Q- Two converging lenses, each with focal length 20 cm are separated by a distance of 60 cm. calculate the location of the final image of an object placed 90 cm in front of the first lens. Describe the properties of the image. Calculate the overall magnification.

When the object is placed with two lenses or a lens and a mirror, the image of the object formed by the first lens behaves as a virtual object for the second lens and thus we get image of this virtual object in the second lens.

For the first lens according to sing conventions $u_1$ = - 90 cm, $f_1$ = + 20 cm and $v_1$ =?

Substituting in the lens formula we get

$$\frac{1}{f_1}=\frac{1}{v_1}-\frac{1}{u_1}$$

Or $$\frac{1}{20}=\frac{1}{v_1}-\frac{1}{-90}$$

Or $$\frac{1}{v_1}=\frac{1}{20}-\frac{1}{90}=\frac{7}{180}$$

Or $v_1$ = 180/7 = 25.7 cm

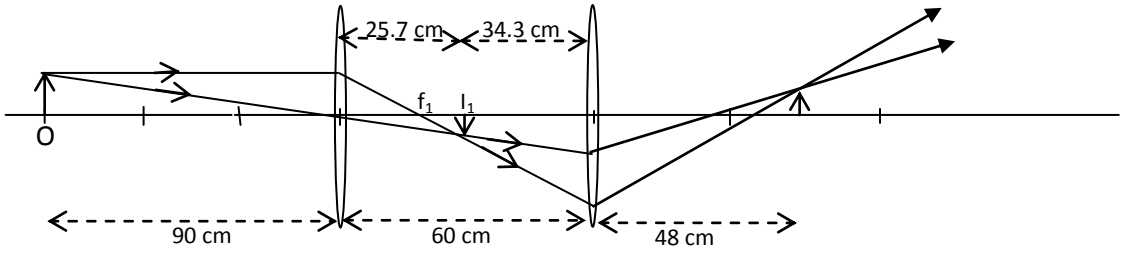
The positive sign shows that the image is on the other side of the lens and is 25.7 cm from the lens.

The magnification is given by

$$m_1=\frac{I_1}{O}=\frac{v_1}{u_1}=\frac{180/7}{-90}=-\frac{2}{7}$$

Hence the image length is 2/7 times the object length.

The negative sign of the magnification shows that the image is inverted.




This image $I_1$ will behave as an object for the second lens and its distance from the second lens is 60-(180/7) = 240/7 = 34.3 cm in front of the second lens. Thus for the second lens we have $u_2$ = - 240/7 cm, $f_2$ = 20 cm and $v_2$ =? Hence using the same formula we have

$$\frac{1}{f_2} = \frac{1}{v_2} - \frac{1}{u_2}$$

Or $$\frac{1}{20} = \frac{1}{v_2} - \frac{7}{-240}$$

Or $$\frac{1}{v_2} = \frac{1}{20} - \frac{7}{240}$$

Or $$\frac{1}{v_2} = \frac{12-7}{240} = \frac{5}{240} = \frac{1}{48}$$

Or $v_2 = 48$ cm

Hence the final image is 48 cm from the second lens on the other side. (60 +48 = 108 cm from the first)

As the image is on the other side of the lens system it will be real.

As the real image in a converging lens is inverted, the inverted image of the inverted first image will be erect. Thus the final image will be erect as compared to the object.

The magnification due to second lens is

$$m_2 = \frac{I_2}{I_1} = \frac{v_2}{u_2} = \frac{48}{-(240/7)} = -\frac{7}{5}$$

Thus the total magnification is given by

$m = m_1 * m_2 = (-2/7)*(-7/5) = 2/5$

Thus the final image is 2/5 = 0.4 times of the object. (m is less than one means the final image is diminished) and it is erect.