SNC2D — The Thin Lens Equation Problems Solutions

Thin Lens Equation: f - focal length, d_o - object distance, d_i - image distance; remember they must all be of the same units (all cm, all m, etc.)

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

Magnification Equation: d_o - object distance; d_i - image distance; h_o - object height, h_i - image height;

$$M = \frac{h_i}{h_o} \quad \text{or} \quad M = -\frac{d_i}{d_o} \qquad \text{(the negative sign means that the image is inverted)}$$

1. An object 25 cm away from a lens produces a focused image on a film 15 cm away. What is the focal length of the converging lens? (9.4 cm)

$d_i = 15$ cm, $d_o = 25$ cm, find f

$$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o} , \quad \frac{1}{f} = \frac{1}{15} + \frac{1}{25} , \quad \frac{1}{f} = 0.06667 + 0.04 = 0.10667$$

$$f = \frac{1}{0.10667} = 9.375 \text{ cm so the focal length is 9.4 cm (rounded)}$$

2. If the focal length of the lens in your camera is 2 cm, at what distance must objects be placed so that a focused image is produced on a piece of film set 3 cm from the lens? (6 cm)

$d_i = 3$ cm, $f = 2$ cm,

$$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o} , \quad \frac{1}{2} = \frac{1}{3} + \frac{1}{d_o} , \quad 0.50 = 0.333 + \frac{1}{d_o} , \quad 0.50 - 0.333 = 0.167 = \frac{1}{d_o}$$

$$d_o = \frac{1}{0.167} = 6 \text{ cm}$$

3. A tree 20 m high is located 40 m from the converging lens of focal length 8.0 cm.
(a) Calculate the distance from the lens to the image. (8.0 cm)
(b) Calculate the magnification. (0.0020)
(c) Calculate the height of the image of the tree. (4 cm, inverted)

$d_o = 40$ m $= 4000$ cm, $f = 8.0$ cm, $h_o = 20$ m $= 20000$ cm

(a) $$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o} , \quad \frac{1}{8} = \frac{1}{d_i} + \frac{1}{4000} , \quad 0.125 = \frac{1}{d_i} + 0.00025 , \quad 0.125 - 0.00025 = \frac{1}{d_i}$$

$$0.12475 = \frac{1}{d_i} , \quad d_i = \frac{1}{0.12475} = 8.0 \text{ cm}$$

(b) $$M = -\frac{d_i}{d_o} = -\frac{8}{4000} = -0.0020 \text{ (image is much smaller than object, and is inverted)}$$

(c) $$M = \frac{h_i}{h_o} , \quad -0.0020 = \frac{h_i}{20000} , \quad -0.0020 \times 20000 = h_i = -4 \text{ cm (negative means it is inverted)}$$

Lens Formula Practice Problems

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