Sat 16 January 2021

Reflection of Light Second Solutions of Pg-198 and 199

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Short Answer Type Questions.

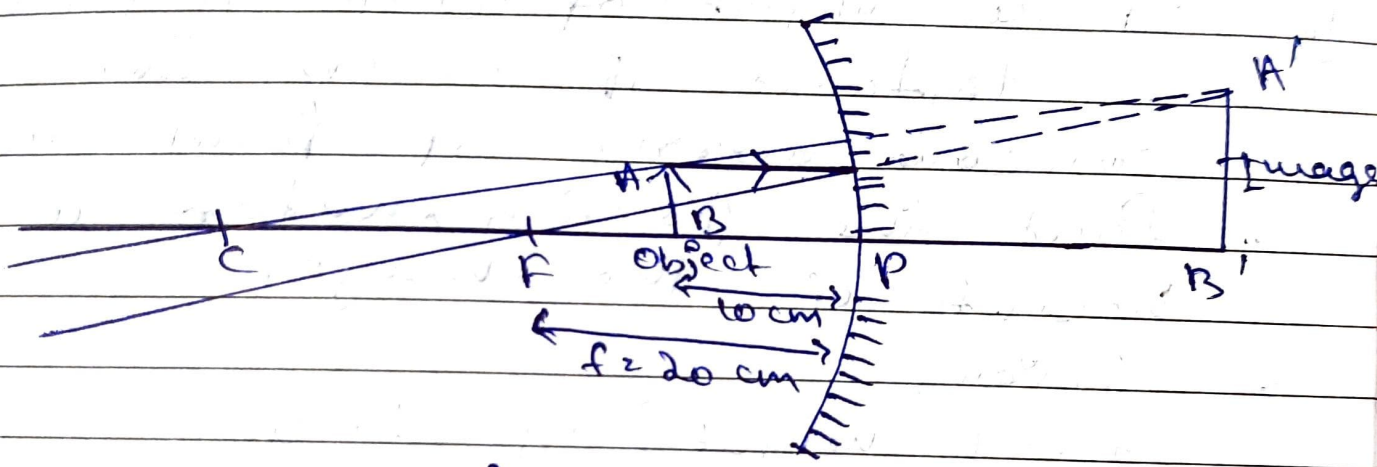
(11) An object is placed at a distance of 10 cm from a concave mirror of focal length 20 cm.

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

(b) Calculate the image distance

(c) state two characteristics of image formed.

Sol (a)



(b) Object distance, $u = -10$ cm

focal length, $f = -20$ cm

image distance, $v = ?$

Mirror formula

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

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

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

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

$v = 20$ cm

Thus, the image distance is 20 cm.

(c) Two characteristics of the image formed is as follows:

(i) It is virtual and erect

(ii) It is magnified.

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

Ans. Given,

Object height; $h_1 = 10$ cm

Object distance; $u = -36$ cm

focal length; $f = -12$ cm

$v = ?$

mirror formula,

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

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

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

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

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

$v = -18$ cm

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

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

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

$\Rightarrow h_2 = -5$ cm

The image is real and inverted.

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

Ans. focal length, $f = -10$ cm

Object height, $h_2 = 2$ cm

image height, $h_1 = 6$ cm

$u = ?$

By using magnification formula

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

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

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

$$v = -3u$$

By mirror formula

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

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

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

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

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

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

Ans. Object distance, $u = -15$ cm

image distance, $v = -10$ cm

focal length, $f = ?$

By using mirror formula

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

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

$$\Rightarrow \frac{-3+(-2)}{30}$$

$$\Rightarrow \frac{-3-2}{30}$$

$$\Rightarrow \frac{-5}{30} = \frac{-1}{6}$$

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

$$\Rightarrow -f = 6$$

$$\Rightarrow f = -6$$

Hence, the focal length will be -6.

