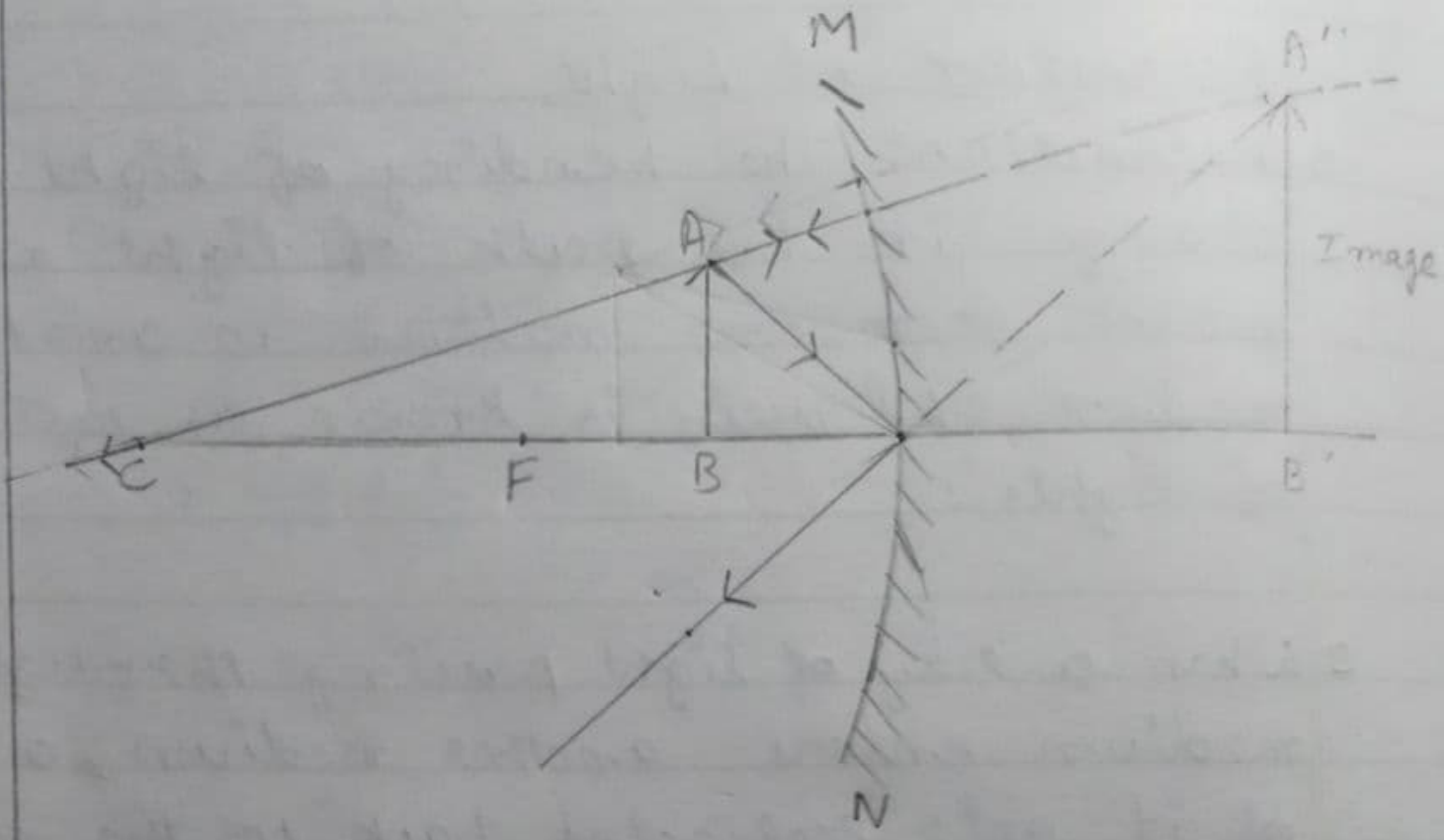
11.

(a)



(b) $f = -20\,cm, u = 10\,cm, v = ?$

We know that

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

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

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

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

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

$$\Rightarrow v = 20\,cm.$$

(c) characteristics of image formed

(i) Image is virtual and enlarged.

(ii) Image is erect.

12. Given $h_1 = 10\,cm$, $u = -36\,cm$, $f = -12\,cm$

We know that

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

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

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

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

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

$$\Rightarrow \frac{1}{v} = \frac{-1}{18}$$

$$\Rightarrow v = -18\,cm$$

∴ The position of the image is 18 cm in front of the mirror.

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

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

$\Rightarrow \frac{h_2}{10} = \frac{-18}{-36_2}^{1}$

$\Rightarrow \frac{h_2}{10} = \frac{-1}{2}$

$\Rightarrow h_2 = -5\,cm$

The image formed is real and inverted.

13. Given:- $f = -10cm$, $h_1 = 2cm$, $h_2 = 6cm$ (erect image)

$$m = \frac{h_2}{h_2} = \frac{6}{2} = 3$$

and

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

$\Rightarrow 3u = -v$

$\Rightarrow v = -3u$ —— (1)

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

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

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

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

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

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

14. Given:- $u = -15\text{cm}$, $v = -10\text{cm}$

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

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

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

$$\Rightarrow \frac{1}{f} = \frac{-3-2}{30}$$

$$\Rightarrow \frac{1}{f} = \frac{-5}{30_6}$$

$$\Rightarrow \frac{1}{f} = \frac{-1}{6}$$

$$\Rightarrow f = -6 \text{ cm}$$

∴ The focal length of the concave mirror is 6cm.

