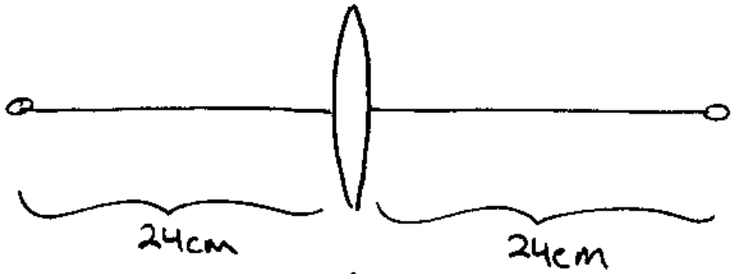
Ch. 24

3.



$$\frac{1}{S_o} + \frac{1}{S_i} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$R_1 = -R_2$
$n = 1.5$

$$\Longrightarrow \frac{1}{24} + \frac{1}{24} = (1.5-1)\left(\frac{1}{R} - \frac{1}{-R}\right)$$

$$\frac{2}{24} = .5\left(\frac{1}{R} + \frac{1}{R}\right)$$

$$\frac{4}{24} = \frac{2}{R}$$

$$6 = \frac{1}{2}R$$

$$R = 12\text{cm}$$

12.

$R_1 > 0$
$R_2 > 0$ for meniscus convex spherical lens
$R_2 > R_1$

$n = 1.5$

Plane Waves $\Longrightarrow S_o = \infty$
$S_i = 100\text{cm}$

$$\frac{1}{\infty} + \frac{1}{100} = (1.5-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$0 + .01 = .5\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = .02$$

12. cont.

$S_o = 200\text{cm}$

$\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$
$\parallel$

$$\frac{1}{200} + \frac{1}{S_i} = .5(.02)$$

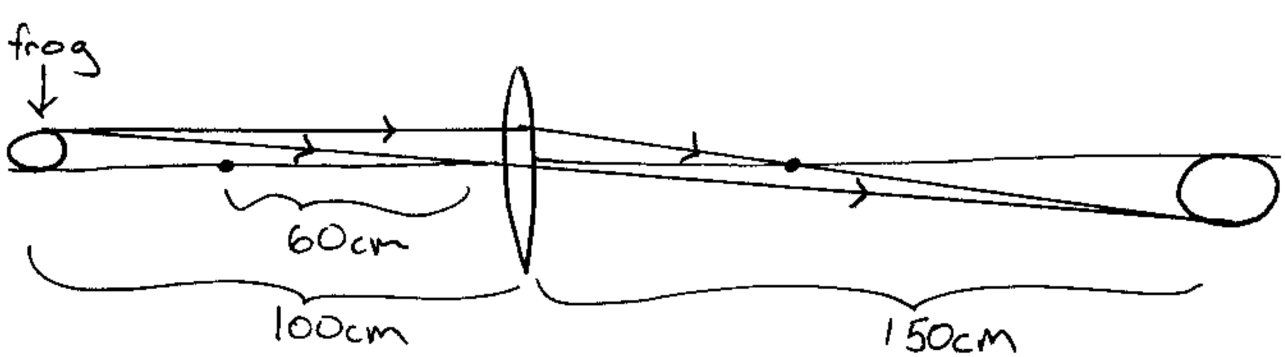
$$\frac{1}{S_i} = .01 - \frac{1}{200}$$
$$= .005$$
$$S_i = \frac{1}{.005} = 200\text{cm}$$

13.

from 12. $\frac{1}{R_1} - \frac{1}{R_2} = .02$ $\quad R_2 > R_1 \therefore R_2 = 100\text{cm}$

$$\frac{1}{R_1} - \frac{1}{100} = .02$$
$$\frac{1}{R_1} = .02 + .01 = .03$$
$$R_1 = 33\tfrac{1}{3}\text{ cm}$$

17.



$$\frac{1}{S_o} + \frac{1}{S_i} = \frac{1}{f}$$
$$\frac{1}{100} + \frac{1}{S_i} = \frac{1}{60}$$
$$\frac{1}{S_i} = \frac{1}{60} - \frac{1}{100}$$

17. cont.

