623.

Problem 44.31 (RHK)

An object is placed 1.12 m *in front of a converging lens, of focal length* 58.0 cm, *which is* 1.97 m *in front of a plane mirror. We have to find* (a) *the distance of the final image measured from the lens, as seen by an eye looking toward the mirror through the lens*; (b) *whether the image is real or virtual*; (c) *whether the final image is upright or inverted*; (d) *the lateral magnification of the final image*.

Solution:

(a)

The converging lens of focal length 0.58 m will form the image of the object, which is placed at 1.12 m in front of it, at a distance i_1 from it. We use the thin lens formula.

We find

$$\frac{1}{1.12\ \text{m}}+\frac{1}{i_1}=\frac{1}{0.58\ \text{m}},$$

or

$$i_1=\frac{1.12\times 0.58}{0.54}\ \text{m}=1.20\ \text{m}.$$

This image will be real and inverted. It is given that a plane mirror is place to the right of the lens at a distance of 1.97 m from it. The image of the object formed by the converging lens will, therefore, be reflected by the plane mirror, which is at a distance $(1.97 - 1.20 = 0.77)$ m from it. Thus a virtual image is formed behind the mirror at a distance $(1.97 + 0.77 = 2.74)$ m from the converging lens. The image although is virtual, but to an observer looking at the mirror it will behave like a real object placed at a distance of 2.74 m from, as the rays from the virtual image appear to converge on the converging lens. The lens will form an image of the virtual image behind the plane mirror, say at a distance i_2 from it. We find i_2 using the thin lens formula. We have

$$\frac{1}{2.74 \text{ m}} + \frac{1}{i_2} = \frac{1}{0.58 \text{ m}},$$

or

$$i_2 = \frac{2.74 \times 0.58}{2.16} \text{ m} = 0.736 \text{ m}.$$

The image will be formed at a distance of 73.6 cm to the left of the lens, which is facing the mirror.

We can now answer the parts (b), (c), and (d) of the problem.

(b) The final image will be real.

(c) As the final image is formed by the lens of an inverted object, it will be upright.

(d) The lateral magnification of the final image will be

$$m = m_1 m_2 m_3 = \left(-\frac{1.20}{1.12} \right) \times (1) \times \left(-\frac{0.736}{2.74} \right) = 0.288.$$