Engineering Optics, Homework 3

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1 Problem 1

Chapter 3, Problem 3

The optical leaver follows the following equation:

$$y = x \cdot \frac{2f'}{a} \tag{1}$$

where f' is the focal length of the lens, a is the distance between the axis and the test rod, and x is the distance between the mirror and the original position.

Given that $f' = 1000\textbf{mm}$, $a = 10\textbf{mm}$, and $y = 2\textbf{mm}$, we can calculate the displacement x;

$$x = \frac{y \cdot a}{2f'} = \frac{2 \cdot 10}{2 \cdot 1000} = 0.02\textbf{mm} \tag{2}$$

Therefore, the mirror rotates by $0.02\textbf{mm}$. the angle of rotation is given by:

$$\theta = \arcsin\frac{x}{a} = \arcsin\frac{0.02}{10} \approx 0.114591635420675\textbf{rad} \tag{3}$$

To summarize, the mirror rotates by **0.02mm**, and the angle of rotation is **0.114591635420675rad**.

2 Problem 2

Chapter 3, Problem 7

The answer is given in the Figure 1 and marked with boxed.

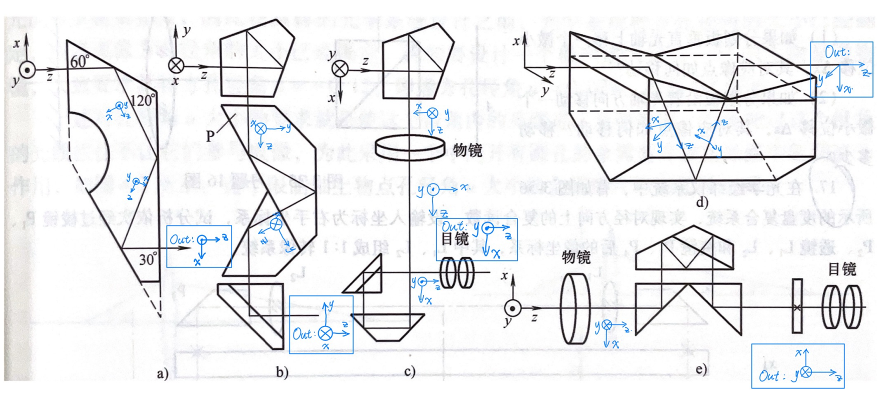

Figure 1: Chapter 3, Problem 7

3 Problem 3

Chapter 3, Problem 13

The Optical Wedge follows the following equation:

$$\delta = \left(n \cdot \frac{\cos I_1'}{\cos I_1} - 1 \right) \alpha \tag{4}$$

where δ is the deviate angle, n is the refractive rate of the wedge, I_1 is the angle of incidence, I_1' is the angle of refraction, and α is the angle of the wedge.

In this case, I_1 and I_1' are small enough, so we have

$$\delta = (n - 1)\alpha = (1.5163 - 1) \cdot 4^\circ = 0.20652^\circ \tag{5}$$

Therefore, the incidence ray deviates by $\mathbf{0.20652^\circ}$. to accomplish the same deviation, the mirror should rotates by θ, where:

$$\boxed{\theta = \frac{\alpha}{2} = 0.10326^\circ} \tag{6}$$

4 Problem 4

Chapter 3, Problem 17

When passing a mirror, the y axis is always perpendicular to the mirror, the z axis is always parallel to the axis, and the x axis will be reversed.

When passing a lens, the z axis is still parallel to the axis, but the x and y axis will be reversed.

In this case, after passing the P_1, the x axis is reversed, so the coordinate system is shown in Figure 2.

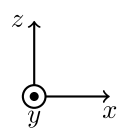

Figure 2: Coordinate System after P_1

Then, passing the P_2, the x axis is reversed again, so the coordinate system is shown in Figure 3. .

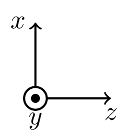

Figure 3: Coordinate System after P_2

After that, padding the reverse lens L_1, the x and y axis is reversed, so the coordinate system is shown in Figure 4

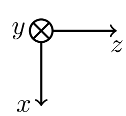

Figure 4: Coordinate System after L_1

And then, padding the reverse lens L_2, the x and y axis is reversed again, so the coordinate system is shown in Figure 5

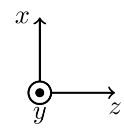

Figure 5: Coordinate System after L_2

The next step is padding the mirror P_3, the x axis will be reversed, so the coordinate system is shown in Figure 6

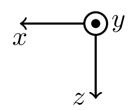

Figure 6: Coordinate System after P_3

Finally, padding the mirror P_4, there is two times reflection, so no axis will be reversed. Therefore the coordinate system is shown in Figure 7

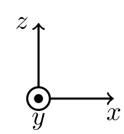

Figure 7: Coordinate System after P_4