$$\frac{1}{S_i} = \frac{10}{600} - \frac{6}{600}$$

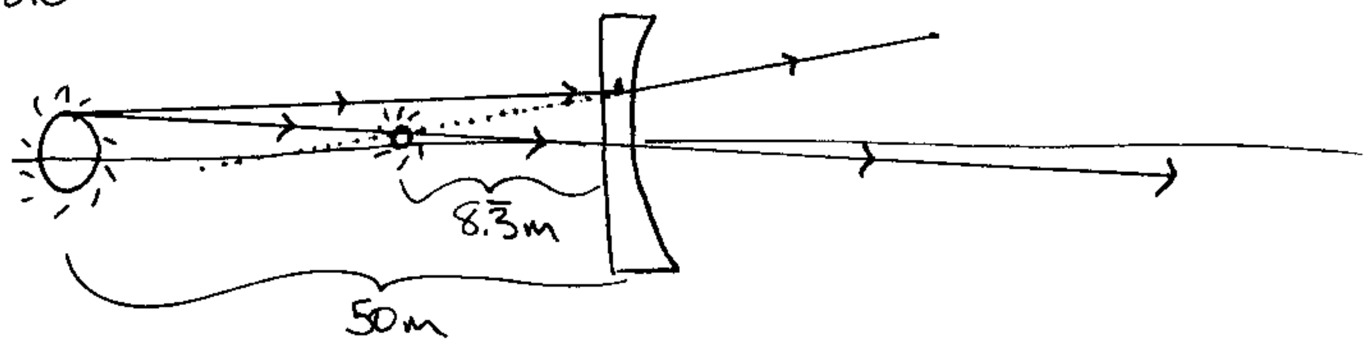
$$= \frac{4}{600} = \frac{1}{150}$$

$$S_i = 150\text{cm}$$

$$M = \frac{-S_i}{S_o} = -\frac{150\text{cm}}{100\text{cm}} = -1.5$$

Image is real, magnified and inverted

20



$$\frac{1}{50} + \frac{1}{S_i} = -\frac{1}{10}$$

$$\frac{1}{S_i} = -\frac{1}{10} - \frac{1}{50}$$

$$= -\frac{6}{50}$$

$$S_i = -\frac{50}{6} = -8.\overline{3}\text{m}$$

$$M = -\frac{S_i}{S_o} = +\frac{8.3\text{m}}{50\text{m}} = 0.1\overline{6}$$

Looks 8.3m away, upright and minimized to ~.17 of original size.

27. $M = \frac{d_n}{f} = 8$

near point for human eye = $d_n = 25cm$

$$f = \frac{d_n}{8} = \frac{25cm}{8} \simeq 3cm$$

30. $|M| = \left| -\frac{S_i}{S_o} \right| = 100$

$$\Rightarrow S_i = 100 S_o$$

but $S_i = 10m$

$$10m = 100 S_o$$

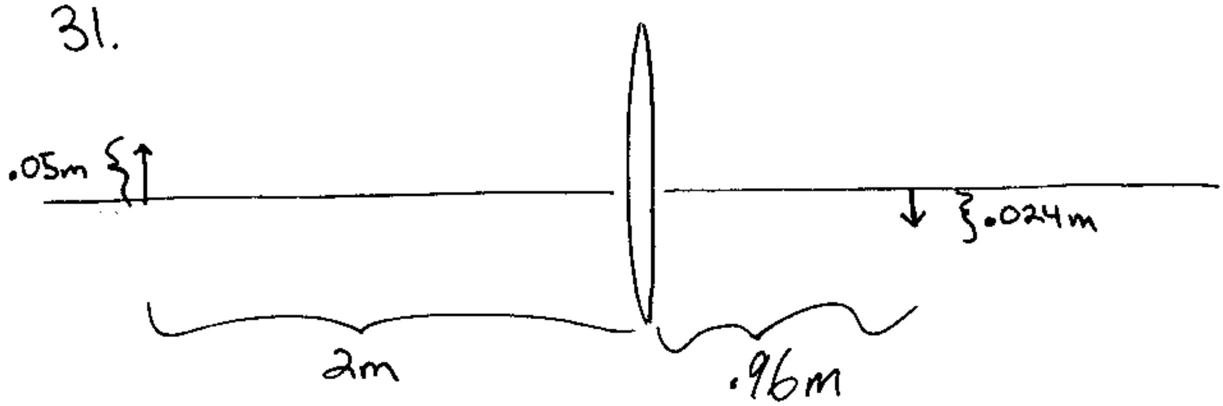
$$\frac{1}{10} = S_o$$

$$\frac{1}{S_o} + \frac{1}{S_i} = \frac{1}{f} \Rightarrow \frac{1}{\left(\frac{1}{10}\right)} + \frac{1}{10} = \frac{1}{f}$$

