10. a) A convex (converging) lens, since a real image is formed.

(b) Since $i = d - p$ and $i/p = 1/2$,

$$p = \frac{2d}{3} = \frac{2(50.0\text{ cm})}{3} = 33.3\text{ cm}.$$

(c) The focal length is

$$f = \left(\frac{1}{i} + \frac{1}{p}\right)^{-1} = \left(\frac{1}{d/3} + \frac{1}{2d/3}\right)^{-1} = \frac{2d}{9} = \frac{2(50.0\text{ cm})}{9} = 11.1\text{ cm}.$$

29. **THINK** The compound microscope shown in Fig. 34-20 consists of an objective and an eyepiece. It's used for viewing small objects that are very close to the objective.

EXPRESS Let f_{ob} be the focal length of the objective, and f_{ey} be the focal length of the eyepiece. The distance between the two lenses is

$$L = s + f_{ob} + f_{ey},$$

where s is the tube length. The magnification of the objective is

$$m = -\frac{i}{p} = -\frac{s}{f_{ob}}$$

and the angular magnification produced by the eyepiece is $m_\theta = (25\text{ cm})/f_{ey}$.

ANALYZE (a) The tube length is

$$s = L - f_{ob} - f_{ey} = 25.0\text{ cm} - 3.00\text{ cm} - 8.00\text{ cm} = 14.0\text{ cm}.$$

(b) We solve $(1/p) + (1/i) = (1/f_{ob})$ for p. The image distance is

$$i = f_{ob} + s = 3.00\text{ cm} + 14.0\text{ cm} = 17.0\text{ cm},$$

so

$$p = \frac{if_{ob}}{i - f_{ob}} = \frac{(17.0\text{ cm})(3.00\text{ cm})}{17.0\text{ cm} - 3.00\text{ cm}} = 3.64\text{ cm}.$$

(c) The magnification of the objective is $m = -\dfrac{i}{p} = -\dfrac{17.0\text{ cm}}{3.64\text{ cm}} = -4.67.$

(d) The angular magnification of the eyepiece is $m_\theta = \dfrac{25\text{ cm}}{f_{ey}} = \dfrac{25\text{ cm}}{8.00\text{ cm}} = 3.13.$

(e) The overall magnification of the microscope is

$$M = mm_\theta = (-4.67)(3.13) = -14.6.$$

LEARN The objective produces a real image I of the object inside the focal point of the eyepiece ($i > f_{ey}$). Image I then serves as the object for the eyepiece, which produces a virtual image I' seen by the observer.

47. (a) We use Eq. 34-8 and note that $n_1 = n_{air} = 1.00$, $n_2 = n$, $p = \infty$, and $i = 2r$:

$$\frac{1.00}{\infty} + \frac{n}{2r} = \frac{n-1}{r}.$$

We solve for the unknown index: $n = 2.00$.

(b) Now $i = r$ so Eq. 34-8 becomes

$$\frac{n}{r} = \frac{n-1}{r},$$

which is not valid unless $n \to \infty$ or $r \to \infty$. It is impossible to focus at the center of the sphere.

90. The singularity the graph (where the curve goes to $\pm\infty$) is at p = 30 cm, which implies (by Eq. 34-9) that f = 30 cm > 0 (converging type lens). For p = 120 cm, Eq. 34-9 leads to i = +40 cm.

92. Since the focal length is a constant for the whole graph, then $1/p + 1/i$ = constant. Consider the value of the graph at p = 20 cm; we estimate its value there to be –10 cm. Therefore, $1/20 + 1/(-10) = 1/60 + 1/i_{new}$. Thus, i_{new} = –15 cm.

93. We use Eqs. 34-3 and 34-4, and note that $m = -i/p$. Thus,

$$\frac{1}{p} - \frac{1}{pm} = \frac{1}{f} = \frac{2}{r}.$$

We solve for p:

$$p = \frac{r}{2}\left(1 - \frac{1}{m}\right) = \frac{35.0\,\text{cm}}{2}\left(1 - \frac{1}{1.70}\right) = 7.21\ \text{cm}.$$