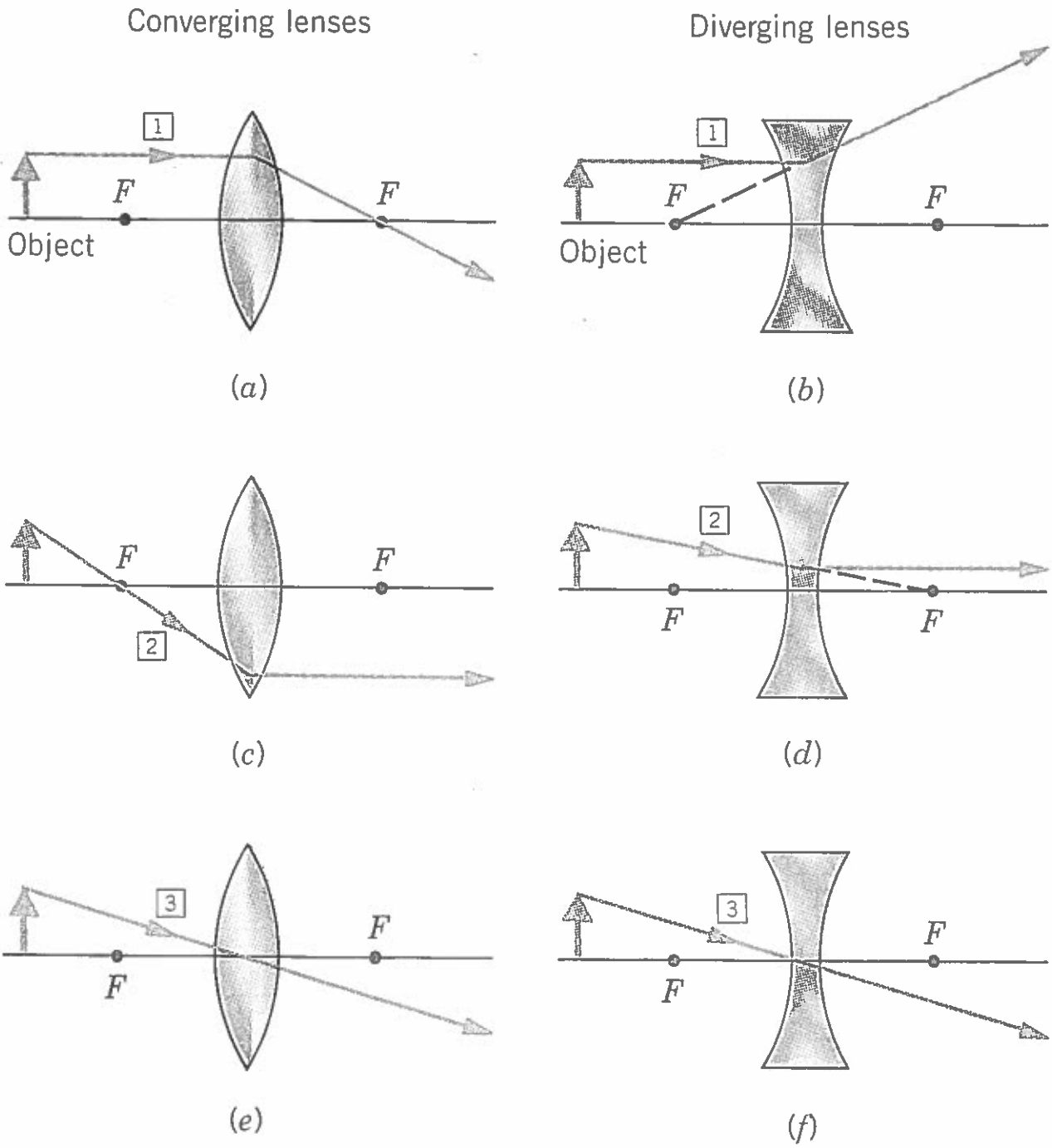
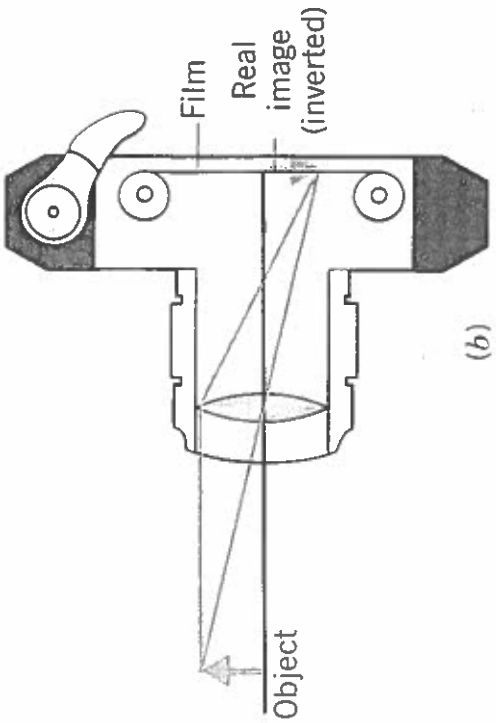


