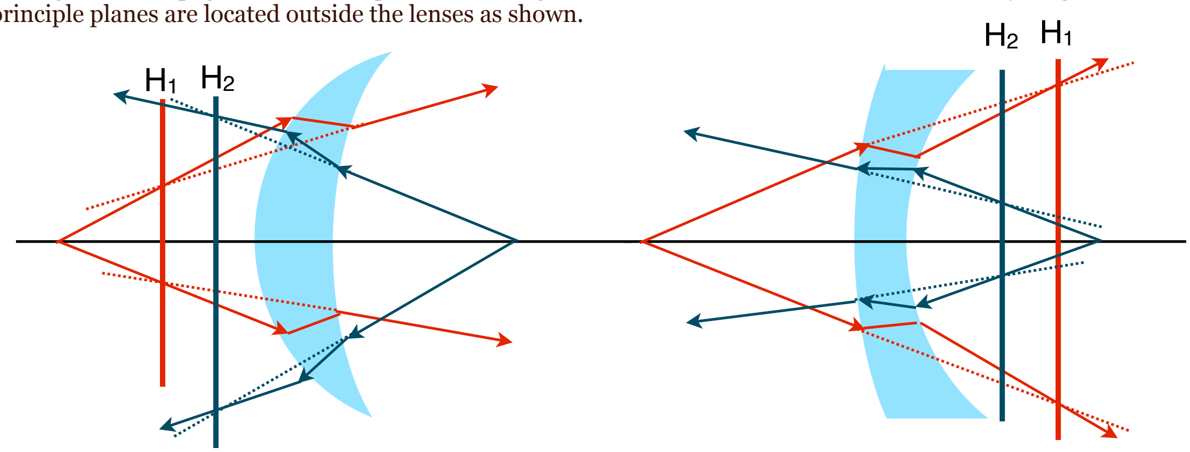
PHYS 3345: OPTICS

Assignment 07: Chapter 06 — Spring 2008

DUE: March 07, 2008

UCA Department of Physics and Astronomy

1. See Figure 6.3 on page 244. For the positive and negative meniscus lenses, construct accurate ray diagrams to show that the principle planes are located outside the lenses as shown.



2. For the positive meniscus lens described in Problem 6.16, calculate the focal length and the locations of the principle planes if the lens is immersed in air. Where would you place an object to result in a real image with transverse magnification $M_T = -1.25$?

$$\frac{1}{f} = (n_L - 1)\left(\frac{1}{R_1} - \frac{1}{R_2} + \frac{(n_L - 1)d_L}{n_L R_1 R_2}\right)$$

$$\frac{1}{f} = (2.4 - 1)\left(\frac{1}{50} - \frac{1}{100} + \frac{(2.4 - 1)(9.6)}{(2.4)(50)(100)}\right)$$

$$f = 64.2\text{mm}$$

$$h_1 = -\frac{f(n_L - 1)d_L}{n_L R_2}$$

$$h_1 = -\frac{(64.2)(2.4 - 1)(9.6)}{(2.4)(100)} = -3.60\text{mm}$$

$$h_2 = -\frac{f(n_L - 1)d_L}{n_L R_1}$$

$$h_2 = -\frac{(64.2)(2.4 - 1)(9.6)}{(2.4)(50)} = -7.19\text{mm}$$

$$M_T = -\frac{f}{x_o}$$

$$-1.25 = -\frac{64.2}{x_o}$$

$$x_o = 51.4\text{mm}$$

$$s_o = x_o + f$$

$$s_o = (64.2 + 51.4) = 115.6\text{mm}$$

3. Hecht, problem 6.16.

$$D_1 = \frac{n_L - n_i}{R_1}$$

$$D_1 = \frac{2.4 - 1.9}{50} = 0.01\text{mm}^{-1}$$

$$D_2 = \frac{n_L - n_i}{-R_2}$$

$$D_2 = \frac{2.4 - 1.9}{-100} = -0.005\text{mm}^{-1}$$

$$\bar{A} = \begin{bmatrix} 1 - D_2\left(\frac{d_L}{n_L}\right) & -D_1 - D_2 + D_1 D_2\left(\frac{d_L}{n_L}\right) \\ \left(\frac{d_L}{n_L}\right) & 1 - D_1\left(\frac{d_L}{n_L}\right) \end{bmatrix}$$

$$\bar{A} = \begin{bmatrix} 1 - (-0.005)\left(\frac{9.6}{2.4}\right) & -0.01 - (-0.005) + (0.01)(-0.005)\left(\frac{9.6}{2.4}\right) \\ \left(\frac{9.6}{2.4}\right) & 1 - (0.01)\left(\frac{9.6}{2.4}\right) \end{bmatrix}$$

