22 February 2024

Winter 2024

experiment 7

Lenses & Optical Instruments

University of Wollongong in Dubai

SUBMITTED BY: →

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PHYS143
Physics for Engineers

Purpose

To determine the focal length *f* of a lens from the image distance *b* and the object distance *g*.

Measure the image distance *b*, and the magnification factor *A* as functions of the object distance *g*.

Hypothesis Statement

It is expected that a converging / convex lens will produce a real inverted image or a virtual magnified image of the object. Additionally, the experimental value of magnification from *b/g* and *B/G* will be similar.

Materials

- Halogen Lamp
- Holding Clip
- Lens
- Optical Bench
- Optical Saddles
- Projection Screen
- Ruler
- Slide
- Transformer

Procedure

1. Set the halogen lamp at the 0 cm mark on the optical bench and tighten the clamp.
2. Set the image at the 10cm mark from the light source.
3. Set the lens at the 30cm mark from the light source.
4. Insert the screen in one of the holding clips and put it at the end of the optical bench.
5. Turn on the light source.
6. Adjust the position of the screen until a clear and sharp image of the object is obtained.
7. Measure the image distance *b* and the image size *B*.
8. Repeat the experiment for other object distances *g* listed in the table.
9. Calculate the ratios *b/g* and *B/G*.
10. Calculate the focal length *f*.

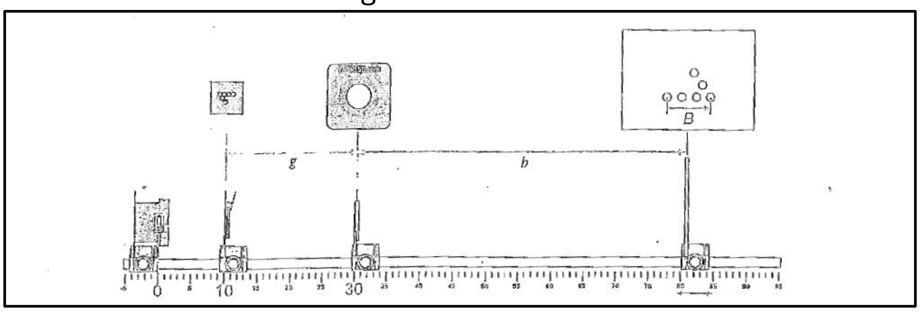

Figure 1: Experimental set-up; side view

Data & Calculations

g (mm)	b (mm)	G (mm)	B (mm)	b/g	B/G	f (mm)
200	525	23	70	2.625	3.04	150
250	350	23	35	1.4	1.52	150
300	275	23	25	0.916	1.086	150
450	210	23	15	0.467	0.652	150
600	185	23	10	0.308	0.434	150
					Average length of focal values	150
2f = 300	275	23	25	0.916	1.086	150

b/*g* = *A* = Magnification

Here, *b* is the distance from the lens to the image and *g* is the distance from the lens to the object.

B/*G* = *A* = Magnification

Here, *B* is the height of the image and *G* is the height of the object.

Observations & Analysis

1. **Describe the appearance of the image of the object on the screen.**

The image "1" appeared real and inverted.

2. **How does the image size depend on the image distance?**

The image size is directly proportional to the image distance. As the image is reflected farther away from the lens, it increases in size.

3. **How does the image size depend on the object distance?**

The object size is inversely proportional to the object distance. As the object is placed farther away from the lens, it decreases in size.

4. **How are the ratios *b/g* and *B/G* related to each other?**

Both *B*/*G* and *b*/*g* ratios are the magnifications of the object. *B*/*G* is the ratio of height of the image to the height of the object, while *b*/*g* is the ratio of distance from lens to image and lens to object.

5. **What is the focal length of the lens?**

The focal length of the lens is +150mm.

6. **For which object distances is the image reduced and for which is it magnified?**

Based on the table above, for the values $200 \leq g \leq 300$, the image produced will be reduced. While for the values $300 \leq g \leq 600$, the image produced will be magnified.

7. **When are the image and the object of equal size?**

From the table above, at g = 2f = 300mm, the experimental magnification values, from *b*/*g* and *B*/*G* are close to 1. This implies that the object and image are of equal size.

Conclusion

1. What was the purpose of this lab?

This lab's purpose was to determine the focal length of a lens from the image and the object distance and measure the image distance, image size, and magnification factor as functions of the object distance.

2. How does the lab we performed relate to what we are studying in class?

The lectures and classes are currently teaching image formation and properties of convex and concave lenses. This lab explains the concepts practically and gives the students in-field experience with the supervision of tutors.

3. Give a brief recap of the procedure used.

Set the halogen lamp, image, and lens on an optical bench. Adjust the screen position, adjust the image distance and size, and repeat for other object distances. Calculate the ratios b/g and B/G, and calculate the focal length f.

4. What problems did you have during the lab? Did you have to modify your procedure?

Fortunately, there were no problems with this lab as the calculated results matched the experimental results. Hence, there was no need to modify the procedure.

5. Do your results make sense? What are the sources of error?

Yes, the results make sense. The sources of error are parallax errors while taking measurements, and misalignment errors of the lenses on the optical bench.

6. What did you learn from this lab?

The team learned the variation of the magnification factor based on image and object distances. They also learned the nature of images produced by convex (converging) lenses, real and inverted, or virtual and magnified images.

7. If you were to repeat this lab in the future, how would you modify or improve the procedure?

If we were to repeat this lab, we would ensure that all lights are turned off before the experiment, as it would make the image more visible on the screen.

