PHYS 462 (optics) HW#5

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1 6.8

We will assume that the flower is short relative to the $4m$ distance to the lense, thus we can make the small angele approximation. We will procede with a matrix approch.

$$T_1 = \begin{bmatrix} 1 & 4 \\ 0 & 1 \end{bmatrix}$$

$$R_2 = \begin{bmatrix} 1 & 0 \\ 5 * (1/1.4 - 1) & 1/1.4 \end{bmatrix}$$

$$T_3 = \begin{bmatrix} 1 & .2 \\ 0 & 1 \end{bmatrix}$$

$$R_4 = \begin{bmatrix} 1 & 0 \\ -2 & 1.4 \end{bmatrix}$$

$$T_5 = \begin{bmatrix} 1 & L \\ 0 & 1 \end{bmatrix}$$

$$T_5 * R_4 * T_3 * R_2 * T_1 = \begin{bmatrix} .714 - 3.429L & 3 - 13L \\ -3.429 & -13 \end{bmatrix}$$

So we will have a image formed at $3 - 13L = 0$ or $L = 3/13m$ beyond the opposite side of the sphere. At a magnification of $.714 - 3.429L = -0.077308$ so it will be inverted and smaller.

2 6.9

We can also do this with matraces

$$R_1 = \begin{bmatrix} 1 & 0 \\ .029 & 2/3 \end{bmatrix}$$

$$T_2 = \begin{bmatrix} 1 & 9 \\ 0 & 1 \end{bmatrix}$$

$$R_3 = \begin{bmatrix} 1 & 0 \\ .075 & 1.5 \end{bmatrix}$$

$$T_4 = \begin{bmatrix} 1 & L \\ 0 & 1 \end{bmatrix}$$

$$T_4 * R_3 * T_2 * R_1 = \begin{bmatrix} 1.26 + .138L & 6 + 1.45L \\ .138 & 1.45 \end{bmatrix}$$

The point where $1.26 + .138L = 0$ will be our focus $f = -1.26/.138cm$ puting our fucus inside of the lense.

3 6.14

see fig1

We can use the thin lense equation to see what hapens to rais originating at infinity. Passing thrugh the first lense they form a image at the focus. In our thin lense equation for the second lense the new object would be at $S_o = -10cm$ so we get $1/-10+1/S_i = 1/-20$ or $1/S_i = 1/20$ or $S_i = 20cm$ we end up with the focal point of the entre system at the right focal point of the diverging lense.

4 6.16

We will simply calculate the matrecies as before.

$$R_1 = \begin{bmatrix} 1 & 0 \\ .01583 & .79167 \end{bmatrix}$$

$$T_2 = \begin{bmatrix} 1 & 9.6 \\ 0 & 1 \end{bmatrix}$$

$$R_3 = \begin{bmatrix} 1 & 0 \\ .01263 & 1.26316 \end{bmatrix}$$

$$R_3 * T_2 * R_1 = \begin{bmatrix} 1.152 & 7.6 \\ 0.034552 & 1.096 \end{bmatrix}$$

using octave the det is 1.

5 6.22

$$R_1 = \begin{bmatrix} 1.00000 & 0.00000 \\ -0.06667 & 0.66667 \end{bmatrix}$$

$$T_2 = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$$

$$R_3 = \begin{bmatrix} 1 & 0 \\ 0 & 1.5 \end{bmatrix}$$

$$R_3 * T_2 * R_1 = \begin{bmatrix} 0.93333 & 0.66667 \\ -0.10000 & 1.00000 \end{bmatrix}$$

from octave the det is 1.

6 6.24

$$R_1 = \begin{bmatrix} 1 & 0 \\ 2/R & 1 \end{bmatrix}$$

$$T_2 = \begin{bmatrix} 1 & d \\ 0 & 1 \end{bmatrix}$$

$$T_2 * R_1 * R_1 * T_2 * R_1$$

This will yeald the same matrix as the book (using octave), however it will be transposed since the book is working in the transposed space relative to us. Also I note that the book is working in the right direction beeing positive, we take the direction the light is traveling to be positive.

Anyway if we plug in $d = r$ we get

$$M = \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix}$$

By inspection if we apply this matrix to itself we will get the identity matrix thus after four reflections we are left with the ray at its origional position and angle.

7 6.28

7.1 a

Spherical aberation since it is a rotationaly symetric aberation.

7.2 b

Coma. See fig 6.23 it is identical.

7.3 c

I think this is astigmatism since it has a little of the cross patern, its a little bit of a bad image so I cant be sure.

8 6.29

8.1 a

Its got the cross pattern so astigmatism.

8.2 b

Coma. See fig 6.23 in the book it looks very similar.