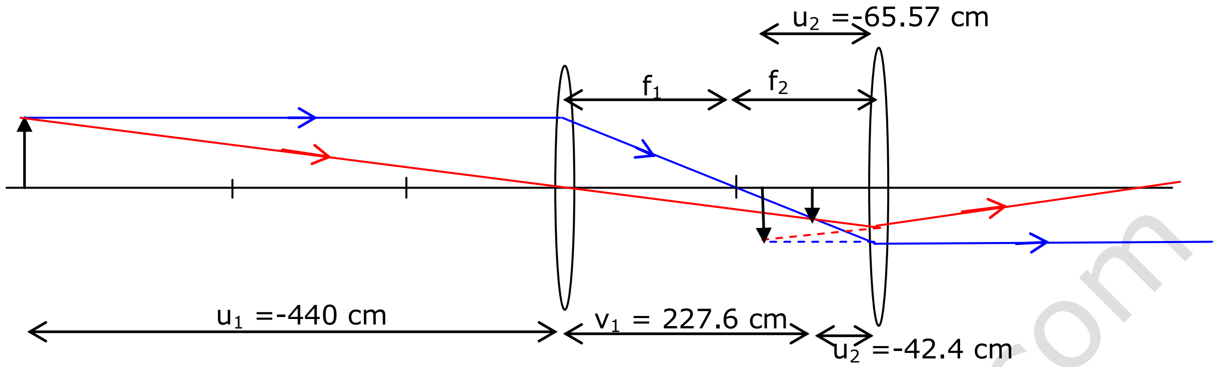
Q- Two convex lenses are separated by the sum of their focal lengths. The first lens has a focal length of 150cm, while the second has a focal length of 120 cm. If a 10 cm high object is placed 440 cm from the first lens, determine the final image position relative to the 150 cm lens, the final image height and orientation.



The relation between the object distance u, image distance v and the focal length f for a lens is given by

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

The sign convention is

1. All distances are measured from the optical center of the lens or pole of the mirror.
2. The distances measured in the direction of the incident rays are taken positive and in the direction opposite to that of incident rays are taken negative.
3. The lengths (object or image) measured above the principle axis are taken positive and in lower half plane are negative.
4. The focal length of converging lens is positive.

1) Now for the first lens u_1 = - 440 cm, v_1 =? and f = 150 cm gives

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}\Rightarrow\frac{1}{150}=\frac{1}{v_1}-\frac{1}{-440}\Rightarrow\frac{1}{v_1}=\frac{1}{150}-\frac{1}{440}=\frac{44-15}{6600}=\frac{29}{6600}$$

Or v_1 = 6600/29 = 227.6 cm

The image distance is positive means that the image is formed on the right side of the lens.

2) The magnification is given by

M = v/u = (6600/29)/(-440) = - 15/29 = - 0.517

(Magnification is negative means the image is inverted)

3) The image formed by the first lens will behave as an object for the second lens. The distance between the two lenses is 150+120 = 270 cm and the image formed by the first lens is 227.6 cm hence the object distance for the second lens is given by

u_2 = - (270 – 227.6) = - 42.4 cm.

4) The image distance for the second lens is given by the lens formula as

$$\frac{1}{f_2}=\frac{1}{v_2}-\frac{1}{u_2}\Rightarrow\frac{1}{120}=\frac{1}{v_2}-\frac{1}{-42.4}\Rightarrow\frac{1}{120}=\frac{1}{v_2}+\frac{1}{42.4}\Rightarrow\frac{1}{v_2}=\frac{1}{120}-\frac{1}{42.4}$$

Or $v_2 = -65.57$ cm

(Negative sign shows that the image is in front of the second lens.)

5) The magnification of the second image is given by

$M_2 = v_2/u_2 = (-65.57)/(-42.4) = 1.55$

Positive magnification means the image is erect of the inverted first image, means inverted as the first image.

Hence final image will be

(a) Real, between the two lens at a distance of 270 - 65.57 = 204.43 cm from the first lens.

(b) The total magnification M is the product of M_1 and M_2 hence

$M = M_1*M_2 = -0.517*1.55 = -0.802$

Hence the height of the final image will be given by

$M = I/O$

Or $I = M*O = -0.802*10 = -8.02$ cm. The image is inverted and diminished.