15cm$

$h_I = 30cm$

$m = \frac{h_I}{h_0} = \frac{3}{1.5} = 2$

$\frac{v}{u} = 2 \Rightarrow v = 2u.$

From mirror formula

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

$\Rightarrow \frac{1}{f} = \frac{3}{2u} \Rightarrow f = \frac{2u}{3}$

$\Rightarrow f = \frac{2}{3}(-15)$

$\Rightarrow f = -10\,cm$