NCERT PHYSICS SOLUTIONS

CHAPTER : 9, RAY OPTICS AND OPTICAL INSTRUMENT CLASS : XII

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Example 9.1

Suppose that - - - - - - - - of the mirror?

Solution:

As laws of reflection are true for all points of the mirror, the image will be of whole object but intensity of the image will be low as the area of reflecting surface is reduced.

Example 9.2

A mobile phone - - - - - - - - to the mirror?

Solution:

Here the magnification is not uniform because the different parts of phone lie at different points on the principal axis.

The part of phone lies at 'C' will form same size image.

The part lies between F and C will form enlarged image beyond C.

As image is not of uniform magnification, we see ~~we~~ distorted image.

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Example 9.3

An object is placed - - - - - - - in each case.

Solution:

$u = -10$ cm

$R = -15$ cm

$f = \frac{R}{2} = \frac{-15}{2}$

$f = -7.5$ cm.

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

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

$v = \frac{fu}{u-f}$

$v = \frac{-7.5 \times (-10)}{-10 + 7.5}$

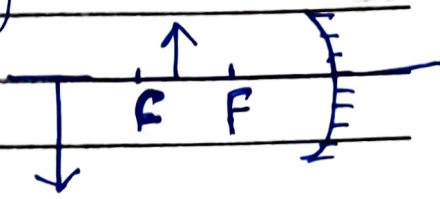
$= \frac{7.5 \times 10}{-2.5}$

$v = -30$ cm.

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

$= -\left(\frac{-30}{-10}\right)$

$m = -3$



Position of image - beyond C at 30 cm
Nature - Real and inverted
magnification - -3

(11) $u = -5$ cm.

$$v = \frac{fu}{u-f}$$

$$= \frac{-7.5 \times (-5)}{-5 + 7.5}$$

$$= \frac{7.5 \times 5}{2.5}$$

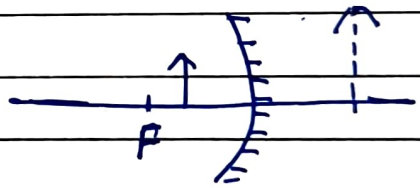
$v = 15$ cm.

Magnification:

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

$$= -\left(\frac{15}{-10}\right)$$

$m = 3$



Position of image = behind the mirror at 15 cm
Nature = Virtual and erect
magnification = 3

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Example 9.4

Suppose while - - - - - - - (d) 9 m away

Solution:

