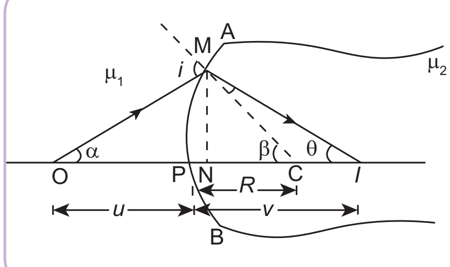
# 9.5 REFRACTION FROM SPHERICAL SURFACES



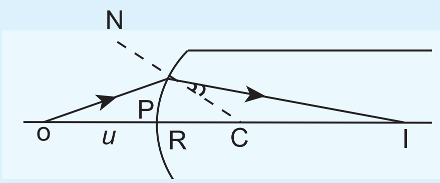

When light passes from a medium of refractive index $\mu_1$ to a medium of refractive index $\mu_2$ through a spherical surface of radius of curvature $R$ then the relation between object distance ($u$) and image distance ($v$) is given by,

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

**Note:** Put values with proper sign convention.

**A small point object is placed at O, which is at a distance of 0.60 metres in the air from a convex spherical surface of refractive index 1.5. If the radius of the curvature is 25 cm, then what is the position of the image on the principal axis?**

**SOLUTION**




$u = -0.6\ m$

Refractive index of spherical surface $(\mu_2) = 1.5$

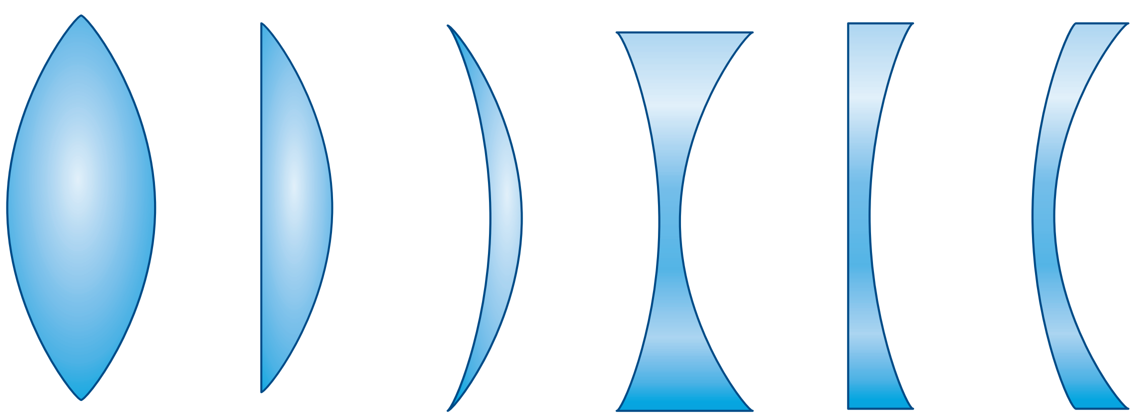
Refractive index of air $(\mu_1) = 1$

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

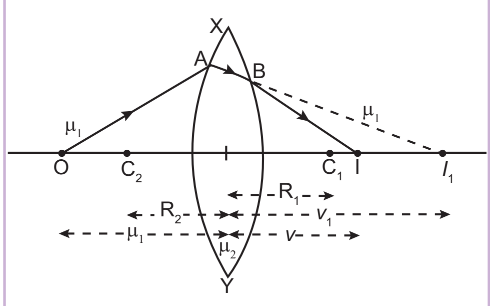
$$\frac{1.5}{v} - \frac{1}{(-0.6)} = \frac{1.5-1}{0.25}$$

$\therefore v = 4.5$ m

# 9.6 THIN LENS



## 9.6.1 LENS MAKER'S FORMULA




The Lens maker formula is used to construct a lens with a specified focal length. A lens has two curved surfaces, but these are not exactly the same. If we know the refractive index "of the material of lens and the medium surrounding the lens"and the radius of the curvature of both the surface, then we can determine the focal length of the lens by using the given lens maker's formula,

$$\frac{1}{f}=(\mu_{21}-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \quad \left[\text{where } \mu_{21}=\frac{\mu_2}{\mu_1}\right]$$

**Note:** Put values with proper sign convention

Thick lenses give coloured images due to dispersion. The variety in the colour of objects we see around us is due to the constituent colours of the light incident on them.

