34-19. $f = +20\,\mathrm{cm}$ (positive, because the mirror is concave); $r = 2f = 2(+20\,\mathrm{cm}) = +40\,\mathrm{cm}$; $i = (1/f - 1/p)^{-1} = (1/20\,\mathrm{cm} - 1/10\,\mathrm{cm})^{-1} = -20\,\mathrm{cm}$; $m = -i/p = -(-20\,\mathrm{cm}/10\,\mathrm{cm}) = +2.0$. The image is virtual and upright. The ray diagram would be similar to Fig. 34-9(a) in the textbook.

34-20. The fact that the magnification is 1 and the image is virtual means that the mirror is flat (plane). Flat mirrors (and flat "lenses" such as a window pane) have $f = \infty$ (or $f = -\infty$ since the sign does not matter in this extreme case), and consequently $r = \infty$ (or $r = -\infty$) by Eq. 34-3. Eq. 34-4 readily yields $i = -10\,\mathrm{cm}$. The magnification being positive implies the image is upright; the answer is "no" (it's not inverted). The ray diagram would be similar to Fig. 34-7(a) in the textbook.

34-21. Since $f > 0$, the mirror is concave. Using Eq. 34-3, we obtain $r = 2f = +40\,\mathrm{cm}$. Eq. 34-4 readily yields $i = +60\,\mathrm{cm}$. Substituting this (and the given object distance) into Eq. 34-6 gives $m = -2.0$. Since $i > 0$, the answer is "yes" (the image is real). Since $m < 0$, our answer is "yes" (the image is inverted). The ray diagram would be similar to Fig. 34-9(c) in the textbook.

34-22. Since $m < 0$, the image is inverted. With that in mind, we examine the various possibilities in Figs. 34-7, 34-9 and 34-10, and note that an inverted image (for reflections from a single mirror) can only occur if the mirror is concave (and if $p > f$). Next, we find i from Eq. 34-6 (which yields $i = 30\,\mathrm{cm}$) and then use this value (and Eq. 34-4) to compute the focal length; we obtain $f = +20\,\mathrm{cm}$. Then, Eq. 34-3 gives $r = +40\,\mathrm{cm}$. As already noted, $i = +30\,\mathrm{cm}$. Yes, the image is real (since $i > 0$). Yes, the image is inverted (as already noted). The ray diagram would be similar to Fig. 34-10(a) and (b) in the textbook.

34-23. Since $r < 0$ then (by Eq. 34-3) $f < 0$, which means the mirror is convex. The focal length is $f = r/2 = -20\,\mathrm{cm}$. Eq. 34-4 leads to $p = +20\,\mathrm{cm}$, and Eq. 34-6 gives $m = +0.50$. No, the image is virtual. No, the image is upright. The ray diagram would be similar to Fig. 34-10(c) and (d) in the textbook.

34-24. Since $0 < m < 1$, the image is upright but smaller than the object. With that in mind, we examine the various possibilities in Figs. 34-7, 34-9 and 34-10, and note that such an image (for reflections from a single mirror) can only occur if the mirror is convex. Thus, we must put a minus sign in front of the "20" value given for f. Eq. 34-3 then gives $r = -40\,\mathrm{cm}$. To solve for i and p we must set up Eq. 34-4 and Eq. 34-6 as a simultaneous set and solve for the two unknowns. The results are $i = -18\,\mathrm{cm}$ and $p = +180\,\mathrm{cm}$. No, the image is virtual (since $i < 0$). No, the image is upright (as already noted). The ray diagram would be similar to Fig. 34-10(c) and (d) in the textbook.

34-25. Knowing the mirror is convex means we must put a minus sign in front of the "40" value given for r. Then, Eq. 34-3 yields $f = r/2 = -20\,\mathrm{cm}$. The fact that the mirror is convex also means that we need to insert a minus sign in front of the "4.0" value given for i, since the image in this case must be virtual (see Figs. 34-7, 34-9 and 34-10). Eq. 34-4 leads to $p = +5.0\,\mathrm{cm}$, and Eq. 34-6 gives $m = +0.8$. No, the image is virtual. No, the image is upright. The ray diagram would be similar to Fig. 34-10(c) and (d) in the textbook.

