Physics 197
Chapter #22 Hw.

**Problem #1 (P3)** The virtual image formed by a concave mirror is <u>always</u> larger than the object.

**Problem #2 (P7)** $d_o = 40\text{cm}$ $f = 52\text{cm}$.

object is inside center of curvature and outside focal Point. Image is **Real** **Inverted** and **Larger** than object.

**Problem #3 (P25)** $R = 26.0\text{cm}$ $f = 13.0\text{cm}$.

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

$$d_i = \frac{f d_o}{d_o - f}$$

| ob $d_i$ | 52cm | 26.0cm | 13.0cm | 7.90cm |
|---|---|---|---|---|
| cm $d_i$ | 16.8 | 26.0cm | undef | -20.14 |
| M | -.294 | 1.00 | undef | +2.54 |

**Problem #4 (P29)**

$M = +5.3 \quad d_o = 2.3\,cm.$

Larger upright (virtual) image $\Rightarrow$ concave mirror.

a)

$$M = +5.3 = -\left(\frac{d_i}{d_o}\right) \; ; \quad d_i = -d_o(5.3)$$

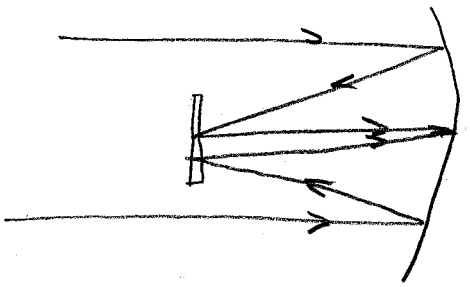
$$d_i = -(2.3cm)(5.3) = -12.19cm$$

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad f = \frac{d_o d_i}{d_i + d_o} = 1.6\,cm$$

b)

$R = 2f = 3.2\,cm$ for Radius of Curvature

**Problem #5 (P33)**



$R = 5.9\,m$

$d_o = \infty$

$d_i = 2.36m.$

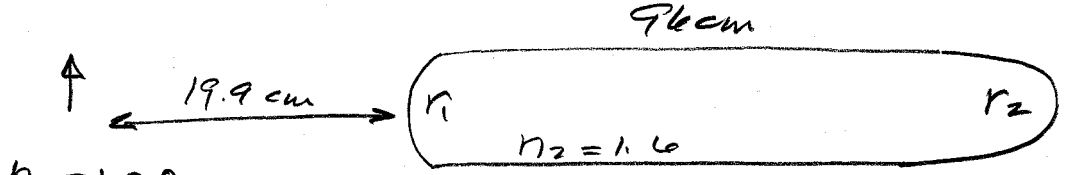
1st address image from large mirror: $\frac{1}{d_{o_L}} + \frac{1}{d_{i_L}} = \frac{2}{R_L}$, $d_{o_L} = \infty \Rightarrow \frac{1}{d_{i_L}} = \frac{2}{R_L} \Rightarrow d_{i_L} = \frac{R_L}{2} = 2.95m$

This becomes the object for the small mirror, but it lies to the left of the small mirror surface $\Rightarrow$ a virtual object $d_{o_S} < 0$

$d_{o_S} = 2.36m - 2.95m = -.59m.$ $\quad \frac{1}{d_{o_S}} + \frac{1}{d_{i_S}} = \frac{2}{R_S}$, $d_{i_S} = 2.36m$ (image appears at large mirror)

$$R_S = 2\left(\frac{d_{i_S} d_{o_S}}{d_{i_S} + d_{o_S}}\right) = 2\left(\frac{2.36m(-.59m)}{2.36m - .59m}\right) = -1.57m.$$ since $R < 0$ small mirror is convex.

**Problem #6 (P 39)**




$r_1 = \pm 8\text{cm}$ $\quad r_2 = \pm 16\text{cm}$

$\frac{n_1}{do_1} + \frac{n_2}{di} = \frac{n_2 - n_1}{r}$ > Apply at each surface > $di = \frac{n_2}{\frac{n_2 - n_1}{r} - \frac{n_1}{do}}$

a) at $r_1$: $r_1 = +8\text{cm}$ $\quad di_1 = \frac{1.60}{\frac{.60}{8\text{cm}} - \frac{1}{19.9\text{cm}}} = +64.65\text{cm}$ to the right of 8cm surface.

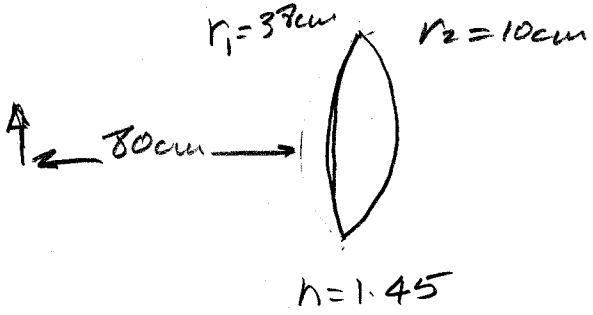
b) at $r_2$: $r_2 = -16\text{cm}$ ; $do_2 = 96\text{cm} - 64.65\text{cm} = 31.35\text{cm}$ : $n_1 = 1.60$, $n_2 = 1.00$

$di_2 = \frac{1.00}{\frac{-.60}{-16\text{cm}} - \frac{1.60}{64.65\text{cm}}} = 78.42\text{cm}.$

d) Final image occurs $78.42 + 96\text{cm}$ from 8cm surface
$= 174.42\text{cm}.$

Final image is a Real image, outside of rod.