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Purpose

To construct a model of the Galileo telescope and determine the angular magnification and the required distance between the lenses as functions of their focal lengths.

Hypothesis Statement

Looking through the Galileo telescope, it is expected that the image will be larger as the telescope magnifies the image using the concept of angular magnification.

Materials

- Lens of different focal lengths
- Optical Bench
- Optical Saddles

Procedure

1. Fix the -100mm concave lens at the 90cm mark on the optical bench.
2. Set the +300mm convex lens at the 70cm mark on the optical bench.
3. Adjust the +300mm convex lens until a magnified and sharp image of the object is seen through the lenses.
4. Measure the distance *d* between the ocular and the objective.
5. Calculate the sum of the focal lengths $f_1 + f_2$ and compare it with the distance *d* between the lenses.
6. Repeat the experiment with a +150mm convex lens.

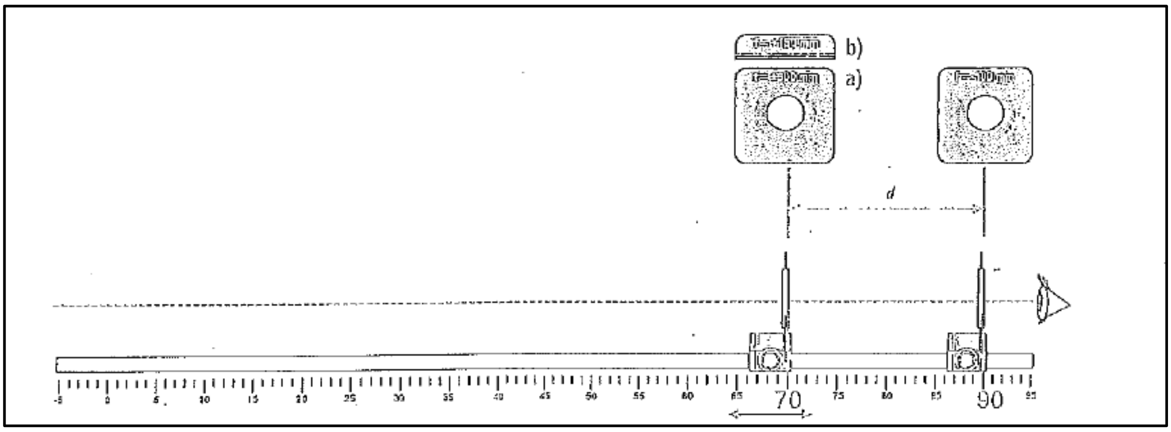

Figure 2: Experiment set-up; side view

Data & Calculations

f_1 (mm)	f_2 (mm)	d (mm)	$f_1 + f_2$ (mm)	A	f_1 / f_2 (mm)
150	-100	45	50	1.5	-1.5
300	-100	189	200	3.0	-3.0

$$A = \frac{F_1}{|F_2|} = \frac{150}{|-100|} = \frac{150}{100} = 1.5$$

Observations & Analysis

1. Describe the size and appearance of the image seen through the ocular.

The image seen through the ocular was magnified in size and upright in appearance.

2. What is the distance between the lenses that gives a sharp image?

The distance between lenses to produce a sharp image varies with the focal length of the lens. A sharp image is produced at a distance of 45mm for a focal length of 150mm and at distance 189mm for a focal length of 300mm, from a light source.

3. What is the relationship between the angular magnification *A* and the ratio $\frac{F_1}{|F_2|}$?

The relationship between angular modification, A, and the ratio of the angle crossed over by the image to the angle crossed over by the object at the eye, is given by $A = \frac{F_1}{|F_2|}$.

4. Which of the objective focal lengths gives the greatest angular magnification?

Based on the table above, the objective focal length value 300mm, gives the greatest angular magnification.

5. What is the relationship between angular magnification and the length of the telescope?

The angular magnification is directly proportional to the telescope's length; therefore, it increases as the telescope length increases.

Conclusion

1. What was the purpose of this lab?

This lab's purpose was to construct a Galileo telescope model and determine the angular magnification and required distance between the lenses as functions of their focal lengths.

2. How does the lab we performed relate to what we are studying in class?

The lectures and classes are currently teaching reflecting, refracting, and angular magnification of telescopes. This lab gives the team practical and hands-on learning experience.

3. Give a brief recap of the procedure used.

A brief recap of the procedure is to adjust the -100mm concave lens to the 90cm mark on the optical bench, adjust the +300mm convex lens until a sharp image is seen, measure the distance between the ocular and objective, and repeat the experiment.

4. What problems did you have during the lab? Did you have to modify your procedure?

Fortunately, there were no problems with this lab as the calculated results matched the experimental results. Hence, there was no need to modify the procedure.

5. Do your results make sense? What are the sources of error?

Yes, the results make sense, as the image produced must be sharp and magnified in size. Some sources of error could be parallax errors while taking measurements, and human errors while measuring distances between the lenses.

6. What did you learn from this lab?

The team practically saw the working and behavior of the Galileo telescope. They have also seen how a telescope produces images to be virtual, magnified, and upright. Using different focal lengths produces sharp images at different distances.

7. If you were to repeat this lab in the future, how would you modify or improve the procedure?

If we were to repeat this lab, we would ensure that the room is well-lit as it makes it easier to see the object in question. Additionally, we would place the optical bench on a suitable place such as a high table so that the image can be viewed easily.

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