Solutions to Physics 108 MT (2017)

1-(a) For the first surface, $n_1 = n_w = \frac{4}{3}$, $n_2 = n_g = 2$, $R_1 = +20$ cm, $S_o = 15$ cm. From

$$\frac{n_1}{S_o} + \frac{n_2}{S_i} = \frac{n_2 - n_1}{R_1}$$

$$\Rightarrow \frac{4/3}{15} + \frac{2}{S_i} = \frac{2 - 4/3}{20}$$

$$\therefore S_i = -36 \text{ cm}$$

For the second surface, $n_1 = 2$, $n_2 = n_{air} = 1$. $R_1 = -20$ cm. $S_o' = d - S_i = 3 - (-36) = 39$ cm.
From

$$\frac{n_1}{S_o'} + \frac{n_2}{S_i'} = \frac{n_2 - n_1}{R_1}$$

$$\Rightarrow \frac{2}{39} + \frac{1}{S_i'} = \frac{1-2}{-20}$$

$$\therefore S_i' = -780 \text{ cm}$$ (i.e., 780 cm to the left of the last surface)

1-(b) $y_o = 1\,\text{cm}$,

$$y_i = y_o \cdot M = y_o M_1 M_2$$

$$= y_o \left(-\frac{n_w \cdot s_i}{n_g \cdot s_o}\right)\left(-\frac{n_g \cdot s_i'}{n_{air} \cdot s_o'}\right)$$

$$= (1\,\text{cm}) \cdot \frac{4}{3} \cdot \frac{(-36)}{15} \cdot \frac{(-780)}{39}$$

$$= +64\,\text{cm}$$

Up right, $64\,\text{cm}$

1-(c) $$\alpha = \frac{y_i}{|s_i'|} = \frac{64}{780} = 0.082\,\text{rad}.$$

1-(d) For a flat surface, the image has the same size as the object. $y_i = 1\,\text{cm}$. As a result,

$$\alpha = \frac{y_i}{d} = \frac{1\,\text{cm}}{25\,\text{cm}} = 0.04\,\text{rad}$$

1-(a) If $n_1 = 4/3$, $n_2 = 3/2$, $R_1 = 20\text{ cm}$, $S_o = 15\text{ cm}$

$$\frac{n_1}{S_o} + \frac{n_2}{S_i} = \frac{n_2 - n_1}{R_1}$$

$$\frac{4/3}{15} + \frac{3/2}{S_i} = \frac{3/2 - 4/3}{20}$$

$$\therefore S_i = -\frac{540}{29}\text{ cm} \simeq -18.6\text{ cm}$$

For the second surface, $n_1 = 3/2$, $n_2 = 1$, $R_1 = -20\text{ cm}$, $S_o' = d - S_i = 3 + \frac{540}{29} = 627/29 = 21.6\text{ cm}$

$$\frac{n_1}{S_o'} + \frac{n_2}{S_i'} = \frac{n_2 - n_1}{R_1}$$

$$\frac{3/2}{627/29} + \frac{1}{S_i'} = \frac{1 - 3/2}{-20} = \frac{1}{40}$$

$$\therefore S_i' \simeq -22.5\text{ cm}$$

1-(b)

$$y_i = y_o M_1 M_2$$

$$= y_o\left(-\frac{n_w}{n_g}\cdot\frac{s_i}{s_o}\right)\left(-\frac{n_g}{n_{air}}\frac{s_i'}{s_o'}\right)$$

$$= 1\,cm\cdot\left(4/3\right)\cdot\frac{(-18.6)}{15}\cdot\frac{(-22.5)}{21.6}$$

$$= 1.7\,cm$$

1-(c) $\alpha = \frac{y_i}{d} = \frac{1.7\,cm}{25\,cm} = 0.069\ rad.$

1-(d) $\alpha = \frac{y_i}{d} = \frac{y_o}{d} = \frac{1\,cm}{25\,cm} = 0.04\,rad$

