1. **A lens has power of – 2.5 D. What is the focal length and nature of the lens?**

Sol. $P = -2.5D, \quad f = ?$

From relation, $P = \frac{1}{f}$

$$f = \frac{1}{p} = \frac{1}{-2.5} = -0.4 \text{ m} = -40 \text{ cm}$$

Negative sign indicates that it is a concave lens.

2. **A doctor has prescribed a corrective lens of power + 1.5 D. Find the focal length of the lens. Is the prescribed lens diverging or converiging? [NCERT]**

Sol. $p = +1.5 \text{ D}$

$$f \text{ (in metres)} = \frac{1}{P} = \frac{10}{15} = \frac{2}{3} \text{m} = 66.6\text{cm}$$

As the focal length and power of the lens is positive therefore, lens is a convex (converging lens).

3. **A person with a myopic eye cannot see beyond 1.2 m distinctly. What should be the nature of the corrective lens used to restore proper vision?**

Sol. Corrective lens required is 'concave lens' of suitable power to restore proper vision. In this cases,

$u = -\infty, \quad v = -1.2\text{m}$

Using lens formula, $\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{-1.2\text{m}} - \frac{1}{\infty} = -\frac{1}{1.2\text{m}}$

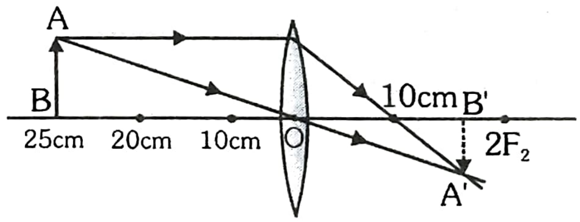
$f = -1.2\text{m}$

Power of lens, $P = -\frac{1}{1.2\text{m}} = -\frac{1}{1.2}\text{D} = -0.83 \text{ D}.$

4. **An object 5 cm in length is held 25 cm away from a converging lens of focal length 10 cm. Draw the ray diagram and find the position, size and the nature of the image formed. [NCERT]**

Sol. $f = +10 \text{ cm}$

$u = -25 \text{ cm}$



Using lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{10} = \frac{1}{v} - \left(\frac{1}{-25}\right)$$

$$\frac{1}{v} = \frac{1}{10} - \frac{1}{25}$$

$$\frac{1}{v} = \frac{3}{50} \text{ cm}$$

$$\Rightarrow v = \frac{50}{3} = 16.7 \text{ cm}$$

The image is real at a distance of 16.7 cm behind the lens.

$$m = \frac{h'}{h} = \frac{v}{u}$$

$$\frac{h'}{5} = \frac{50/3}{-25} \Rightarrow h' = \frac{50/3 \times 5}{-25} = -\frac{10}{3} \text{ cm}$$

Height of the image is 3.3 cm in height.

5. The refractive index of diamond is 2.47 and that of glass is 1.51. How much faster does light travel in glass than in diamond?

Sol. Let n_1 and n_2 be the refractive indices and v_1 and v_2 be the velocity of light in diamond and glass respectively, then

$$n_1 = \frac{c}{v_1} \text{ or } v_1 = \frac{c}{n_1} = \frac{3\times10^8 \text{ m/s}}{2.47} = 1.215 \times 10^8 \text{ m/s}$$

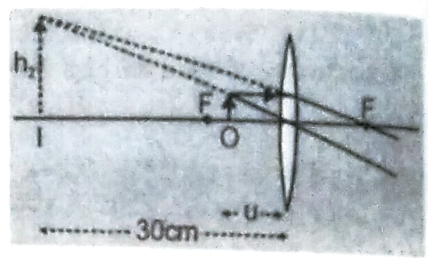
$$n_2 = \frac{c}{v_2} \text{ or } v_2 = \frac{c}{n_2} = \frac{3\times10^8 \text{ m/s}}{1.51} = 1.987 \times 10^8 \text{ m/s}$$

$$v_2 - v_1 = (1.987 - 1.215) \times 10^8 = 0.772 \times 10^8 \text{ m/s}$$
$$= 7.72 \times 10^7 \text{ m/s}$$

Thus light travels 7.72×10^7 m/s faster in glass than diamond.

6. A magnifying lens has a focal length of 10 cm. (a) Where should the object be placed if the image is to be 30 cm from the lens ? (b) What will be the magnification ?

Sol. (a) In case of magnifying lens, the lens is convergent and the image is erect, enlarged, virtual, between infinity and object and on the same side of lens.



