40. We use Eq. 34-8 (and Fig. 34-11(d) is useful), with n_1 = 1.6 and n_2 = 1 (using the rounded-off value for air):

$$\frac{1.6}{p}+\frac{1}{i}=\frac{1-1.6}{r}$$

Using the sign convention for r stated in the paragraph following Eq. 34-8 (so that $r=-5.0$ cm), we obtain i = –2.4 cm for objects at p = 3.0 cm. Returning to Fig. 34-38 (and noting the location of the observer), we conclude that the tabletop seems 7.4 cm away.

41. (a) We use Eq. 34-10:

$$f=\left[(n-1)\left(\frac{1}{r_1}-\frac{1}{r_2}\right)\right]^{-1}=\left[(1.5-1)\left(\frac{1}{\infty}-\frac{1}{-20\text{ cm}}\right)\right]^{-1}=+40\text{ cm}.$$

(b) From Eq. 34-9,

$$i=\left(\frac{1}{f}-\frac{1}{p}\right)^{-1}=\left(\frac{1}{40\text{ cm}}-\frac{1}{40\text{ cm}}\right)^{-1}=\infty.$$

80. (a) The image from lens 1 (which has f_1 = +15 cm) is at i_1 = –30 cm (by Eq. 34-9). This serves as an "object" for lens 2 (which has f_2 = +8 cm) with $p_2 = d - i_1$ = 40 cm. Then Eq. 34-9 (applied to lens 2) yields i_2 = +10 cm.

(b) Eq. 34-11 yields $M = m_1m_2 = (-i_1/p_1)(-i_2/p_2) = i_1i_2/p_1p_2 = -0.75$.

(c) The fact that the (final) image distance is a positive value means the image is real (R).

(d) The fact that the magnification is a negative value means the image is inverted (I).

(e) The image is on the side opposite from the object (relative to lens 2).

81. (a) The image from lens 1 (which has f_1 = +8 cm) is at i_1 = 24 cm (by Eq. 34-9). This serves as an "object" for lens 2 (which has f_2 = +6 cm) with $p_2 = d - i_1$ = 8 cm. Then Eq. 34-9 (applied to lens 2) yields i_2 = +24 cm.

(b) Eq. 34-11 yields $M = m_1m_2 = (-i_1/p_1)(-i_2/p_2) = i_1i_2/p_1p_2 = +6.0$.

(c)The fact that the (final) image distance is a positive value means the image is real (R).

(d) The fact that the magnification is positive means the image is not inverted (NI).

(e) The image is on the side opposite from the object (relative to lens 2).

82. (a) The image from lens 1 (which has $f_1 = –6$ cm) is at $i_1 = –3.4$ cm (by Eq. 34-9). This serves as an "object" for lens 2 (which has $f_2 = +6$ cm) with $p_2 = d – i_1 = 15.4$ cm. Then Eq. 34-9 (applied to lens 2) yields $i_2 = +9.8$ cm.

(b) Eq. 34-11 yields $M = –0.27$.

(c) The fact that the (final) image distance is a positive value means the image is real (R).

(d) The fact that the magnification is a negative value means the image is inverted (I).

(e) The image is on the side opposite from the object (relative to lens 2).

83. To analyze two-lens systems, we first ignore lens 2, and apply the standard procedure used for a single-lens system. The object distance p_1, the image distance i_1, and the focal length f_1 are related by:

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

Next, we ignore the lens 1 but treat the image formed by lens 1 as the object for lens 2. The object distance p_2 is the distance between lens 2 and the location of the first image. The location of the final image, i_2, is obtained by solving

$$\frac{1}{f_2} = \frac{1}{p_2} + \frac{1}{i_2}$$

where f_2 is the focal length of lens 2.

