Homework Solutions
11/14/2007

Problems

41.

$$\frac{1}{p_1}+\frac{1}{q_1}=\frac{1}{f_1}$$

$$\frac{1}{30cm}+\frac{1}{q_1}=\frac{1}{15cm}$$

$$\frac{1}{q_1}=\frac{2}{30cm}-\frac{1}{30cm}=\frac{1}{30cm}$$

$$q_1=30cm$$

$$p_2=40cm-30cm=10cm$$

$$\frac{1}{p_2}+\frac{1}{q_2}=\frac{1}{f_2}$$

$$\frac{1}{10cm}+\frac{1}{q_2}=\frac{1}{15cm}$$

$$\frac{1}{q_2}=\frac{1}{15cm}-\frac{1}{10cm}$$

$$\frac{1}{q_2}=\frac{2}{30cm}-\frac{3}{30cm}=\frac{-1}{30cm}$$

$$q_2=-30cm$$

$$M_1 = -\frac{q}{p} = -\frac{30cm}{30cm} = -1$$

$$M_2 = -\frac{q}{p} = -\frac{-30cm}{10cm} = 3$$

$$M_{total} = M_1 M_2 = (-1)(3) = -3$$

The overall magnification of the image is 3 and it is inverted from the original object.

43.

$$\frac{1}{4.00cm} + \frac{1}{q_1} = \frac{1}{8.00cm}$$

$$\frac{1}{q_1} = \frac{1}{8.00cm} - \frac{2}{8.00cm} = \frac{1}{-8.00cm}$$

$$q_1 = -8.00cm$$

$$p_2 = 6.00cm - (-8.00cm) = 14.00cm$$

$$\frac{1}{14.00cm} + \frac{1}{q_2} = \frac{1}{-16.00cm}$$

$$\frac{1}{q_2} = -\frac{1}{16.00cm} - \frac{1}{14.00cm} = -0.1339$$

$$q_2 = -7.47cm$$

$$M_1 = -\frac{q}{p} = -\frac{-8.00cm}{4.00cm} = 2$$

$$M_2 = -\frac{q}{p} = -\frac{-7.47cm}{14.00cm} = 0.533$$

$$M_{total} = M_1 M_2 = (+2)(+0.533) = +1.07$$

The position of the final image is 7.47 cm in front of the second lens because the negative image distance corresponds to an image in front of the lens. The overall magnification of the image is +1.07 so the image is upright and, virtual (since the overall image is on the same side of the second lens as the object --> negative image distance) and 1.07 cm tall.

44.

$$50.0cm - 31.0cm = 19.0cm$$

$$q_2 = -19.0cm$$

$$\frac{1}{p_2} + \frac{1}{-19.0cm} = \frac{1}{20.0cm}$$

$$\frac{1}{p_2} = \frac{1}{20.0cm} + \frac{1}{19.0cm} = 0.1026$$

$$p_2 = 9.74cm$$

$$q_1 = 50cm - 9.74cm = +40.26cm$$

$$\frac{1}{p_1} + \frac{1}{q_1} = \frac{1}{f_1}$$

$$\frac{1}{p_1} + \frac{1}{40.26cm} = \frac{1}{10.0cm}$$

$$\frac{1}{p_1} = \frac{1}{10.0cm} - \frac{1}{40.26cm} = 0.07516$$

$$p_1 = 13.3cm$$

$$M_{total} = M_1 M_2 = \left(-\frac{q_1}{p_1}\right)\left(-\frac{q_2}{p_2}\right) = \left(-\frac{40.26cm}{13.3cm}\right)\left(-\frac{-19.0cm}{9.74cm}\right)$$

$$M_{total} = -5.90$$

a. The original object should be located 13.3 cm in front of the left lens.

b. The overall magnification is –5.90.

c. The final image is inverted because $M<0$ and virtual since $q_2$ is negative.