$R = 2\ m$

Speed of jogger = 5 m/s

(a) $u = -39\ m$

$R = 2\ m$

$f = 1\ m$

$$V = \frac{fu}{u-f}$$

$$= \frac{1 \times (-39)}{-39-1}$$

$$= \frac{-39}{-40} = \frac{39}{40}\ m$$

After 1 sec

$u = -39 + 5$

$u = -34\ m$

$$V = \frac{fu}{u-f} = \frac{1 \times (-34)}{-34-1}$$

$$= \frac{-34}{-35} = \frac{34}{35}\ m$$

Shift in the position of V

$$= \frac{39}{40} - \frac{34}{35}$$

$$= \frac{39}{40} - \frac{34}{35}$$

$$= \frac{39 \times 35 - 34 \times 40}{40 \times 35}$$

$$= \frac{8(39 \times 7 - 34 \times 8)}{40 \times 35_7}$$

$$= \frac{273 - 272}{280}$$

$$\text{shift} = \frac{1}{280}$$

Hence speed of image $= \frac{1}{280}$ m/s

(b) $u = -29$ m

$$v = \frac{fu}{u - f}$$

$$= \frac{1 \times (-29)}{-29 - 1} = \frac{-29}{-30}$$

$$= \frac{29}{30}$$

After 1 sec

$$u = -29 + 5$$

$$u = -24 \text{ m}$$

$$v = \frac{1 \times (-24)}{-24-1}$$

$$= \frac{24}{25}$$

shift in $v = \frac{29}{30} - \frac{24}{25}$

$$= \frac{29 \times 25 - 30 \times 24}{30 \times 25}$$

$$= \frac{5(29 \times 5 - 6 \times 24)}{30 \times 25_5}$$

$$= \frac{145 - 144}{150}$$

$$v = \frac{1}{150}$$

Hence speed of $v = \frac{1}{150}$ m/s

(c) $u = -19$ m

$$v = \frac{1 \times (-19)}{-19-1}$$

$$= \frac{19}{20} \text{ m}$$

After 1 sec

$$u = -19 + 5$$

$$= -14 \text{ m}$$

$$V = \frac{1 \times (-14)}{-14-1} = \frac{14}{15}$$

Shift in image position

$$= \frac{19}{20} - \frac{14}{15} = \frac{57-56}{60}$$

$$= \frac{1}{60}$$

Hence speed of image $= \frac{1}{60}$ m/s

(d) $u = -9$ m

so $V = \frac{1 \times (-9)}{-9-1}$

$$= \frac{9}{10} m$$

After I see

$$u = -9+5 = -4 m$$

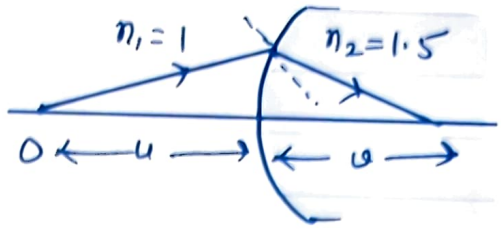
then $V = \frac{1 \times (-4)}{-4-1} = \frac{4}{5}$

Shift in $V = \frac{9}{10} - \frac{4}{5}$

$$\frac{9-8}{10} = \frac{1}{10}$$

Hence speed of $V = \frac{1}{10}$ m/s

Example 9.5



Given,

$u = -100\ cm$

$R = 20\ cm$

$n_1 = 1$, $n_2 = 1.5$

$v = ?$

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$

$$\frac{1.5}{v} - \frac{1}{-100} = \frac{1.5-1}{20}$$

$$\frac{1.5}{v} + \frac{1}{100} = \frac{0.5}{200}$$

$$\frac{1.5}{v} = \frac{5}{200} - \frac{1}{100} = \frac{3}{200}$$

$$\frac{1.5}{v} = \frac{3}{200}$$

$$v = \frac{1.5 \times 200}{3} = 100$$

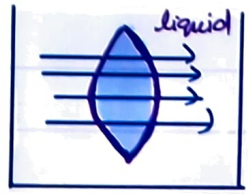
$v = 100\ cm$ Ans

Example 9.6

The refractive index of liquid must be equal to the refractive index of the lens to make the lens disappear. i.e $n = 1.47$.

It could not be water ($n_w = 1.33$) because it is less than refractive index of lens.

It could be glycerine ($n = 1.46$)



EXAMPLE 9.7

Example 9.7 (i) If $f = 0.5$ m for a glass lens, what is the power of the lens? (ii) The radii of curvature of the faces of a double convex lens are 10 cm and 15 cm. Its focal length is 12 cm. What is the refractive index of glass? (iii) A convex lens has 20 cm focal length in air. What is focal length in water? (Refractive index of air-water = 1.33, refractive index for air-glass = 1.5.)

$a n_g$ $a n_w$

Sol^n(i)

$$P = \frac{1}{(m)}$$

$$= \frac{10}{0.5} = +2\,D$$ Ans

(ii) Given

$R_1 = 10$ cm

$R_2 = -15$ cm

$f = 12$ cm

$_1\mu_2 = {}_a\mu_g = ?$

$$\frac{1}{f} = (_1\mu_2 - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{12} = (\mu - 1)\left(\frac{1}{10} + \frac{1}{15}\right)$$

$$\frac{1}{12} = (\mu - 1)\left(\frac{5}{30}\right)$$

$$(\mu - 1) = \frac{6}{12} = \frac{1}{2}$$

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

$$\mu = 1 + \frac{1}{2} = \frac{3}{2} = 1.5$$

$$_1\mu_2 = {}_a\mu_g = {}_a\mu_l = 1.5$$ Ans

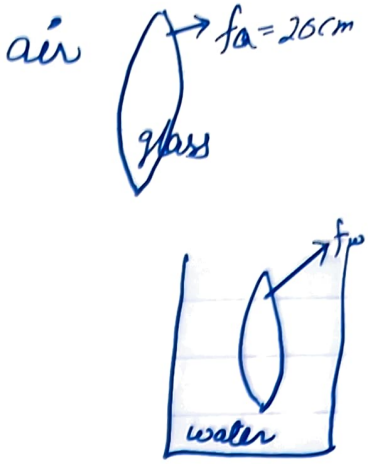
(iii) Given

$f_a = 20$ cm

$f_w = ?$

$a\mu_w = 1.33$

$a\mu_g = 1.5$



By Lens Maker's formula

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

In air

$$\frac{1}{f_a} = (a\mu_g - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad -(1)$$