FIGURE 26.19 a, b, c, d, e, f



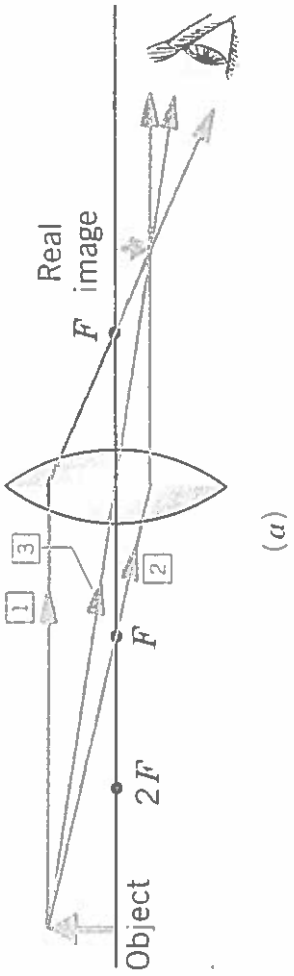


FIGURE 26.20 a, b 199

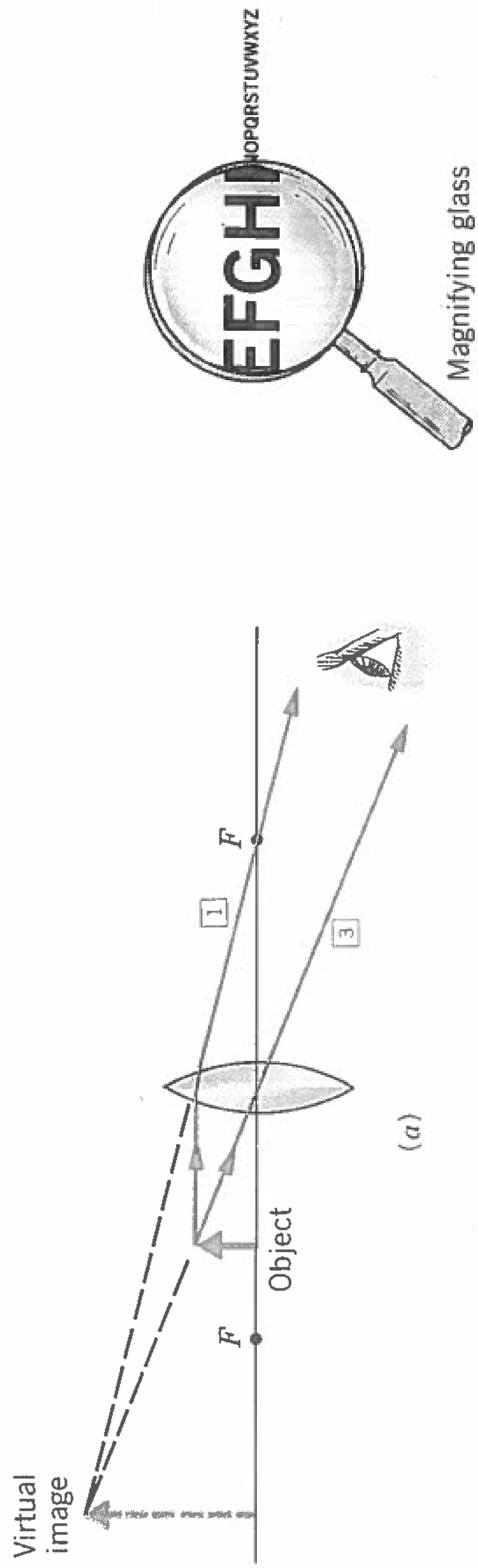


FIGURE 26.22 a, b

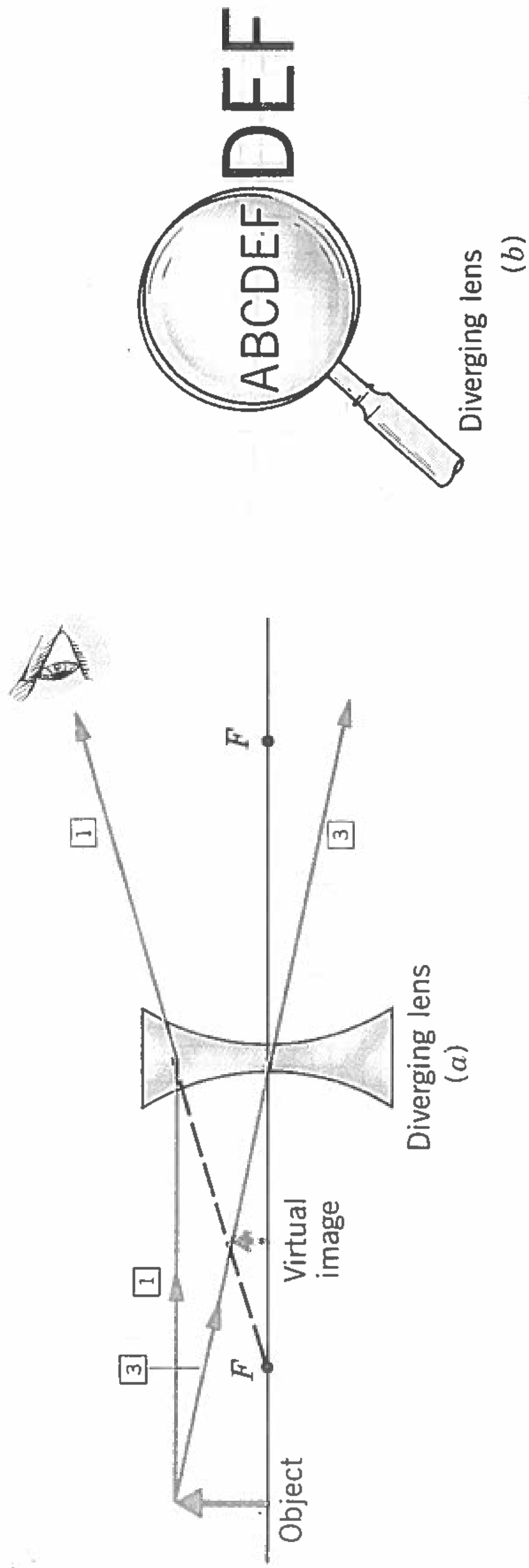


FIGURE 26.23 a, b

Thin lens EQUATION

Thin lens means the thickness of lens << focal length.

$$\frac{1}{o} + \frac{1}{i} = \frac{1}{f}$$ — Thin lens or mirror EQUATION

$$\frac{n_o}{o} + \frac{n_i}{i} = \frac{n_i - n_o}{R}$$

Sign convention

$o, i > 0$ if image and/or object are real

$o, i < 0$ if image and/or object are virtual

$f > 0$ if converging lens

$f < 0$ if diverging lens

$h_o, h_i > 0$ if upright

$h_o, h_i < 0$ if inverted

$$M = \frac{h_i}{h_o} = -\frac{i}{o}$$

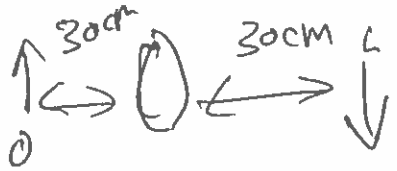
eg/ 10 cm high object 30cm from on left a 15cm focal length converging lens

Where will image form?

How tall is image?

Upright or inverted image?

