Q- A convex and a concave lens, each of focal length 10 cm are placed at a distance of 10 cm from each other. An object is placed at a distance of 20 cm in front of the convex lens. Find the position of final image and discuss the properties of the final image.

Here 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.

a) For the first lens according to sing conventions u_1 = - 20 cm, f_1 = + 10 cm and v_1 =?
Substituting in the lens formula we get

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

Or $$\frac{1}{10} = \frac{1}{v_1} - \frac{1}{-20}$$

Or $$\frac{1}{v_1} = \frac{1}{10} - \frac{1}{20} = \frac{1}{20}$$

Or v_1 = 20 cm

The positive sign shows that the image is on the other side of the lens and is 20 cm from the lens.

The magnification is given by

$$m_1 = \frac{I_1}{O} = \frac{v_1}{u_1} = \frac{20}{-20} = -1$$

Hence the image length is the same as the object. The negative sign of the magnification shows that the image is inverted.
(This result can be obtained directly as the object is at a distance twice of the focal length 2f from the converging lens, the image will be at the same distance on the other side, real, inverted and of the same size.)

This image I_1 will behave as virtual object for the second lens and its distance from the second lens is 20 - 10 = 10 cm behind the second lens. Thus for the second lens we have u_2 = + 10 cm, f_2 = - 10 cm and v_2 =? Hence using the same formula we have

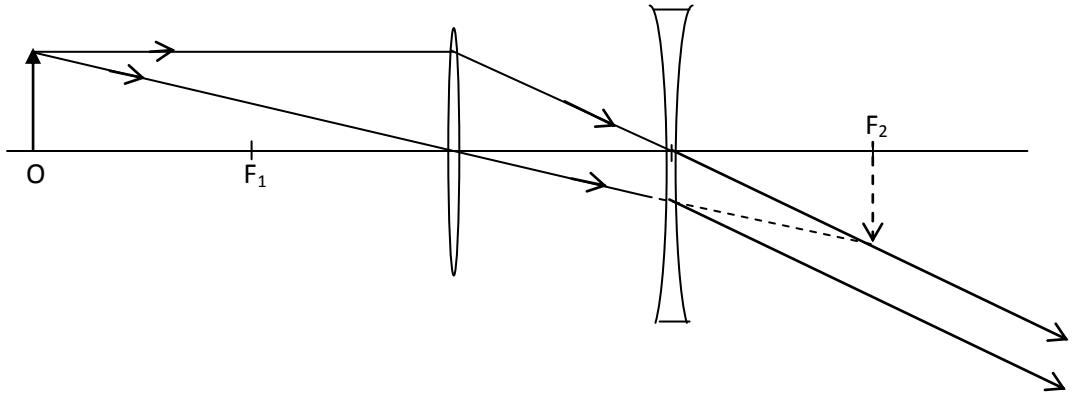
$$\frac{1}{f_2} = \frac{1}{v_2} - \frac{1}{u_2}$$

Or $$\frac{1}{-10} = \frac{1}{v_2} - \frac{1}{+10}$$

Or $$\frac{1}{v_2} = 0$$

Or $v_2 = \infty$

Hence the final image is at infinity.



(This result can be obtained directly as the light beam is converging to a point in focal plane of a diverging lens on the other side, the beam will become parallel and will meet at infinity and the final image will be at infinity.)

As the final image is at infinity we can't say that it is real or virtual.

As the final image is at infinity we can't say that it is erect or inverted.

The magnification due to second lens is

$$m_2 = \frac{I_2}{I_1} = \frac{v_2}{u_2} = \frac{\infty}{10} = \infty$$

Thus the total magnification is given by

$m = m_1 * m_2 =$ infinity

(Actually the magnification of the image seen by our eye in such cases is calculated by the ratio of the angle subtended by the image on eye and the angle subtended by the object, but here the length of the object is not given and thus calculation of angles is not possible. That type of problems we will learn with microscopes and telescopes)