$f = 10$ cm and $v = -30$ cm

and hence from lens-formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

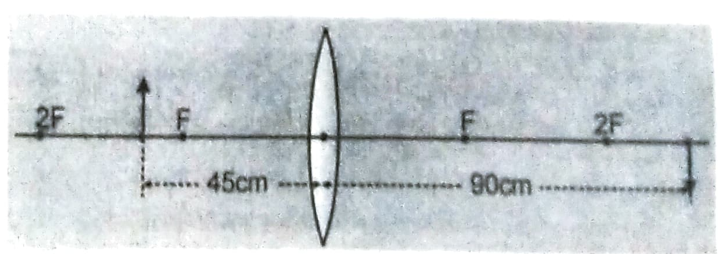
we have $\frac{1}{-30} - \frac{1}{u} = \frac{1}{10}$ i.e., $u = -7.5$ cm

So the object must be placed in front of lens at a distance of 7.5 cm (which is < f) from it.

(b) $m = \left[\frac{h_2}{h_1}\right] = \frac{v}{u} = \frac{-30}{-7.5} = 4$ i.e., image is erect, virtual and four times the size of object.

7. An object 25 cm high is placed in front of a convex lens of focal length 30 cm. If the height of image formed is 50 cm, find the distance between the object and the image ?

Sol. As object is in front of the lens, it is real and as



$h_1 = 25$ cm, $f = 30$ cm, $h_2 = -50$ cm

$$m = \frac{h_2}{h_1} = \frac{-50}{25} = -2$$

$$m = \frac{f}{f+u} \Rightarrow -2 = \frac{30}{30+u}$$

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

As in this situation object and image are on opposite sides of lens, the distance between object and image $d_1 = u + v = 45 + 90 = 135$ cm

If the image is erect (i.e., virtual)

$$m = \frac{f}{f+u} \Rightarrow 2 = \frac{30}{30+u} \Rightarrow u = -15 \text{ cm} \Rightarrow m = -\frac{v}{u} \Rightarrow 2 = \frac{-v}{-15} \Rightarrow v = 30 \text{ cm.}$$

As in the situation both image and object are in front of the lens, the distance between object and image $d_2 = v - u = 30 - 15 = 15$ cm

11. A tank is filled with water to a height of 12.5 cm. The apparent depth of a needle lying at the bottom of the tank is measured by a microscope to be 9.4 cm. What is the refractive index of water? If water is replaced by a liquid of refractive index 1.63 upto the same height. What will be apparent depth ?

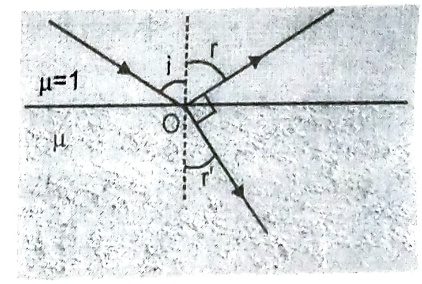
Sol. Here, real depth = 12.5 cm; apparent depth = 9.4 cm; μ = ?

$$\because \quad \mu = \frac{\text{real depth}}{\text{apparent depth}} \qquad \therefore \quad \mu = \frac{12.5}{9.4} = 1.33$$

Now, in the second case, $\mu = 1.63$, real depth = 12.5 cm; apparent depth d_{ap} = ?

$$\therefore \quad 1.63 = \frac{12.5}{d_{ap}} \qquad \Rightarrow \qquad d_{ap} = \frac{12.5}{1.63} = 7.67 \text{ cm}$$

12. A ray of light is incident on a transparent glass slab of refractive index 1.62. If the reflected and refracted rays are mutually perpendicular, what is the angle of incidence ? [$\tan^{-1}(1.62) = 58.3°$]



Sol. According to given problem, $\quad r + 90° + r' = 180°$

i.e, $\quad r' = 90° - r$

or $\quad r' = (90° - i) \qquad [\because \angle i = \angle r]$

And as according to Snell's law

$1 \sin i = \mu \sin r'$

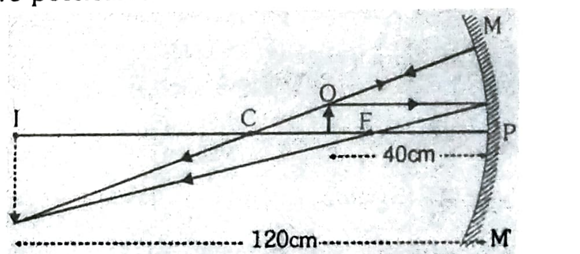
$\sin i = \mu \sin(90 - i) \qquad \Rightarrow \qquad \sin i = \mu \cos i \; [\because \quad \sin(90 - i) = \cos i]$

or $\quad \tan i = \mu \qquad$ or $\quad i = \tan^{-1}\mu = \tan^{-1}(1.62) = 58.3°$

13. The focal length of a concave mirror is 30cm. Find the position of the object in front of the mirror, so that the image is three times the size of the object.

Sol. As the object is in front of the mirror it is real and for real object the magnified image formed by concave mirror can be inverted (i.e.,real) or erect (i.e.,vitual), so there are two possibilities.