Real or virtual image?



$$\frac{1}{o} + \frac{1}{i} = \frac{1}{f} \Rightarrow \frac{1}{i} = \frac{1}{f} - \frac{1}{o}$$

$$\frac{1}{i} = \frac{1}{+15\,cm} - \frac{1}{+30cm} = \frac{2-1}{30\,cm} = \frac{1}{30cm}$$

$$i = 30\,cm$$

$\Rightarrow$ real

$$\frac{hi}{ho} = \frac{-i}{o}$$

$$hi = ho\left(\frac{-i}{o}\right) = 10cm\left(\frac{-30cm}{30cm}\right)$$

$$hi = -10\,cm$$

$\rightarrow$ inverted

10 cm high inverted real image

30 cm on opposite side of lens

Than the object!

ex/ 10 cm high object 30 cm to left of a 15 cm focal length diversing lens.

where is image formed?
How tall is image?
upright or inverted?
real or virtual?

$$\frac{+}{o} + \frac{1}{i} = \frac{1}{f} \Rightarrow \frac{1}{i} = \frac{1}{f} - \frac{1}{o}$$

$$\frac{1}{i} = \frac{1}{-15cm} - \frac{1}{30cm} = \frac{-2-1}{30cm} = \frac{-3}{30cm}$$

$$i = -10cm$$

→ Virtual image

$$h_i = h_o\left(\frac{-i}{o}\right) = (10cm)\left(\frac{-(-10cm)}{30cm}\right)$$

$$h_i = +\frac{10}{3}cm = 3,333\,cm$$

→ upright

$\frac{10}{3}$ cm high upright virtual image 10 cm from lens on same side as object.

26-52

Diverging lens held 13.0 cm above line of Print. image is 5.0 cm beneath lens.

a) is the image real or virtual?

b) what is focal length of lens.

Image real or virtual?

image same side of lens as object $\Rightarrow$ virtual image

$$\frac{1}{o} + \frac{1}{i} = \frac{1}{f} = \frac{1}{+13.0\,cm} + \frac{1}{-5.0\,cm}$$

$$\frac{1}{f} = 0.07692\,cm^{-1} - 0.200\,cm^{-1} = -0.123\,cm^{-1}$$

$$f = \frac{1}{-0.123\,cm^{-1}} = -8.13\,cm$$

↑ Diverging lens

ex/ How far from a +20 cm focal length lens should an object be to produce a virtual image 50 cm from the lens?

$$\frac{1}{f} = \frac{1}{o} + \frac{1}{i} \Rightarrow \frac{1}{o} = \frac{1}{f} - \frac{1}{i}$$

$$\frac{1}{o} = \frac{1}{+20\,cm} - \frac{1}{-50\,cm} = \frac{5-(-2)}{100\,cm}$$

$$\frac{1}{o} = \frac{7}{100\,cm} \qquad o = \frac{100\,cm}{7}$$

$$\boxed{o = 14.3\,cm}$$

26-51

Camera supplied with two interchangeable lenses $f_1 = 35.0\ mm$ $f_2 = 150.0\ mm$

A woman height 1.60 m stands 9.00 m in front of camera.

What is height of her image on the image sensor as produced by each lens?

$h_o = 1.60\ m$ $f_1 = +35.0 \times 10^{-3}\ m$

$o = 9.00\ m$ $f_2 = +150.0 \times 10^{-3}\ m$

$h_{i_1} = ?$ $h_{i_2} = ?$

$$h_i = h_o\left(\frac{-i}{o}\right) \qquad h_{i_1} = h_o\left(\frac{-i_1}{o}\right)$$

$$h_{i_2} = h_o\left(\frac{-i_2}{o}\right)$$

$$\frac{1}{i} = \frac{1}{f} - \frac{1}{o} = \frac{o-f}{of}$$

$$i = \frac{of}{o-f} \qquad i_1 = \frac{of_1}{o-f_1} \qquad i_2 = \frac{of_2}{o-f_2}$$

$$h_{i_1} = h_o\left(\frac{-0f_1}{0-f_1}\right) = h_o\left(\frac{0f_2}{f_1-0}\right)$$

$$h_{i_1} = \frac{(1.60\,m)(9.00\,m)(35.0\times10^{-3}\,m)}{(35.0\times10^{-3}\,m - 9.00\,m)}$$

$$h_{i_1} = -6.25\times10^{-3}\,m = \underline{-6.25\ mm}$$

$$h_{i_2} = \frac{(1.60\,m)(9.00\,m)(150\times10^{-3}\,m)}{150\times10^{-3}\,m - 9.00\,m}$$

$$h_{i_2} = -2.71\times10^{-2}\,m = \underline{-27.1\ mm}$$