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

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

(ii) what is the position of image?

ans. Object height, $h_1 = 3$ cm

Object distance, $u = -8$ cm

image height, $h_2 = 4.5$ cm

(i) We know that

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

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

$$\Rightarrow \frac{1.5}{1} = \frac{v}{+8}$$

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

$$\Rightarrow v = 12 \text{ cm}$$

Now, by using mirror formula

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

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

$$\Rightarrow \frac{2 + (-3)}{24} = \frac{1}{f}$$

$$\Rightarrow -\frac{1}{24} = \frac{1}{f}$$

$$\Rightarrow -f = 24$$

$$f = -24$$

$v = 12$ cm

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

(16) A converging mirror forms a real image of height 4 cm of an

Object of height 1 cm placed 20 cm away from the mirror:

(i) Calculate the image distance

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

Ans. image height ; $h_2 = -4$ cm (real image)

Object height ; $h_1 = 1$ cm

Object distance ; $u = -20$ cm

image distance ; $v = ?$

by using magnification

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

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

$$\Rightarrow -v = -20 \times (-4)$$

$$\Rightarrow -v = 80 \text{ cm}$$

$$\Rightarrow v = -80 \text{ cm}$$

Image formed in front of the concave mirror.

(ii) focal length ; $f = ?$

by using mirror's formula

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

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

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

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

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

$$\frac{1}{f} = \frac{-1}{16}$$

$$-f = 16$$

$$f = -16 \text{ cm}$$

(17) An object of size 7 cm is placed at 27 cm in front of a concave mirror of focal length 18 cm. At what distance from the mirror should be screen be placed so that a sharp focused image can be obtained? Find the size and nature of image.

Ans Object height ; $h_1 = 7$ cm

Object distance ; $u = -27$ cm

focal length ; $f = -18$ cm

by using Image distance $= ?$

by using mirror formula

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

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

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

$\Rightarrow \frac{1}{v} = \frac{1}{-u} + \frac{1}{27}$

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

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

$\Rightarrow -v = 54$

$\Rightarrow v = -54$ cm

Thus, the screen should be placed at a distance of 54 cm in front of the concave mirror.

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

Ans. Object height, $h_1 = 3$ cm

Object distance, $u = -10$ cm

focal length, $f = -20$ cm

Image distance, $v = ?$

By using mirror formula,

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

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

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

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

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

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

$$\Rightarrow v = 20 \text{ cm}$$

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

image height = h_2

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

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

$$\Rightarrow m = 6 \text{ cm}$$

Image is 6 cm in size, virtual and erect.

(19) A concave mirror has a focal length of 4 cm and an object 2 cm tall is placed 9 cm away from it. Find the nature, position and size of the image formed.

Sol: Object height ; $h_1 = 2$ cm
Object distance ; $u = -9$ cm
focal length ; $f = -4$ cm
image distance ; $v = ?$
by using mirror formula

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

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

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

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

$$\Rightarrow \frac{1}{v} = \frac{-9+4}{36} = \frac{-5}{36}$$

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

$$\Rightarrow -5v = 36$$

$$\Rightarrow v = \frac{36}{5} = 7.2 \text{ cm}$$

→ True, the image is formed at a distance 7.2 cm in front of the mirror.

image height; $h_2 = ?$

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

$$m = \frac{-7.2}{-9} = \frac{h_2}{2}$$

$$m = \frac{7.2}{9} = \frac{h_2}{2}$$

$$m = 9h_2 = 14.4 \text{ cm}$$

$$h_2 = \frac{14.4}{9} = 1.6 \text{ cm}$$

So, image is 1.6 cm 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:

(a) the focal length of the mirror

(b) where must the object be placed to give a virtual image three

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focus the height of the object?

ans. Given,

Object distance, $u = -20$ cm

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

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

$\Rightarrow v = -60$ cm

by using mirror formula

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

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

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

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

$\therefore f = -15$ cm

(b) for virtual image,

magnification, $m = 3$

focal length, $f = -15$ cm

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

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

$-v = 3u$

$v = -3u$

by using mirror formula

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

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

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

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

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

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

Ans radius of curvature, $r = -3$ cm

magnification, $m = 5$ (virtual image)

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

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

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

$\Rightarrow -v = 5u$

$\Rightarrow v = -5u$

by using mirror formula

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

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

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

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

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

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

Ans. $R = -1.5$ m (Concave mirror)

$\Rightarrow -10$ cm

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

by using mirror formula

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

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

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

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

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

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

$$\Rightarrow v = -\frac{37}{40} = 0.81 \text{ m}$$

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

(23) An object of 5.0 cm in size is placed at a distance of 20 cm from a converging mirror of focal length 15 cm. At what distance from the mirror should a screen be placed to get the

sharp image ? Also calculate the size of the image.

