PHYS143

Physics for Engineers

Lab Report - 7

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Instructor

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Experiment 1: Lens Equation

Purpose:

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

Hypothesis:

The magnification factor A of a converging lens, the ratio of image size B and object size G are dependent on the image distance b and object distance g

$$A = \frac{B}{G} = \frac{b}{g}$$

Where b and g are related to the focal length f of the lens by the lens equation:

$$\frac{1}{b} + \frac{1}{g} = \frac{1}{f}$$

Therefore, the values measured during the experiment can be used to determine the focal length of the lens

Materials:

- 1 optical lamp
- 1 optical bench
- 4 optical saddles
- 1 holding clip
- 1 white screen
- A slide with numeral 1
- A lens of focal length +150mm
- A ruler

Procedure:

- Setup the experiment as shown in the diagram with the light source, object, lens and screen positioned accordingly

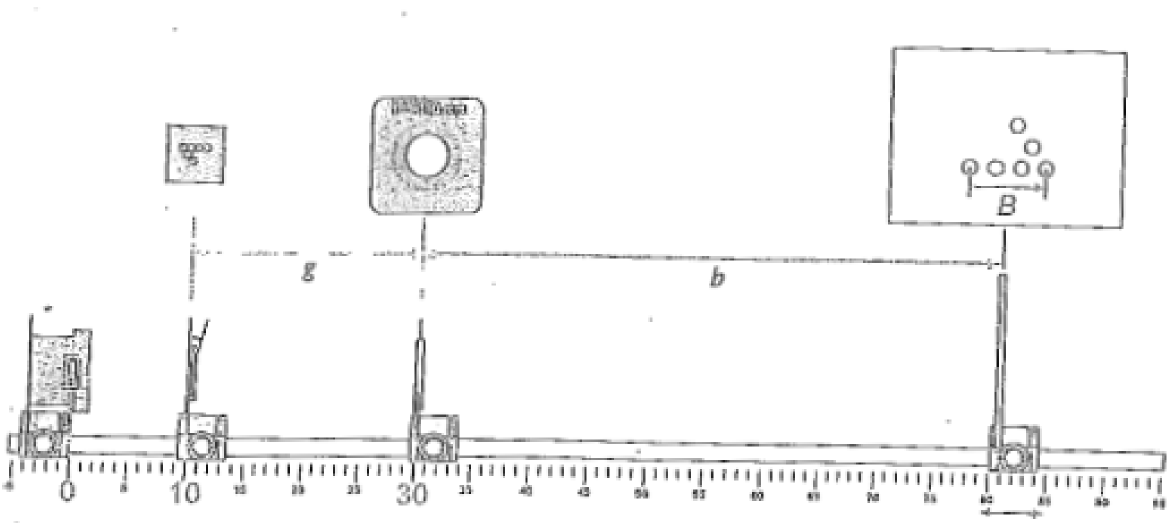

Fig. 1: Experiment 1 setup (sideview)

- Vary the distance ***g*** between the object and lens according to the values given in the table
- Adjust the screen until a sharp image is formed then measure and record the distance ***b*** between the image and lens for each varied value of ***g***
- Measure the size ***B*** of the image formed using a ruler then repeat all steps for different values of ***g***

Data Table:

G = 23mm

g / mm	b / mm	B / mm	b / g	B / G	f / mm
200	516	63	2.58	2.74	144.1
250	330	32	1.32	1.29	142.2
300	275	22	0.916	0.96	143.5
450	242	16	0.537	0.69	157.4
600	221	13	0.368	0.57	161.5
				Average focal length	**149.74**
2f = 299.48	2.75	22	0.918	0.95	**143.35**

Analysis Questions:

a) **Describe the appearance of the image of the "1" on the screen.**

The appearance of image 1 on the screen should be real and inverted.

b) **How does this image size depend on the image distance?**

The image size depends on the image distance in a proportional way which means when magnification decreases distance increases.

c) **How does the image size depend on the object distance?**

The size of an object in an image is inversely proportional including the object's size and its distance from the camera. And also when the distance between the object and the camera changes, the size of the object in the image will also change.

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

They are similar but they only differ when it comes to human error like not viewing it exactly or properly.

e) **What is the focal length of the lens?**

This might vary from group to group but what we got was 149.74mm as the focal length.

f) **For which object distances is the image reduced and for which is it magnified?**

For values 200 and 250 the object distances are magnified but for 450 and 600 the object distances are reduced.

g) **When are the image and the object of equal size?**

At object distance 300 it is neither magnified or reduced.