15. Given:- $h_1 = 3cm$, $u = -8\ cm$, $h_2 = 4.5$

(i) $m = \frac{h_2}{h_1} = \frac{4.5}{3} = 1.5$

and

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

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

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

$$\Rightarrow v = 12\ cm$$

we have

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

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

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

$$\Rightarrow f = -24\ cm$$

(ii) So, the image is formed 12 cm behind the concave mirror.

16. Given :- $h_2 = -4$ cm (real image)

$h_1 = 1$ cm

$u = -20$ cm

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

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

$\Rightarrow v = -80$ cm

Image forms in front of the concave mirror.

(ii) $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

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

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

$\Rightarrow f = -16$ cm.

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

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

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

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

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

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

$\Rightarrow v = -54$ cm.

The screen should be placed in front of the concave mirror of 54 cm.

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

$$\Rightarrow -\frac{(-54)}{(-27)} = \frac{h_2}{7}$$

$$\Rightarrow h_2 = -14 \text{ cm}$$

Image is 14 cm in size, real and inverted.

18. Given: $h_1 = 3$cm, $u = -10$ cm, $f = -20$cm

We know that

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

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

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

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

$$\Rightarrow v = 20\,cm$$

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

And

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

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

$$\Rightarrow \frac{h_2}{3} = \frac{2}{1}$$

$$\Rightarrow h_2 = 6\,cm$$

Image is 6 cm in size, virtual and erect.

19. Given :- $h_1 = 2\,cm$, $u = -9\,cm$, $f = -4\,cm$

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

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

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

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

$$\Rightarrow \frac{1}{v} = \frac{-5}{36}$$

$$v = -7.2 \text{ cm}$$

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

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

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

$$\Rightarrow h_2 = -1.6 \text{ cm}$$

So, image is 1.6 cm in size, real and inverted.

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

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

$$m = -3 = \frac{-v}{-20}$$

$$\Rightarrow -3 \times 20 = v$$

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

We have

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

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

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

$$\Rightarrow \frac{1}{f} = \frac{-1}{15}$$

$$\Rightarrow f = -15\,cm.$$

(b) Virtual image $m = 3$ and $f = -15\,cm$

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

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

$$\Rightarrow v = -3u$$

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

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

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

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

$$\Rightarrow u = -10 \text{ cm}$$

$\therefore$ So, Object should be placed 10 cm from the concave mirror.

21. Given:- $R = -3$ cm (concave mirror)

$m = 5$ (virtual)

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

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

$$\Rightarrow v = -5u$$

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

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

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

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

∴ The mirror should be placed 1.2 cm away from the dental cavity.

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

$u = -10\ m$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\Rightarrow \frac{h_2}{5} = -3$$

$$\Rightarrow h_2 = -15 \text{ cm}$$

height of image = -15 cm.

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

$u = -10$ cm

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

$\Rightarrow 3 = \frac{-V}{-10}$

$\Rightarrow V = 30\ cm$

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

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

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

$\Rightarrow \frac{-20}{300} = \frac{1}{f}$

$\Rightarrow f = -15\ cm$

Radius of curvature $= R = 2f$

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

25. Given: $h_1 = 50\ mm$, $f = -100\ mm$, $u = -300\ mm$

by

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

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

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

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

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

$\Rightarrow v = -150 \text{ mm}$

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

$\frac{-(-150)}{-300} = \frac{h_2}{50}$

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

$\Rightarrow h_2 = -25 \text{ mm}$

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

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

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

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

$\Rightarrow -u = -4v$

$\Rightarrow u = 4v$

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

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

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

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

$$\Rightarrow -4v = 100$$

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

$$\Rightarrow v = -25 \text{ cm}$$

$$u = 4v$$

$$\Rightarrow u = 4 \times (-25)$$

$$\Rightarrow u = -100 \text{ cm}$$

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

$\Rightarrow v = -25\ cm$

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

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

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

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

Case-2

Given:- $m = \frac{-1}{5}$, $f = \frac{-50}{2}\ cm$

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

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

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

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

$\Rightarrow \frac{6}{u} = \frac{-3}{50} \Rightarrow u = \frac{300}{-3} = -100\ cm$

$\Rightarrow u = -100\ cm$

28. (a)

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

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

$$\Rightarrow \frac{1}{v} + \frac{1}{-20} = \frac{1}{-12}$$

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

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

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

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

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

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

$$\Rightarrow \frac{1}{v} = \frac{-1}{12} + \frac{1}{4} = \frac{-1+3}{12} = \frac{2}{12}$$

$$\Rightarrow v = 6\ cm.$$

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

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

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

$$\Rightarrow m = \frac{-10}{2.5}$$

$$\Rightarrow m = -4$$

and we know that

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

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

$$\Rightarrow v = -200\,mm$$

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

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

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

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

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

$\Rightarrow f = -4\,cm.$

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

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

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

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

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

$\Rightarrow v = 30\,cm$

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

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

$\Rightarrow m = 2$

$\therefore$ So, the image is formed 30 cm

behind the mirror and the magnification is +2.