Edward Auttonberry

**Lab 8: Some More Optics**

2/11/2020

PHYS 262 – 001

With:

Michael Hirchak

and

Thienduc Doan

**Objective**

The objective of this lab is to further validate the notions and ideas of ‘virtual’ images/objects versus their ‘real’ counterparts, and that the virtual images are theoretically valid in terms of optical projections.

**Theory**

The theory is functionally the same as that used in the previous lab, which is that when light passes through a lens, the direction that the light follows upon exiting the lens will have been adjusted by a factor proportional to the focal length of the lens. When light passes through a lens, the image that the light carries before passing through the lens and the image warped by magnification after passing through the lens are referred to as the ‘real’ and ‘virtual’ images respectively. The magnitude of the scaling between the real and virtual images are proportional to the focal length of the lens.

Eq. 8-1

Where *d*0 is the distance of the real object from the lens, *di* is the distance between the virtual object and the lens, and *f* is the focal length of the lens.

**Procedure**

At out disposal in these experiments, we were revisited with the same materials as previously. This included the ruled optical bench, the two lenses (100 mm and 200 mm), a light source projecting an image, and a target screen for the magnification of that image to land upon. In the beginning, the “exact” focal lengths of the lenses were experimentally determined using the same procedure as the last lab. Specifically, the lens in question was placed in a certain position on the bench, and the screen was adjusted until the virtual image was clear. This was done four times for both lenses, and an experimental focal length was derived using Equation 8-1. The four resulting focal lengths were averaged to obtain a “final” focal length for each lens.

Both lenses were placed on the optical bench in front of the light source. The screen was then adjusted, just as before, until the image projected by the light source was once again clear. The location of both lenses and the screen were noted.

**Data**

Shown below are the experimental focal lengths for the two lenses:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 10 cm Lens | | | | | | |
| I [cm] | L [cm] | S [cm] | Do [cm] | Di [cm] | f-1 [cm-1] | F [cm] |
| 0 | 15 | 45.5 | -15 | -30.5 | -0.099453552 | -10.05494505 |
| 0 | 20 | 40 | -20 | -20 | -0.1 | -10 |
| 0 | 25 | 41.75 | -25 | -16.75 | -0.099701493 | -10.02994012 |
| 0 | 30 | 45.1 | -30 | -15.1 | -0.099558499 | -10.0443459 |
|  |  |  |  |  | |AVG(F)| [cm] | 10.03230777 |

**Table 8-1.** The collection of centimeter measurements taken for real projection distance, virtual projection distance, and the experimentally determined focal length for the 10 cm lens and the image passing through it.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 20 cm Lens | | | | | | |
| I [cm] | L [cm] | S [cm] | Do [cm] | Di [cm] | f-1 [cm-1] | F [cm] |
| 0 | 40 | 80.2 | -40 | -40.2 | -0.049875622 | -20.04987531 |
| 0 | 35 | 81.7 | -35 | -46.7 | -0.049984705 | -20.00611995 |
| 0 | 30 | 89.2 | -30 | -59.2 | -0.050225225 | -19.9103139 |
| 0 | 45 | 81 | -45 | -36 | -0.05 | -20 |
|  |  |  |  |  | |AVG(F)| [cm] | 19.99157729 |

**Table 8-2.** The collection of centimeter measurements taken for real projection distance, virtual projection distance, and the experimentally determined focal length for the 20 cm lens and the image passing through it.

And the final positions of the entire configuration for part B:

|  |  |
| --- | --- |
| Part B Positions [cm] | |
| Light Source | 0 |
| 10 cm Lens | 17.5 |
| 20 cm Lens | 33 |
| Sheet | 39.5 |

**Table 8-3.** The positions of the light source, lenses, and receiving sheet in on the light bench for Part B of the lab.

**Analysis**

Using the focal length of the 10 cm lens, calculated previously via averages, in tandem with the positions of the light source and the lens, the position of the virtual object created by the image passing through the 10 cm lens can be derived. The positions given in Table 8-3 are plugged in to get a virtual image location of **23.51 cm**. A similar process can be applied using the same function and table of data to get the position of the “real” image from the perspective of the 20 cm lens. This came out to be **23.36 cm**. The “real” image for the 20 cm lens, coming second in the physical arrangement, is in fact the virtual image for the 10 cm lens, according to the theory. For this reason, these two positions should be the same. In this case, we observe a **0.638%** error margin for this experiment, which is very low and highly validating. Unfortunately, we encountered issues with any such success with the order of the lenses swapped, with a near 70% error. There is some kind of sweet spot that had to be found for this data to resolve in this desired way.

**Conclusions**

Based on the incredibly low error margin observed for this experiment, the theory of basic optics and magnification still holds quite true. In fact, it can be reasonably assumed that the only reason any error was observed at all can be attributed to a few simple factors. First, the exact position of the second lenses virtual image had to be “eyeballed” for a clear projection against the screen, which is imprecise for obvious reasons. Second, the nature of the experimental determinations of focal length, even though they near matched the inscribed focal lengths of 10 cm and 20 cm, also depended on some amount of human judgement among the order of “this is good now.” These two factors resulted in slightly “off” values being taken for focal length and position, accounting for the discrepancy observed between image positions. This likely accounts for our inability to perform Part B successfully for the inverse configuration as well. Because the relationship between images and focal length is exponential in some regard, the error grows really fast for large distances between images. All-in-all, this lab is definitely a success and upholds the theory.