2-(a) $s_o = 9\,cm$, $R = -20\,cm$. from

$$\frac{1}{s_o} + \frac{1}{s_i} = -\frac{2}{R}$$

$$\frac{1}{9} + \frac{1}{s_i} = (-)\cdot\frac{2}{(-20)}$$

$$\therefore s_i = -90\,cm \text{ (inside the mirror)}.$$

2-(b) For a flat mirror, $s_i = -s_o$. Thus the distance between the object & the image is $2s_o$. Let $d = 2s_o$, we have

$$s_o = \frac{d}{2} = 12.5\,cm$$

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2-(c) Since $s_i = -s_o$, the pupil is at $2s_o$ away, i.e., 26 cm. The angular size of a 4mm pupil is then

$$\alpha = \frac{4\,mm}{26\,cm} = 0.015\,rad$$

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2-(d) The size of the pupil is $y_i = y_o\left(-\frac{s_i}{s_o}\right) = 40\,mm$.
At the distance $s_o + (-s_i) = 99\,cm$, $\alpha = 4cm/99cm \simeq 0.04\,rad$

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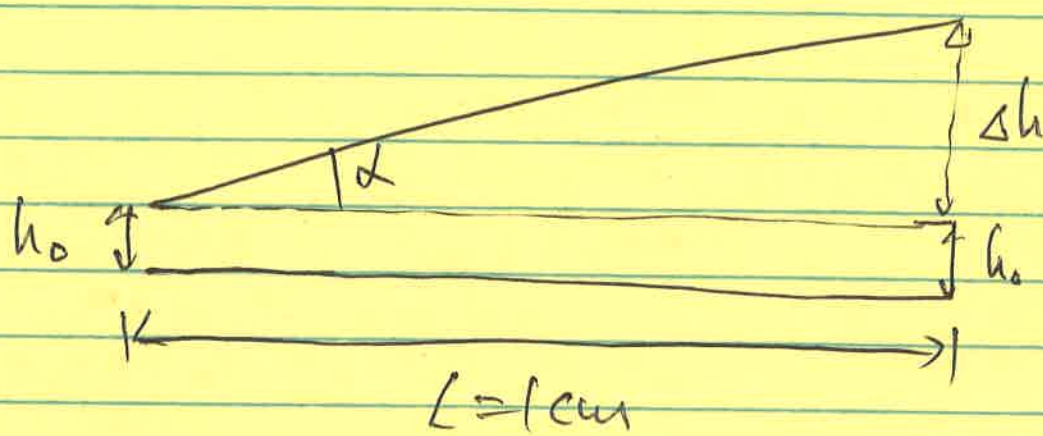
3.



The height change between neighboring fringes is

$$\delta h = \frac{\lambda}{2n_{air}\cos\theta_{air}} = \lambda$$

For 50 fringes, $\Delta h \cong 50 * \delta h = 50\lambda = 30\mu m$

$$\alpha = \frac{\Delta h}{L} = \frac{30\mu m}{10^4 \mu m} = 3\times10^{-3}\ \text{rad}$$

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4-(a)

$$I_d(t) = I_1(d) + I_2(d) + 2\sqrt{I_1(d)\,I_2(d)}\,\cos\Delta\phi_{12}$$

$$= \frac{I_{inc}}{2}\left(1-\cos\left(\frac{4\pi}{\lambda}(x_2-x_1)\right)\right)$$

$$= \frac{I_{inc}}{2}\left(1-\cos\left(\frac{4\pi}{\lambda}\cdot v\cdot t\right)\right)$$

$$= \frac{I_{inc}}{2}\left(1-\cos\left(2\pi\cdot\left(\frac{2v}{\lambda}\right)\cdot t\right)\right)$$

It is a sinusoidal function of time with a time frequency

$$f = \frac{2v}{\lambda} = 2 * \frac{1\ cm/sec}{0.5\times10^{-4}\ cm} = 4\times10^{4}\ Hz.$$

4-(b) $\tau = \frac{1}{f} = 25\ \mu s = 2.5\times10^{-5}\ sec$ #