In water

$$\frac{1}{f_w} = (w\mu_g - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad -(2)$$

$(1) \div (2)$

$$\frac{1/f_a}{1/f_w} = \frac{(a\mu_g - 1)}{(w\mu_g - 1)}$$

$$\frac{f_w}{f_a} = \frac{(1.5-1)}{\left(\frac{\mu_g}{\mu_w} - 1\right)} = \frac{0.5}{\left(\frac{1.5}{1.33} - 1\right)}$$

$$\frac{f_w}{f_a} = \frac{0.5}{\frac{1.5 - 1.33}{1.33}} = \frac{0.5 \times 1.33}{0.17}$$

$$f_w = \frac{0.5 \times 133}{17} \times f_a$$

$$= \frac{0.5 \times 133}{17} \times 20 = \frac{1330}{17}$$

$$f_w = 78.2 \text{ cm}$$

Focal length in water = 78.2 cm Ans

Example 9.8 Find the position of the image formed by the lens combination given in the Fig. 9.20.

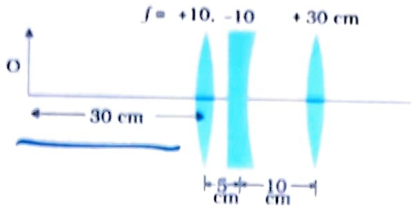
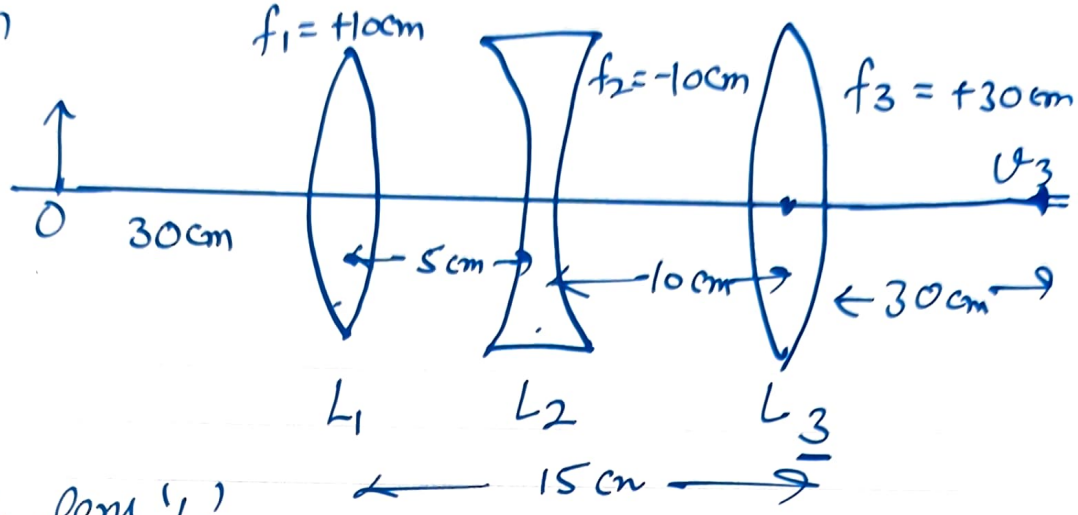


FIGURE 9.20

Soln



For lens 'L_1'

$u_1 = -30$ cm

$f_1 = +10$ cm

By $\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u_1} \Rightarrow \frac{1}{v_1} = \frac{1}{f_1} + \frac{1}{u_1}$

$\frac{1}{v_1} = \frac{3\times 1}{3\times 10} - \frac{1}{30} = \frac{2}{30}$ 15

or $v_1 = +15$ cm

For lens 'L_2'

$f_2 = -10$ cm

$u_2 = 10$ cm

OR

$\frac{1}{v_2} = \frac{1}{f_2} + \frac{1}{u_2} = \frac{1}{-10} + \frac{1}{10} = 0$

$v_2 = \infty$

As $u = f$, object is at focus F, so image is formed at ∞.

i.e $v_2 = \infty$

Image is formed at ∞

For lens 'L_3'

$u_3 = \infty$

$f_3 = +30\,cm$

$v_3 = ?$

OR

$$\frac{1}{v_3} = \frac{1}{f_3} + \frac{1}{u_3}$$

$$\frac{1}{v_3} = \frac{1}{30} + \frac{1}{\infty} = \frac{1}{30}$$

$$v_3 = 30\,cm$$

As object for L_3 is at ∞, so image is formed at focus. i.e at f_3 distance.

$$v_3 = 30\,cm \quad Ans$$