$$10.1 = \frac{1}{f}$$

$$f = .099m = 9.9cm$$

31.



$$M = -\frac{S_i}{S_o} = \frac{y_i}{y_o} = \frac{-.024\,m}{.05\,m}$$

$$= -.48$$

$$-\frac{S_i}{S_o} = -.48$$

$$S_i = .48\,S_o$$

but $S_o = 2m$

$$\Longrightarrow S_i = .48(2m)$$

$$= .96m$$

$$\frac{1}{f} = \frac{1}{S_o} + \frac{1}{S_i}$$

$$= \frac{1}{2} + \frac{1}{.96}$$

$$= 1.542$$

$$f = \frac{1}{1.542} = .65m$$

32. $S_o = 3.84 \times 10^8 m \quad f = .05m$

$$\frac{1}{S_i} = \frac{1}{.05} - \frac{1}{3.84 \times 10^8}$$

$$= 20 - 2.6 \times 10^{-9}$$

$$\simeq 20$$

$$S_i = .05m$$

$$|M| = \frac{.05}{3.84 \times 10^8} = 1.3 \times 10^{-10}$$

$$\frac{y_i}{y_o} = M$$

$$y_i = M y_o$$

$$= (1.3 \times 10^{-10})(.273 \cdot 1.27 \times 10^7 m)$$

$$= 4.5 \times 10^{-4} m$$

$$= 0.45 mm$$

47. $$\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} = \frac{1}{10} + \frac{1}{-20} + \frac{1}{5}$$

$$= \frac{2}{20} - \frac{1}{20} + \frac{4}{20}$$

$$= \frac{5}{20}$$

$$f_{eq} = \frac{20}{5} = 4cm$$

$f_{eq} > 0 \therefore$ can form real images

61. a) $M_A = M_{TO} M_{AE}$

$$M_{TO} = -\frac{L}{f_o} = -20$$

$$M_{AE} = \frac{d_n}{f_E} = 10$$

$$M_A = (-20)(10) = -200X$$

just means image is inverted

b) $L = 160\text{mm}$

$$\frac{L}{f_o} = 20 \Longrightarrow f_o = \frac{160\text{mm}}{20} = 8\text{mm}$$

$d_n = 250\text{mm}$

$$\frac{d_n}{f_E} = 10 \Longrightarrow f_E = \frac{250\text{mm}}{10} = 25\text{mm}$$

c) $-(S_i - f_o) = -L$

$$S_i = L + f_o$$

$$\frac{1}{f_o} = \frac{1}{S_i} + \frac{1}{S_o} \Longrightarrow \frac{1}{f_o} = \frac{1}{L+f_o} + \frac{1}{S_o}$$

$$\frac{1}{S_o} = \frac{1}{f_o} - \frac{1}{L+f_o}$$

$$= \frac{L+f_o}{f_o(L+f_o)} - \frac{f_o}{f_o(L+f_o)}$$

$$= \frac{L}{f_o(L+f_o)}$$

61 c) cont.

$$S_o = \frac{f_o(L+f_o)}{L} = \frac{8mm(160mm+8mm)}{160mm}$$

$$= 8.4mm$$

67 $D = 50cm \longrightarrow R = 25cm$

$$f = -\frac{R}{2} = \frac{-25}{2} = -12.5cm$$

75. $f = -\frac{R}{2} \Longrightarrow \frac{1}{S_o} + \frac{1}{S_i} = \frac{-2}{R}$