Conclusion:

This experiment helped us understand the role of focal length and how the distance between the object and lens changes the magnification factor. By learning about the properties of concave and convex lenses in class, we were better equipped for the experiment and this further improved our understanding of lenses. To perform this experiment, a lens is placed between the object and screen and is moved till a sharp image is produced on the screen. No modifications were made to the procedure and overall the experimental results were very similar to the calculated results.

Experiment 2: Galileo Telescope

Purpose:

To construct a model of the Galileo telescope and use it to determine the angular magnification ***A*** and the required distance ***d*** between the lenses as functions of their focal lengths

Hypothesis:

The angular magnification is achieved by using a converging lens and a diverging lens separated by a distance d which is equal to the sum of the focal lengths of the two lenses:

$$d = f_1 + f_2$$

The angular magnification can be calculated using the formula:

$$A = \frac{f_1}{|f_2|}$$

Materials:

- 1 optical bench
- 2 optical saddles
- 3 different lenses of focal lengths: +150mm, +300mm and -100mm

Procedure:

- Set up the experiment as shown in the diagram with the -100mm lens positioned at the end and a +150mm lens positioned after it

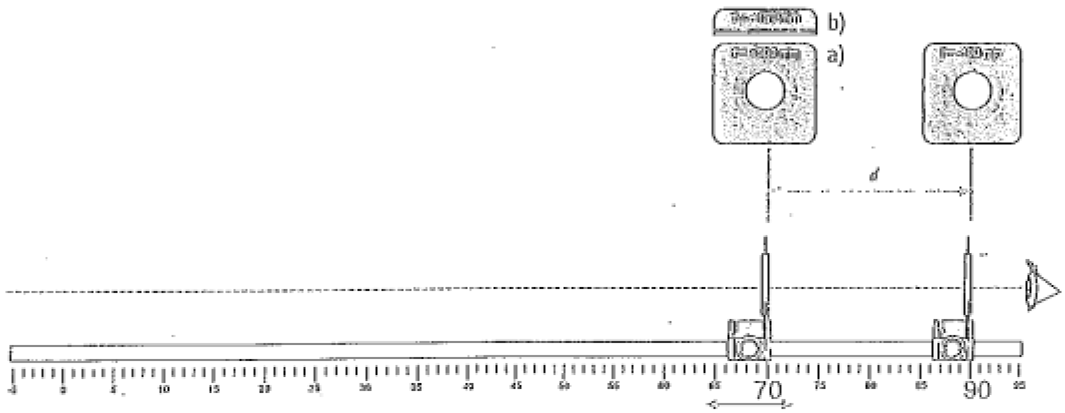

Fig. 2: Experiment 2 setup (sideview)

- Observe a distant object through the lenses and adjust the objective(+150mm) lens until a clearer image is obtained
- Measure the distance ***d*** between the ocular(-100mm) and objective(+150mm) lens
- Repeat the experiment using the +300mm lens as the objective lens

Data and Observations:

f1 / mm	f2 / mm	d / mm	f1+f2 / mm	A	f1 / f2
150	-100	50	50	1.5	-1.5
300	-100	175	200	3.0	-3.0

After finding the values of f1 and f2, the distance between the beams was calculated by adding f1 and f2. This was done to find the calculated value at which the image is sharpest. Magnification is now found by dividing f1 by f2.

Analysis Questions:

a) **Describe the size and appearance of the image seen through the ocular.**

The size and appearance of the image seen through the ocular will be magnified and upright.

b) **What is the distance between the lenses that gives a sharp image?**

The distance formula between the lenses and the sharp image will be f1 subtracted f2. (f1 - f2).

c) **What is the relationship between the angular magnification A and the ratio f1/|f2|**

The angular magnification A is defined as the ratio of the angle crossed over by the image to the angle crossed over by the object at the eye. The angular magnification is given by the formula: A = f1 / I f2 I .

d) **Which of the objective focal lengths gives the greatest angular magnification?**

The objective focal length 300 is what gives the greatest angular magnification as proven in the table above.

e) **What is the relationship between the angular magnification and the length of the telescope?**

The relationship between the angular magnification and the length of the telescope is proportional.

Conclusion:

In this experiment, we constructed a model of a Galileo telescope using two lenses of different focal lengths and how to calculate magnification using the focal lengths. A concave and convex lens are placed at a distance from each other and adjusted until a sharp image is placed in the field of view of the telescope, and is visible through the eyepiece. A possible source of error could be due to size perception and improper measurement of the distance between the lenses.