$$\bar{A} = \begin{bmatrix} 1.02 & -0.0052 \\ 4 & 0.96 \end{bmatrix}$$

$$|\bar{A}| = (1.02)(0.96) - (-0.0052)(4) = 1$$

4. Hecht, problem 6.22.

$$D_1 = \frac{n_L - n_i}{R_1}$$

$$D_1 = \frac{1.5 - 1}{-10} = -0.05\text{cm}^{-1}$$

$$D_2 = \frac{n_L - n_i}{-R_2} = 0$$

$$\bar{A} = \begin{bmatrix} 1 & -D_1 \\ \left(\frac{d_L}{n_L}\right) & 1 - D_1\left(\frac{d_L}{n_L}\right) \end{bmatrix}$$

$$\bar{A} = \begin{bmatrix} 1 & -(-0.05) \\ \left(\frac{1}{1.5}\right) & 1 - (-0.05)\left(\frac{1}{1.5}\right) \end{bmatrix}$$

$$\bar{A} = \begin{bmatrix} 1 & 0.05 \\ 0.667 & 1.033 \end{bmatrix}$$

$$\bar{r}_{i1} = \begin{bmatrix} n_{i1}\alpha_{i1} \\ y_{i1} \end{bmatrix} = \begin{bmatrix} \alpha_i \\ 2.0\text{cm} \end{bmatrix}$$

$$\bar{r}_{t2} = \begin{bmatrix} n_{t2}\alpha_{t2} \\ y_{t2} \end{bmatrix} = \begin{bmatrix} (1)(0) \\ 2.0\text{cm} \end{bmatrix} = \begin{bmatrix} 0 \\ 2.0\text{cm} \end{bmatrix}$$

$$\bar{r}_{t2} = \bar{A}\bar{r}_{i1}$$

$$\begin{bmatrix} 0 \\ 2.0\text{cm} \end{bmatrix} = \begin{bmatrix} 1 & 0.05 \\ 0.667 & 1.033 \end{bmatrix}\begin{bmatrix} \alpha_i \\ 2.0\text{cm} \end{bmatrix}$$

$$(1)\alpha_i + (0.05)(2) = 0$$

$$\alpha_i = -0.10\text{rad}$$

5. A thick bi-concave lens ($n_L = 1.5$) has $R_1 = -10.0$cm, $R_2 = +5.0$cm and thickness $d_L = 1.00$cm. Find the system matrix and use it to determine the front and back focal points and the locations of the principle planes. Determine the location and size of the image of an object 1.00cm tall placed 10.0cm in front of the front principle plane.

$$D_1 = \frac{n_L - n_i}{R_1} \qquad D_2 = \frac{n_L - n_i}{-R_2}$$

$$D_1 = \frac{1.5 - 1}{-10} = -0.05\text{cm}^{-1} \qquad D_2 = \frac{1.5 - 1}{-5.0} = -0.10\text{cm}^{-1}$$

$$\bar{A} = \begin{bmatrix} 1 - D_2\left(\frac{d_L}{n_L}\right) & -D_1 - D_2 + D_1 D_2\left(\frac{d_L}{n_L}\right) \\ \left(\frac{d_L}{n_L}\right) & 1 - D_1\left(\frac{d_L}{n_L}\right) \end{bmatrix}$$

$$\bar{A} = \begin{bmatrix} 1 - (-0.10)\left(\frac{1}{1.5}\right) & -(-0.05) - (-0.10) + (-0.05)(-0.10)\left(\frac{1}{1.5}\right) \\ \left(\frac{1}{1.5}\right) & 1 - (-0.05)\left(\frac{1}{1.5}\right) \end{bmatrix}$$

$$\bar{A} = \begin{bmatrix} 1.067 & 0.153 \\ 0.667 & 1.033 \end{bmatrix}$$

$$a_{12} = -\frac{1}{f}$$

$$f = -\frac{1}{0.153} = -6.54\text{cm}$$

$$h_1 = \frac{n_{i1}(1 - a_{11})}{-a_{12}}$$

$$h_1 = \frac{(1)(1 - 1.067)}{-0.153} = +0.438\text{cm}$$

$$h_2 = \frac{n_{t2}(a_{22} - 1)}{-a_{12}}$$

$$h_2 = \frac{(1)(1.033 - 1)}{-0.153} = -0.218\text{cm}$$

$$ffl = f - h_1$$

$$ffl = -6.54 - (0.438) = -6.98\text{cm}$$

$$bfl = f - h_2$$

$$bfl = -6.54 - (-0.218) = -6.32\text{cm}$$

$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}$$

$$\frac{1}{10} + \frac{1}{s_i} = -\frac{1}{6.54}$$

$$s_i = -3.95\text{cm}$$

$$M_T = -\frac{s_i}{s_o} = -\frac{-3.95}{10}$$

$$M_T = 0.395$$