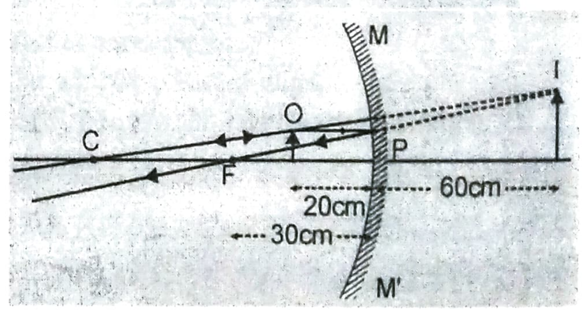
(a) If the image is inverted (i.e., real)



$$m = \frac{f}{f-u} \Rightarrow -3 = \frac{-30}{-30-u} \Rightarrow u = -40 \text{ cm}$$

Object must be at a distance of 40 cm in front of the mirror (in between C and F).

(b) If the image is erect (i.e., virtual)



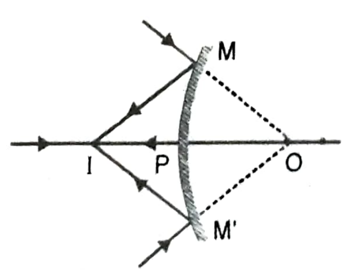
$$m = \frac{f}{f-u}$$

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

Object must be at a distance of 20 cm in front of the mirror (in between F and P).

14. A beam of light converges towards a point O, behind a convex mirror of focal length 20 cm. Find the nature and position of image if the point O is (a) 10 cm behind the mirror (b) 30 cm behind the mirror.

Sol. (a) For this situation object will be virtual as shown in figure.



Here u =+10 cm and f = +20 cm.

$$\therefore \quad \frac{1}{v} + \frac{1}{+10} = \frac{1}{+20} \qquad \text{i.e.,} \quad v = -20 \text{ cm}$$

i.e., the image will be at a distance of 20 cm in front of the mirror and will be real, erect and enlarged with

$$m = -\left[-\frac{20}{10}\right] = +2$$

(b) For this situation also object will be virtual as shown in Figure.

09
14
10

Here, $u = +30$ cm and $f = +20$ cm

$\therefore \quad \frac{1}{v} + \frac{1}{+30} = \frac{1}{+20}$ i.e., $v = +60$ cm

i.e.,the image will be at a distance of 60 cm behind the mirror and will be virtual, inverted and enlarged with $m = -\left[+\frac{60}{30}\right] = -2$

15. An object of size 7.0cm is placed at 27cm in front of a concave mirror of focal length 18cm. At what distance from the mirror should a screen be placed, so that a sharp focussed image can be obtained? Find the size and the nature of the image. [NCERT]

Sol. Mirror : concave $u = -27\text{cm},\ f = -18\text{cm},\ v = ?$

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

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-18} + \frac{1}{27} = \frac{-3+2}{54} = -\frac{1}{54}\text{ cm}$$

$v = -54\text{cm}$

The screen should be placed at a distance of 54cm from the mirror in front of it.

$$m = -\frac{v}{u} = -\frac{-54}{-27} = -2$$

Image is real and magnified, two times the object $-2 = \frac{h'}{h}$

$h' = -2 \times 7\text{cm} = -14\text{cm}$ high

The image is real, inverted, enlarged and 14 cm high.

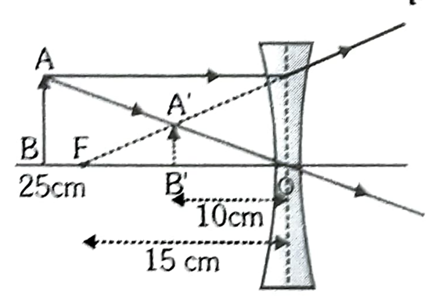
16. A concave lens of focal length 15 cm forms an image 10 cm from the lens. How far is the object placed from the lens? Draw the ray diagram – [NCERT]

Sol. Using lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{-10\text{cm}} - \frac{1}{u} = \frac{1}{-15\text{cm}}$$

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

$u = -30\text{cm}$



Thus, the object is placed at a distance of 30 cm from concave lens.