$S_o = .10m \quad R = 1.00m$

$$\frac{1}{S_i} = -\frac{2}{1} - \frac{1}{.10}$$

$$= -2 - 10$$

$$S_i = -\frac{1}{12} = -.08\bar{3}m \text{ or } -8.\bar{3}cm$$

$$M = -\frac{-.083}{.10} = 8.3$$

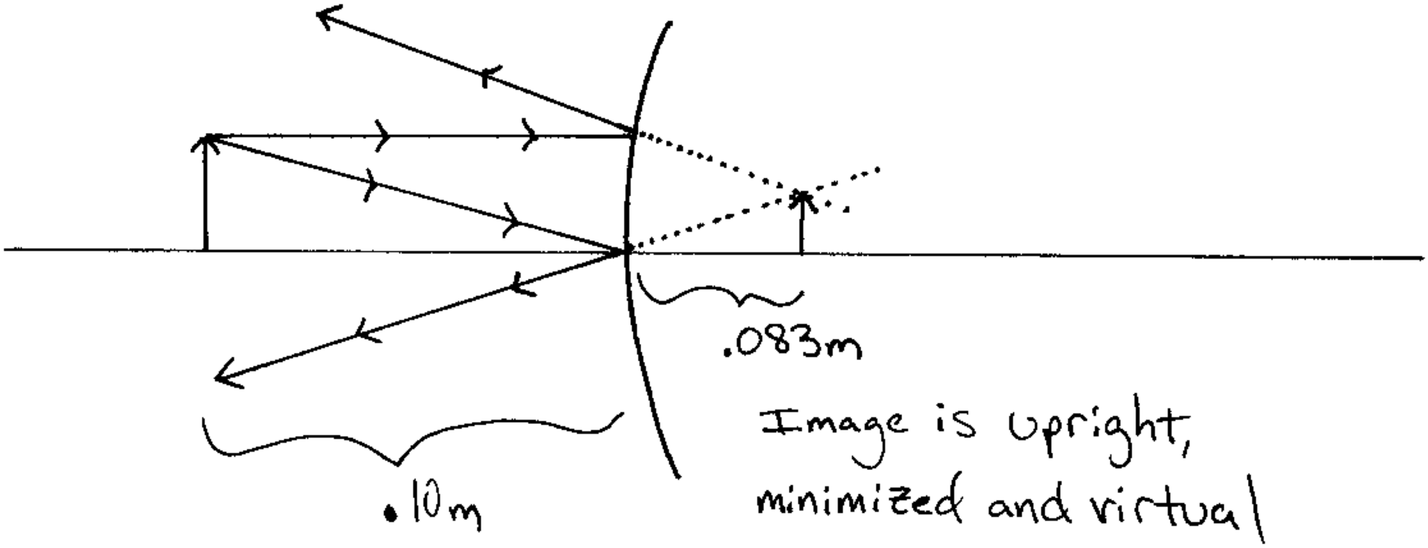


Image is upright, minimized and virtual

77. $S_o = 500{,}000\,m \quad R = -1m$

$$\frac{1}{S_o} + \frac{1}{S_i} = -\frac{2}{R}$$

$$\frac{1}{S_i} = \frac{+2}{1} - \frac{1}{500{,}000}$$

$$\simeq 2$$

$$S_i = \frac{1}{2}m$$

$$|M| = \left|-\frac{S_i}{S_o}\right| = \frac{\frac{1}{2}}{500{,}000} = 1\times10^{-6}$$

Satellite = 2m in diameter

$$(1\times10^{-6})(2m) = 2\times10^{-6}m$$

$$= 2\,\mu m \text{ in diameter}$$

79. $M = +2 = \frac{-S_i}{S_o}$

but $S_o = 1.5cm \Longrightarrow -S_i = (1.5cm)(2)$

$$S_i = -3cm$$

$$\frac{1}{S_o} + \frac{1}{S_i} = -\frac{2}{R}$$

$$\frac{1}{1.5} + \frac{1}{-3} = -\frac{2}{R}$$

$$\frac{1}{3} = -\frac{2}{R}$$

$$3 = -\frac{1}{2}R$$

$$R = -6cm$$

80. $$\frac{1}{S_i}+\frac{1}{S_o}=-\frac{2}{R}$$

$$\frac{1}{S_i}=-\left(\frac{2}{R}+\frac{1}{S_o}\right)$$

$$=-\left(\frac{2S_o+R}{RS_o}\right)$$

$$S_i=-\frac{RS_o}{2S_o+R}$$

$$M=-\frac{S_i}{S_o}=\frac{-\left(\frac{-RS_o}{2S_o+R}\right)}{S_o}=\frac{R}{2S_o+R}$$