34-26. Since the image is inverted, we can scan Figs. 34-7, 34-9 and 34-10 in the textbook and find that the mirror must be concave. This also implies that we must put a minus sign in front of the "0.50" value given for m. To solve for f, we first find $i = +12\,\mathrm{cm}$ from Eq. 34-6 and plug into Eq. 34-4; the result is $f = +8\,\mathrm{cm}$. Thus, $r = 2f = +16\,\mathrm{cm}$. Yes, the image is real (since $i > 0$). The ray diagram would be similar to Fig. 34-10(a) and (b) in the textbook.

34-27. Convex, since $f < 0$. Eq. 34-3 gives $r = -60\,\mathrm{cm}$. Eq. 34-4 leads to $p = +30\,\mathrm{cm}$, and Eq. 34-6 gives $m = +.50$. The image is virtual and upright. The ray diagram would be similar to Fig. 34-10(c) and (d) in the textbook.

34-28. Concave since same side, hence $f = +20\,\mathrm{cm}$ Eq. 34-3 gives $r = +40\,\mathrm{cm}$. Eq. 34-4 leads to $i = +30\,\mathrm{cm}$, and Eq. 34-6 gives $m = -.50$. The image is real and inverted. The ray diagram would be similar to Fig. 34-10(c) and (d) in the textbook.

34-29. Inverted so $m = -.40$. Eq. 34-6 gives $i = +12\,\mathrm{cm}$. Eq. 34-4 leads to $f = 8.57\,\mathrm{cm}$, so concave. $r = -17.1\,\mathrm{cm}$. The image is real and inverted. The ray diagram would be similar to Fig. 34-10(a) and (b) in the textbook.

34-30. Since $m = -.70$, the image is inverted and Eq. 34-6 gives $i = 28\,\mathrm{cm}$. Eq. 34-4 leads to $f = +16.5\,\mathrm{cm}$, so concave. $r = +32.9\,\mathrm{cm}$. The image is real and inverted. The ray diagram would be similar to Fig. 34-10(a) and (b) in the textbook.

34-31. Since $m = +.20$, the mirror must be convex and the image upright and virtual (see problem 24). The ray diagram would be similar to Fig. 34-10(c) and (d) in the textbook. Since $i = -.20 \times p$, Eq. 34-4 leads to $1/f = (1-5)/p$ where $f = -30\,\mathrm{cm}$ so $p = +120\,\mathrm{cm}$ which gives $i = -24\,\mathrm{cm}$

34-69. Since $m > 0$ (alt since $0 < p < |f|$), the image is virtual. Since $m > 1$, converging lens: $f = +20$ cm. $1/i = 1/f - 1/p$ yields $i = -13.3$ cm, so $m = 1.67$ (clearly upright).

34-70. Since $p < |f|$, the image is virtual. Since $m < 1$, diverging lens: $f = -20$ cm. $1/i = 1/f - 1/p$ yields $i = -5.71$ cm, so $m = .71$ (clearly upright).

34-71. $0 < m < 1$ says virtual (clearly upright) and diverging; $i = -mp = -4$ cm. $1/f = 1/p + 1/i$ yields: $f = -5.33$ cm

34-72. $m < 0$ says inverted, real and converging; $i = -mp = 4$ cm. $1/f = 1/p + 1/i$ yields: $f = 3.2$ cm

34-80. The following problems follow the same formula: (1) determine: $1/i_1 = 1/f_1 - 1/p_1$; (2) determine: $p_2 = d - i_1$; (3) determine: $1/i_2 = 1/f_2 - 1/p_2$; determine: $M = m_1 m_2 = (-i_1/p_1) \cdot (-i_2/p_2)$.

(1): $1/i_1 = 1/15 - 1/10$; $i_1 = -30$ cm
(2): $p_2 = 10 + 30 = 40$ cm
(3): $1/i_2 = 1/8 + 1/40$; $i_2 = 10$ cm
(4): $M = (30/10) \cdot (10/40) = -.75$
real, inverted

34-81. (1): $1/i_1 = 1/8 - 1/12$; $i_1 = 24$ cm
(2): $p_2 = 32 - 24 = 8$ cm
(3): $1/i_2 = 1/6 - 1/8$; $i_2 = 24$ cm
(4): $M = (-24/12) \cdot (-24/8) = 6$
real, upright

34-82. (1): $1/i_1 = 1/12 - 1/15$; $i_1 = 60$ cm
(2): $p_2 = 67 - 60 = 7$ cm
(3): $1/i_2 = 1/10 - 1/7$; $i_2 = -23.3$ cm
(4): $M = (-60/15) \cdot (23.3/7) = -13.3$
virtual, inverted