**Problem #7 (P41)**




a) $$\frac{1}{f} = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right) = (1.45-1)\left(\frac{1}{38cm} - \frac{1}{10cm}\right)$$

$$\frac{1}{f} = -3.32 \times 10^{-2}\,cm \;\Rightarrow\; f = -30.16\,cm.$$

b) $$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad d_i = \frac{f d_o}{d_o - f} = \frac{(-30.16cm)(80cm)}{(80cm - (-30.16cm))} = -21.9\,cm.$$ to Left of Lens.

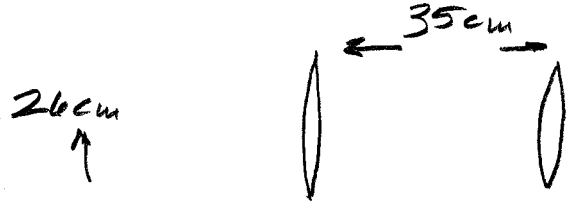
c) $$M = -\frac{d_i}{d_o} = -\left(\frac{-21.9}{80}\right) = +.274$$

d) Image is Virtual and upright.

**Problem #8 (P49)**

$f_1 = f_2 = 10\ cm.$

a)




find image from 1st lens:

$$d_{i_1} = \frac{f d_{o_1}}{d_{o_1} - f_1} = \frac{(26cm)(10cm)}{16cm} = 16.25cm$$

This becomes the object for the second lens

find image from 2nd lens:

$$d_{i_2} = \frac{f_2 d_{o_2}}{d_{o_2} - f_2}, \quad d_{o_2} = 35cm - 16.25cm = 18.75cm.$$

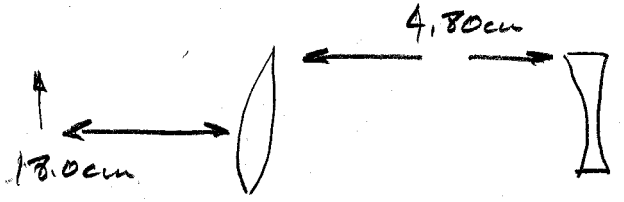
$$d_{i_2} = \frac{(10cm)(18.75cm)}{8.75cm} = 21.4cm.$$

Total distance from object = 26cm + 35cm + 21.4cm = 82.43cm to the right of object.

b) Image is upright

d) $M_T = M_1 \times M_2 = \left(\frac{16.25}{26}\right)\left(\frac{18.75}{21.4}\right) = .548$

**Problem #9 (P59)**




$f_1 = 8.50\text{cm}$ $\quad f_2 = -29.0\text{cm}$

a) at 1st lens $\quad d_{i_1} = \dfrac{f_1 d_{o_1}}{d_{o_1} - f_1} = \dfrac{(8.50\text{cm})(18\text{cm})}{(18 - 8.50)\text{cm}} = 16.1\text{cm}.$

This image is to the right of the second lens, and is a virtual object ($d_o < 0$).

at 2nd lens: $\quad d_{o_2} = -(16.1\text{cm} - 4.80\text{cm}) = -11.3\text{cm}.$

$$d_{i_2} = \frac{f_2 d_{o_2}}{d_{o_2} - f_2} = \frac{(-29.0\text{cm})(-11.3\text{cm})}{-11.3\text{cm} - (-29.0\text{cm})} = 18.51\text{cm}.$$

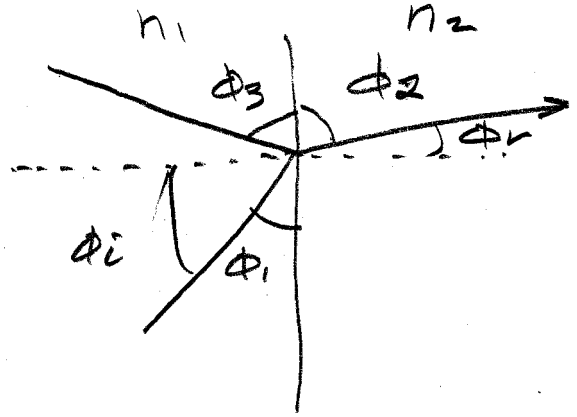
Total distance from object
$= 18 + 4.80 + 18.51 = 41.31\text{cm}$
from object

b) $M_T = M_1 \times M_2 = \left(\dfrac{16.1}{18}\right)\left(\dfrac{-11.3}{18.51}\right) = -.546$

c) Final image is inverted and real. > note: a virtual object yielded a real image, inverted wrt original object but upright wrt virtual object.

Problem #10






$\phi_2 = 60^\circ$ , $\phi_3 = 37.2^\circ$

$n_1 = 1.2$ , $n_2 = ?$

$$\phi_i = \frac{\pi}{2} - \phi_3 = 90^\circ - 37.2^\circ = 52.8^\circ$$

$$n_1 \sin\theta_i = n_2 \sin\theta_r \quad ; \quad \theta_r = 90^\circ - 60^\circ = 30^\circ$$

$$n_1 \sin(52.8^\circ) = n_2 \sin(30^\circ)$$

$$n_2 = \frac{(1.2)\sin(52.8^\circ)}{\sin(30^\circ)} = 1.91$$

$$n = \frac{c}{v_n} \quad > \quad v_n = \frac{c}{n} = \frac{3\times10^8 \text{ m/s}}{1.91}$$

$$v_n = 1.57\times10^8 \text{ m/s}$$