Ans $h_1 = 5$ cm

$u = -20$ cm

$f = -15$ cm

$h_2 = ?$

by using mirror formula

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

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

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

$$\frac{1}{v} = \frac{-3}{300} = \frac{-1}{60}$$ cm

$v = -60$ cm

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

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

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

$-20\ h_2 = -60 \times 5$

$h_2 = \frac{-60 \times 5}{-20}$

$h_2 = 15$ cm

Thus, the height of the image is

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

Ans. $m = 3$ (virtual image)

$u = -10$ cm

$R = ?$

We know that

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

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

$$-v = -30$$

$$v = 30 \text{ cm}$$

By using mirror formula

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

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

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

$$\Rightarrow \frac{1}{v} = \frac{-200}{30000}$$

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$\frac{1}{v} + \frac{-2}{-300}$

$v = -150$ mm

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

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

$-300 h_2 = -150 \times 50$

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

The image would be 25 mm high.

$\frac{1}{30} + \frac{1}{-60} = \frac{1}{f}$

$\frac{-30}{300} = \frac{1}{f}$

$f = -15$ cm

Radius of curvature $= R = 2f$

$= 2(-15)$

$= -30$ cm

(Q) A bright object 50 mm high stands on the axis of a concave mirror of focal length

100 mm and at a distance of 300 mm from the concave mirror. How big will the image be?

Ans. $h_1 = 50$ mm

$f = -100$ mm

$u = -300$ mm

$h_2 = ?$

by using mirror formula

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

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

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

$$\Rightarrow \frac{1}{v} = \frac{-200}{30000}$$

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

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

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

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

The image will be 25 mm high.

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

Ans $f = -20$ cm

$m = 1/4$th (real image)

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

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

$-u = -4v$

$u = 4v$

by using mirror formula

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

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

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

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

$f = 4V$

$u = 4(-25)$

$f = -100$ cm

The object should be placed 100 cm on 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 $-\frac{1}{5}$?

Ans. Case 1 :-

$u = -50$ cm

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

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

$-\frac{1}{2} = -\frac{v}{-50}$

$v = -25$ cm

by using mirror formula.

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

$$\Rightarrow \frac{1}{-25} + \frac{1}{-10} = \frac{1}{f}$$

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

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

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

Case 2:

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

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

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

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

Now by using mirror formula

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

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

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

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

(21) An object is placed (a) 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.

Ans (a) $u = -20$ cm

$f = -12$ cm

by using mirror formula

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

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

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

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

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

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

$v = -30$ cm

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

The image is real and inverted.

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

$f = -12\,cm$

by using mirror formula

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

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

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

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

$$\Rightarrow v = 6$$

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

The image is virtual and erect.

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

Ans. $h_2 = 1\ cm = 10\ mm$ (real image)

$h_1 = 20.5\ mm$

$u = -5\ cm = -50\ mm$

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

$$m = \frac{-10}{25}$$

$$m = -4$$

We know that

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

$$-4 = \frac{v}{-50}$$

$$v = +200\ mm$$

$$v = -20\ cm$$

The image is formed 20 cm in front of the mirror and real by using mirror formula

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

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

$$\frac{1}{f} = \frac{-15}{60}$$

$$f = -4\ cm$$

(30) A man holds a 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 the image, & calculate the magnification.

One Radius of curvature, $R = -60$ cm (Concave mirror)

$f = -30$ cm

$u = -15$ cm

by mirror formula

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

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

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

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

$$v = 30\ cm$$

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

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

$m = 2$

So the image formed 30 cm behind the magnification is +2.