34-83. (1): $1/i_1 = 1/9 - 1/20$; $i_1 = 16.4$ cm
(2): $p_2 = 8 - 16.4 = -8.36$ cm
(3): $1/i_2 = 1/5 + 1/8.36$; $i_2 = 3.13$ cm
(4): $M = (-16.4/20) \cdot (3.13/8.36) = -.31$
real, inverted

34-84. (1): $1/i_1 = -1/6 - 1/8$; $i_1 = -3.43$ cm
(2): $p_2 = 12 + 3.43 = 15.4$ cm
(3): $1/i_2 = 1/6 - 1/15.4$; $i_2 = 9.82$ cm
(4): $M = (3.43/8) \cdot (-9.82/15.4) = -.27$
real, inverted

34-88. If you consider the path of an incoming ray, parallel to the optic axis, but displaced so that it just hits the outer edge of the objective, which then comes to the focus at f_{ob} and hits the outer edge of the eyepiece, silimar triangles reports:

$$\frac{d_{\mathrm{ob}}}{f_{\mathrm{ob}}} = \frac{d_{\mathrm{ey}}}{f_{\mathrm{ey}}}$$

or

$$d_{\mathrm{ey}} = \frac{f_{\mathrm{ey}}}{f_{\mathrm{ob}}} \cdot d_{\mathrm{ob}} = \frac{d_{\mathrm{ob}}}{m_\theta} = 2.08 \text{ mm}$$

34-89. (a) If L is the distance between the lenses, then according to Fig. 34-18, the tube length is $s = L - f_{\text{ob}} - f_{\text{ey}} = 25.0\,\text{cm} - 4.00\,\text{cm} - 8.00\,\text{cm} = 13.0\,\text{cm}$.

(b) We solve $(1/p) + (1/i) = (1/f_{\text{ob}})$ for p. The image distance is $i = f_{\text{ob}} + s = 4.00\,\text{cm} + 13.0\,\text{cm} = 17.0\,\text{cm}$, so

$$p = \frac{i f_{\text{ob}}}{i - f_{\text{ob}}} = \frac{(17.0\,\text{cm})(4.00\,\text{cm})}{17.0\,\text{cm} - 4.00\,\text{cm}} = 5.23 \text{ cm} .$$

(c) The magnification of the objective is

$$m = -\frac{i}{p} = -\frac{17.0\,\text{cm}}{5.23\,\text{cm}} = -3.25 .$$

(d) The angular magnification of the eyepiece is

$$m_\theta = \frac{25\,\text{cm}}{f_{\text{ey}}} = \frac{25\,\text{cm}}{8.00\,\text{cm}} = 3.13 .$$

(e) The overall magnification of the microscope is

$$M = m m_\theta = (-3.25)(3.13) = -10.2 .$$

`telescope.txt:` The power of (relaxed eye) magnifiers is given by Eq. 34-12:

$$m_\theta = \frac{25 \text{ cm}}{f}$$

so "5×" corresponds to $f_{ey} = 5$ cm. Since the two lenses should be separated by $f_{ob} + f_{ey} = 80$ cm, we have $f_{ob} = 75$ cm. Finally the magnification of a telescope is given by Eq. 34-15:

$$m_\theta = \frac{-f_{ob}}{f_{ey}} = -15$$

`2006/211t2_06.pdf #3` For the converging lens:

$$p_1 = 200 \text{ cm} \quad f_1 = 30 \text{ cm} \Rightarrow i_1 = 35.294 \text{ cm} \quad p_2 = -3.294 \text{ cm}$$

For the diverging lens:

$$p_2 = -3.294 \text{ cm} \quad f_2 = -3 \text{ cm} \Rightarrow i_2 = -33.6 \text{ cm}$$

The height of this final (virtual & upright) image, h'', can be found from the magnifications and the object size (h):

$$h'' = m_1 m_2 h = \frac{-35.294}{200} \cdot \frac{33.6}{-3.294} \cdot 1 \text{ cm} = 1.8 \text{ cm}$$

The angular size of the image (in the small angle approximation):

$$\theta'' = \frac{1.8}{33.6} \quad \text{whereas} \quad \theta = \frac{1}{200}$$

so the angular magnitification is: $m_\theta = 10.7$