NCERT Highlights

**When a biconvex lens of glass having a refractive index of 1.47 is dipped in a liquid, it acts as a plane sheet of glass. This implies that the liquid must have a refractive index** **(AIPMT 2006)**

**(a) equal to that of glass** **(b) less than one**

**(c) greater than that of glass** **(d) less than that of glass**

**SOLUTION**

Refractive index of the glass of the biconvex lens, $\mu_g=1.47$

From the lens maker's formula, we have,

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

where, $\mu_L$ is the refractive index of liquid in which lens is dipped.

According to the question, when the biconvex lens is dipped in liquid then it acts a plane sheet of glass, which means, $f=\infty$ . So,

$$\frac{1}{f}=0$$

$$\therefore \mu_L=\mu_g$$

Hence, option (a) is correct.

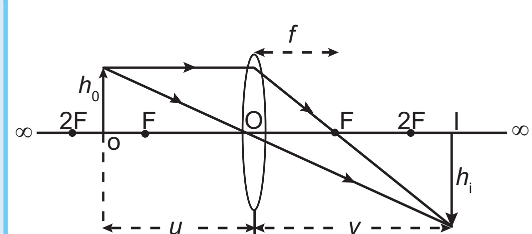
## 9.6.2 LENS FORMULA

The focal length of a lens is given by the relation:

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

Magnification, $m=\frac{h_i}{h_0}=\frac{v}{u}$

**Note:** Put values with proper sign convention



**Where should an object be placed in front of a convex lens to obtain an image on the same side of the object at a distance of 30 cm from the lens? Also, find magnification. (Focal length of the convex lens is 10 cm)**

**SOLUTION**

The focal length of the convex lens,

$f = 10$ cm

Image distance, $v = -30$ cm

Using the lens formula, we have

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

$$\frac{1}{u} = \frac{1}{v} - \frac{1}{f} = -\frac{1}{30} - \frac{1}{10}$$

$$u = -\frac{30}{4} = -7.5 \text{ cm}$$

Hence, the object should be placed at the distance of 7.5 cm from the lens.

Magnification, $m = \dfrac{v}{u} = \dfrac{-30}{-7.5} = 4$

# 9.7 POWER OF A LENS

Power of the a lens is defined as the reciprocal of focal length in metre, that is,

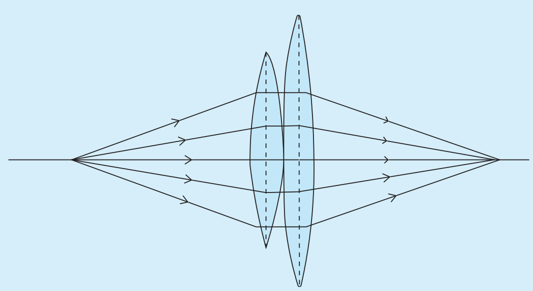
$$P = \frac{1}{f}$$

The SI unit of power of the lens is dioptre (D).

The equivalent power for a system, where two thin lenses sharing an axis are kept in contact with each other, is given by the following formula:

$$P = P_1 + P_2$$

The focal length of the combination, $\dfrac{1}{f} = \dfrac{1}{f_1} + \dfrac{1}{f_2}$



Compound Lens

## Beyond NCERT

If two thin coaxial lenses are placed at a small separation $d$

The focal length of the combination is given by:

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

The power of the combination is given by:

$$P = P_1 + P_2 - P_1 P_2 d$$