17. An object 5.0 cm in length is placed at a distance of 20 cm in front of a convex mirror of radius of curvature 30 cm. Find the position of the image, its nature and size. [NCERT]

Sol. Radius of curvature of convex mirror (R) = 30 cm

$\therefore$ Focal length of convex mirror (f) $= \frac{R}{2} = \frac{30\text{cm}}{2} = 15$ cm

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

Object distance, $u = -20\text{cm}$

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{15} + \frac{1}{20} = \frac{4+3}{60} = \frac{7}{60}\text{ cm}$$

$$v = \frac{60}{7}\text{ cm} = 8.57\text{cm}$$

The image is virtual, behind the mirror and erect.

$$m = \frac{h'}{h} = -\frac{v}{u} = \frac{h'}{5\text{cm}} = \frac{-60/7\text{cm}}{-20\text{cm}} \Rightarrow h' = \frac{-60/7\text{cm} \times 5\text{cm}}{-20\text{cm}} = \frac{3}{7} \times 5\text{cm} = \frac{15}{7}\text{ cm}$$

$h' = +2.14\text{cm}$ [It is erect and diminished].

18. The near point of a certain eye is 100 cm in front of the eye. What lens should be used to see clearly an object 25 cm in front of the eye?

Sol. $u = -25\text{cm}, \quad v = -100\text{cm}$

using lens formula, $\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{-100\text{cm}} - \frac{1}{-25\text{cm}} = \frac{-1+4}{100\text{cm}} = \frac{3}{100}\text{cm}$

$f = \frac{100}{3}\text{cm} = 33.3\text{cm}$

Hence a converging lens of focal length 33.3 cm is required.

19. Light enters from air to glass having refractive index 1.50. What is the speed of light in the glass? The speed of light in vacuum is 3×10^8 m/s.

Sol. Refractive index $\mu_g = 1.5$

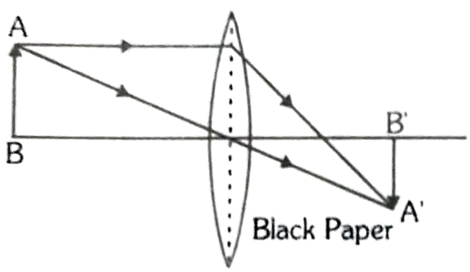
Speed of light in vacuum $c = 3 \times 10^8$ m/s

Speed of light in glass, $v = ?$

$$\mu_g = \frac{c}{v}$$

$$v = \frac{c}{\mu_g} = \frac{3 \times 10^8}{1.5} = 2 \times 10^8 \text{ m/s}$$

20. One-half of a convex lens is covered with a black paper. Will this lens produce a complete image of the object? Verify your answer experimentally. Explain your observations. [NCERT]



Sol. Yes, it wil produce a complete image of the object, as shown in fig. This can be verified experimentally by observing the image of a distance object like tree on a screen, when lower half of the lens is covered with a black paper. However, the intensity of brightnes of image will reduce.

21. An object is placed at a distance of 10 cm from a convex mirror of focal length 15 cm. Find the position and nature of the image. [NCERT]

Sol. Here, object distance, $u = -10$ cm forcal length, $f = 15$ cm, Image distance, $v = ?$

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

$\therefore \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{15} + \frac{1}{10} = \frac{2+3}{30} = \frac{5}{30} = \frac{1}{6}, \quad v = 6$ cm

Here, + sign of v indicates that image is at the back of the mirror. It must be virtual, erect and smaller in size than the object.

22. The magnification produced by a plane mirror is +1. What does this mean? [NCERT]

Sol. As $m = \frac{h_2}{h_1} = +1$, $h_2 = h_1$

i.e., size of image is equal to size of the object. Further, + sign of m indicates that the image is erect and hence virtual.

23. Find the focal length of a lens of power – 2.0 D. What type of lens is this? **[NCERT]**

Sol. Here, focal length f = ?, power P = – 2.0 D

As $f = \frac{100}{P}$

$\therefore \quad f = \frac{100}{-2.0} = -50$ cm.

24. A person needs a lens of power –5.5 dioptres for correcting his distant vision. For correcting his near vision he needs a lens of power + 1.5 dioptre. What is the focal length of the lens required for correcting (i) distant vision, and (ii) near vision? **[NCERT]**

25. The far point of a myopic person is 80 cm in front of the eye. What is the nature and power of the lens required to correct the problem?

Sol. Distance of far point, x = 80 cm, P = ?

For viewing distant objects, focal length of corrective lens,

$f = -x = 80$ cm

$P = \frac{100}{f} - \frac{100}{-80} = -1.25$ D. The lens is concave.

26. Make a diagram to show how hypermetropia is corrected. The near point of a hypermetropic eye is 1 m. What is the power of the lens required to correct this defect? Assume that the near point of the normal eye is 25 cm. **[NCERT]**

Sol. Make diagram yourself

Here, x' = 1 m = 100 cm, d = 25, f = ?

From $f = \frac{x'd}{x'-d}$

$f = \frac{100 \times 25}{100 - 25} = 33.3$ cm

$P = \frac{100}{f} = \frac{100}{33.3} = 3D$

27. Why is a normal eye not able to see clearly the objects placed closer than 25 cm? [NCERT]

Sol. This is because the focal length of eye lens cannot be decreased below a certain minimum limit.