(a) Since lens 1 is converging, $f_1 = +9$ cm, and we find the image distance to be

$$i_1 = \frac{p_1 f_1}{p_1 - f_1} = \frac{(20\text{ cm})(9\text{ cm})}{20\text{ cm} - 9\text{ cm}} = 16.4\text{ cm}.$$

This serves as an "object" for lens 2 (which has $f_2 = +5$ cm) with an object distance given by $p_2 = d – i_1 = –8.4$ cm. The negative sign means that the "object" is behind lens 2. Solving the lens equation, we obtain

$$i_2 = \frac{p_2 f_2}{p_2 - f_2} = \frac{(–8.4\text{ cm})(5.0\text{ cm})}{–8.4\text{ cm} - 5.0\text{ cm}} = 3.13\text{ cm}.$$

(b) Te overall magnification is $M = m_1 m_2 = (-i_1 / p_1)(-i_2 / p_2) = i_1 i_2 / p_1 p_2 = –0.31$.

(c) The fact that the (final) image distance is a positive value means the image is real (R).

(d) The fact that the magnification is a negative value means the image is inverted (I).

(e) The image is on the side opposite from the object (relative to lens 2).

Since this result involves a negative value for p_2 (and perhaps other "non-intuitive" features), we offer a few words of explanation: lens 1 is converging the rays towards an image (that never gets a chance to form due to the intervening presence of lens 2) that would be real and inverted (and 8.4 cm beyond lens 2's location). Lens 2, in a sense, just causes these rays to converge a little more rapidly, and causes the image to form a little closer (to the lens system) than if lens 2 were not present.

84. (a) The image from lens 1 (which has $f_1 = +12$ cm) is at $i_1 = +60$ cm (by Eq. 34-9). This serves as an "object" for lens 2 (which has $f_2 = +10$ cm) with $p_2 = d - i_1 = 7$ cm. Then Eq. 34-9 (applied to lens 2) yields $i_2 = -23$ cm.

(b) Eq. 34-11 yields $M = m_1 m_2 = (-i_1 / p_1)(-i_2 / p_2) = i_1 i_2 / p_1 p_2 = -13$.

(c) The fact that the (final) image distance is negative means the image is virtual (V).

(d) The fact that the magnification is a negative value means the image is inverted (I).

(e) The image is on the same side as the object (relative to lens 2).

85. (a) The image from lens 1 (which has $f_1 = +6$ cm) is at $i_1 = -12$ cm (by Eq. 34-9). This serves as an "object" for lens 2 (which has $f_2 = -6$ cm) with $p_2 = d - i_1 = 20$ cm. Then Eq. 34-9 (applied to lens 2) yields $i_2 = -4.6$ cm.

(b) Eq. 34-11 yields $M = +0.69$.

(c) The fact that the (final) image distance is negative means the image is virtual (V).

(d) The fact that the magnification is positive means the image is not inverted (NI).

(e) The image is on the same side as the object (relative to lens 2).

86. (a) The image from lens 1 (which has $f_1 = +8$ cm) is at $i_1 = +24$ cm (by Eq. 34-9). This serves as an "object" for lens 2 (which has $f_2 = -8$ cm) with $p_2 = d - i_1 = 6$ cm. Then Eq. 34-9 (applied to lens 2) yields $i_2 = -3.4$ cm.

(b) Eq. 34-11 yields $M = -1.1$.

(c) The fact that the (final) image distance is negative means the image is virtual (V).

(d) The fact that the magnification is a negative value means the image is inverted (I).

(e) The image is on the same side as the object (relative to lens 2).

87. (a) The image from lens 1 (which has $f_1 = -12$ cm) is at $i_1 = -7.5$ cm (by Eq. 34-9). This serves as an "object" for lens 2 (which has $f_2 = -8$ cm) with

$$p_2 = d - i_1 = 17.5 \text{ cm}.$$

Then Eq. 34-9 (applied to lens 2) yields $i_2 = -5.5$ cm.

(b) Eq. 34-11 yields $M = +0.12$.

(c) The fact that the (final) image distance is negative means the image is virtual (V).

(d) The fact that the magnification is positive means the image is not inverted (NI).

(e) The image is on the same side as the object (relative to lens 2).