Answer on Question #55829, Physics / Optics

A fruit fly of height H sits in front of lens 1 on the central axis through the lens. The lens forms an image of the fly at a distance d = 30 cm from the fly; the image has the fly's orientation and height H_I = 2.5 H. What are (a) the focal length f_1 of the lens and (b) the object distance p_1 of the fly?

The fly then leaves lens 1 and sits in front of lens 2, which also forms an image at d = 30 cm that has the same orientation as the fly, but now H_I = 0.86 H. What are (c) f_2 and (d) p_2?

Solution:

Definitions of the terms :

p = object distance

i = image distance

d = distance between image and object

f = focal length

m = magnification

In this case m > +1, and we know that lens 1 is converging (producing a virtual image), so that our result for focal length should be positive.

Since

$$|i_1 + p_1| = d$$

and

$$m = -\frac{i_1}{p_1} = 2.5$$

we find

$$i_1 = -2.5p_1$$

$$|-2.5p_1 + p_1| = d$$

$$p_1 = \frac{d}{1.5} = \frac{30}{1.5} = 20 \text{ cm}$$

and

$$i_1 = -2.5 * 20 = -50 \text{ cm}$$

Thin lens equation

$$\frac{1}{p_1} + \frac{1}{i_1} = \frac{1}{f_1}$$

sign rules

p is positive = object is in front of the lens

i is negative = image is on the same side of the object (virtual image !)

f is positive = converging lens

Substitute the values, you get ,

$$\frac{1}{20} - \frac{1}{50} = \frac{1}{f_1},$$

$$\frac{3}{100} = \frac{1}{f_1}$$

$$f_1 = \frac{100}{3} = +33.3 \text{ cm}$$

(c) In this case 0 < m < 1 and we know that lens 2 is diverging (producing a virtual image), so that our result for focal length should be negative. Since $|p_2 + i_2| = 30$ cm and

$$i_2 = -0.86p_2,$$

we find

$$|p_2 - 0.86p_2| = 30 \text{ cm}$$

$$p_2 = \frac{30}{0.14} = 214.29 \text{ cm}$$

and

$$i_2 = -0.86 * \frac{30}{0.14} = -184.29 \text{ cm}$$

Substituting these into Thin lens equation leads to

$$\frac{0.14}{30} - \frac{0.14}{30 * 0.86} = \frac{1}{f_2},$$

$$-\frac{49}{64500} = \frac{1}{f_2}$$

$$f_2 = -\frac{64500}{49} = -1316.33 \text{ cm}$$

Answer: (a) $f_1 = \frac{100}{3} = +33.3$ cm; (b) $p_1 = 20$ cm

(c) $f_2 = -1316.33$ cm; (d) $p_2 = 214.29$ cm

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