84. $$M=-\frac{S_i}{S_o}=-0.064$$

$$S_i=0.064S_o$$

but $S_o=25cm$

$$S_i=.064(25cm)$$

$$=1.6cm$$

$$\frac{1}{S_o}+\frac{1}{S_i}=-\frac{2}{R}$$

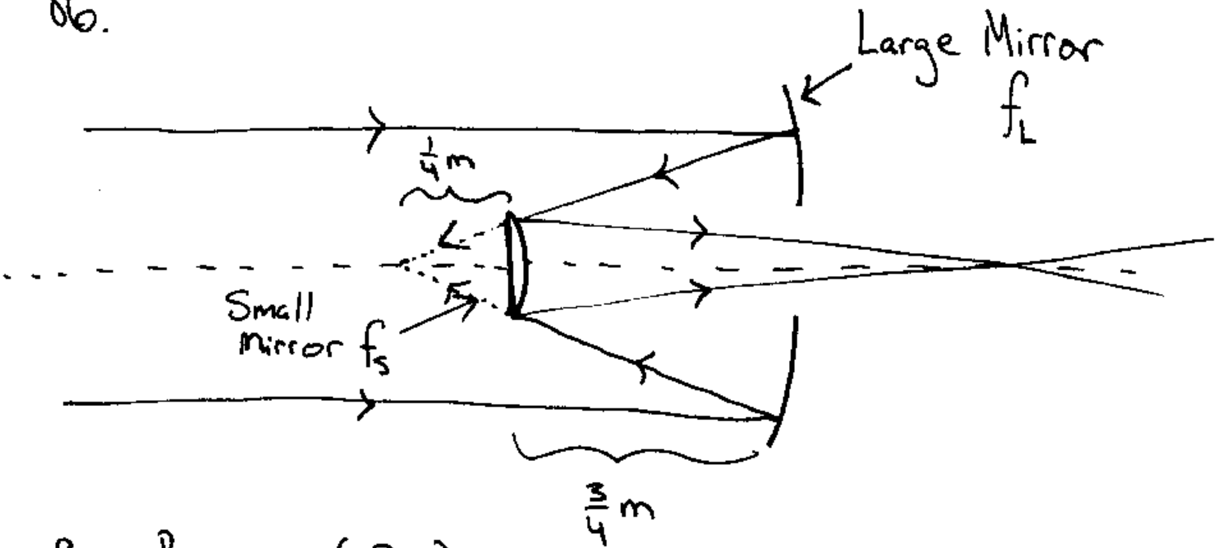
$$\frac{1}{25}+\frac{1}{1.6}=-\frac{2}{R}$$

$$\frac{1.6+25}{40}=-\frac{2}{R}$$

$$R=-\frac{2(40)}{1.6+25}$$

$$=-3cm$$

86.



$$f_L = -\frac{R_L}{2} = -\frac{(-2m)}{2} = +1m$$

Star $\longrightarrow S_o = \infty$

$$\frac{1}{f_L} = \frac{1}{S_o} + \frac{1}{S_i}$$

$$\frac{1}{1} = \frac{1}{\infty} + \frac{1}{S_i} \Longrightarrow S_i = 1m$$

S_i for Large Mirror becomes S_o for small mirror

$1m - \frac{3}{4}m = .25m$ behind small mirror $\therefore$ virtual

S_o small mirror $= -.25$

virtual

$$f_s = -\frac{R}{2} = -\frac{.6m}{2} = -.30m$$

$$\frac{1}{-.25m} + \frac{1}{S_i} = \frac{1}{-.30m}$$

$$\frac{1}{S_i} = \frac{1}{-.3} + \frac{1}{.25} = \frac{.25-.3}{-.075} = \frac{2}{3}m$$

$$S_i = \frac{3}{2}m$$

$$f_{eff} = \frac{3}{4}m + \frac{3}{2}m$$

$$= \frac{9}{4} \text{ or } 2.25m$$