SAMPLE PROBLEM 4 Locating the Image

A small toy building block is placed 7.2 cm in front of a lens. An upright, virtual image of magnification 3.2 is noticed (Figure 7). Where is the image located?

SAMPLE PROBLEM 5 Finding the Magnification of a Diverging Lens

A coin of height 2.4 cm is placed in front of a diverging lens. An upright, virtual image of height 1.7 cm is noticed on the same side of the lens as the coin (Figure 8). What is the magnification of the lens?

$h_o = 2.4\,cm$

$h_i = 1.7\,cm$

$M = \frac{h_i}{h_o}$

$M = \frac{1.7\,cm}{2.4\,cm}$

$M = 0.7083$

$M \doteq 0.71$

no units

∴ The magnification of the lens is 0.71.

+

1. A converging lens has a focal length of 23 cm. A frog is (object) 32 cm from the lens. Use the thin lens equation to calculate where the image of the frog will be located.

$d_i = ?$

$f = 23\text{ cm}$

$d_o = 32\text{ cm}$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$\frac{1}{23} = \frac{1}{32} + \frac{1}{d_i}$$

$$\frac{1}{23} - \frac{1}{32} = \frac{1}{d_i}$$

$$0.01222 = \frac{1}{d_i}$$

$$0.01222\, d_i = 1$$

$$d_i = \frac{1}{0.01222}$$

$$d_i = 81.7778$$

$$d_i \doteq 81.8\text{ cm}$$

∴ The image will be located 81.8 cm on the opposite side of the object.

2. A pencil is located 53 cm from a diverging lens. An upright, virtual (object) image of the pencil is observed 18 cm from the lens. Use the thin lens equation to calculate the focal length of this lens.

f

$d_o = 53\text{ cm}$

$d_i = -18\text{ cm}$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$\frac{1}{f} = \frac{1}{53} - \frac{1}{18}$$

$$\frac{1}{f} = -0.03669$$

$$1 = -0.03669\, f$$

$$\frac{1}{-0.03669} = f$$

$$-27.3\text{ cm} = f$$

∴ The focal length of the diverging lens is 27.3 cm

3. A diverging lens has a focal length of 34 cm. An upright, virtual image of a small booklet is located 13 cm behind the lens. Where is the booklet located? d_i

d_o

$f = -34\text{cm}$ $\quad d_i = -13\text{cm}$

$d_o = ?$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$\frac{1}{-34} = \frac{1}{d_o} - \frac{1}{13}$$

$$\frac{1}{13} - \frac{1}{34} = \frac{1}{d_o}$$

$$0.0975 = \frac{1}{d_o}$$

$$d_o = \frac{1}{0.0975}$$

$d_o = 21.05\text{cm}$

∴ The booklet is located 21cm behind the lens

4. A converging lens has a focal length of 16 cm. An insect is located 11 cm from the lens. Where will the image of the insect be located?

d_i

$f = 16\text{cm}$ $\quad d_i = ?$

$d_o = 11\text{cm}$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$\frac{1}{16} = \frac{1}{11} + \frac{1}{d_i}$$

$$\frac{1}{16} - \frac{1}{11} = \frac{1}{d_i}$$

$$-0.0284 = \frac{1}{d_i}$$

$$d_i = \frac{1}{-0.0284}$$

$d_i = -35.2$

∴ The image will be located 35.2 cm behind the lens on the same side as the object

5. A vase of height 12 cm is placed in front of a converging lens. An inverted image of height 35 cm is noticed on the other side of the lens. TA C

   (a) Use the magnification equation to calculate the magnification of the lens.

   (b) What type of image is it?

$h_o = 12\text{ cm}$ → inverted

$h_i = -35\text{ cm}$

a) $M = \frac{h_i}{h_o}$

$= \frac{-35}{12}$

$M = -2.91$

b) The image is real as it is on the other side of the lens.

6. A playing card of height 14 cm is placed in front of a converging lens. An inverted, real image of height 7.9 cm is noticed on the other side of the lens. What is the magnification of the lens? TA C

$h_o = 14\text{ cm}$

$h_i = -7.9$ → inverted.

$M = ?$

$M = \frac{h_i}{h_o}$

$M = \frac{-7.9}{14}$

$M = -0.56$

7. A postage stamp of height 2.8 cm is placed in front of a diverging lens. A virtual image of height 1.3 cm is noticed on the same side of the lens as the stamp. T/I C

   (a) What is the magnification of the lens?

   (b) What is the attitude of the image?

$h_o = 2.8\text{ cm}$

$h_i = 1.3\text{ cm}$

a) $M = ?$

$$M = \frac{h_i}{h_o}$$

$$= \frac{1.3}{2.8}$$

$$\boxed{M = 0.46}$$

b) The attitude is upright as magnification is positive.

8. A small fork is placed 9.4 cm in front of a lens. An upright, virtual image of the fork with a magnification of 5.6 times is observed. K/U T/I C

(a) Where is the image located? — $d_i = ?$

(b) What is the focal length for this lens? — $f = ?$

(c) What kind of lens is this? Explain. → converging or diverging?

$d_o = 9.4$

$M = +5.6$

↓ upright

a) $M = -\frac{d_i}{d_o}$

$5.6 = -\frac{d_i}{9.4}$

$5.6 \times 9.4 = -d_i$

$52.64 = -d_i$

$\boxed{-52.64 = d_i}$

The object is 52.64 cm on the same side of the lens.

b) $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

$\frac{1}{f} = \frac{1}{9.4} + \frac{1}{-52.64}$

$\frac{1}{f} = \frac{1}{9.4} - \frac{1}{52.64}$

$\frac{1}{f} = \frac{52.64 - 9.4}{(9.4)(52.64)}$

$\frac{1}{f} = \frac{43.24}{494.816}$

$f = \frac{494.816}{43.24}$

$f = 11.44\text{cm}$

c) The lens is converging as f is positive.