UNIVERSITY OF WOLLONGONG IN DUBAI

LAB REPORT 7

LENSES AND OPTICAL INSTRUMENTS

Subject: PHYS143 (DB123) Physics for Engineers.

Group Members:

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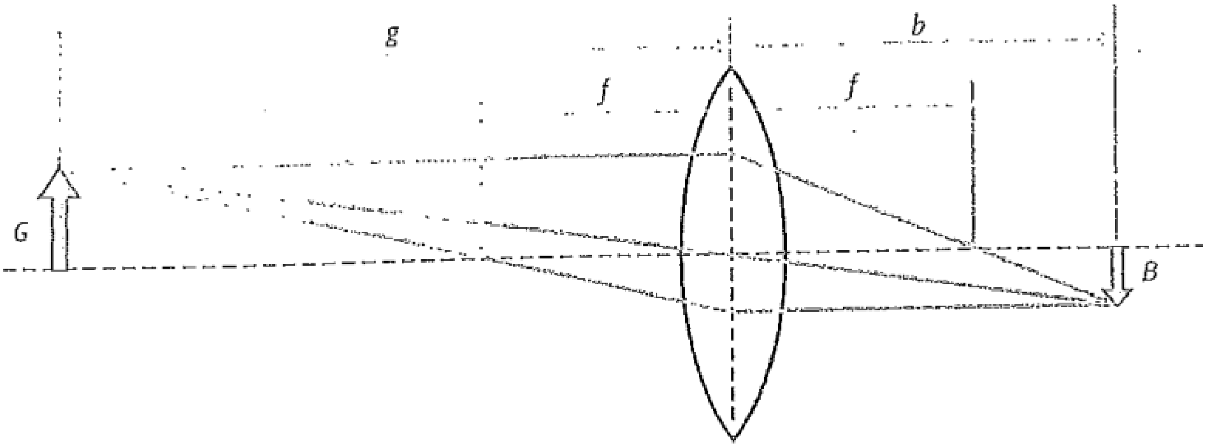
EXPERIMENT 1



Sample image of the experiment done

Purpose

The objective of this experiment was to determine the focal length (f) of the lens from the image distance b which is to be measured, the object distance g, and the magnification A of the image.

Hypothesis

It is expected that a convex (converging) lens such as the one used in this experiment will produce an inverted real image or virtual magnified image of the object. It is also expected that the calculated value of the magnification from b/g and B/G for each value of g will be similar to each other.

Materials used

- Halogen Lamp
- Optical bench
- Optical saddles
- Holding clip
- White Screen
- Slide
- Lens (f = +150 mm)
- Ruler

Procedure

Experimental set-up:

1) Set the halogen lamp at the 0 cm mark on the optical bench (tighten the clamp).
2) Set the image 10 cm from the light source (tighten the clamp).
3) Set the +150 mm at the 30 cm mark (tighten the clamp) for the first part of the experiment. This value of g varies over the course of the whole experiment. These values are mentioned in the table below.
4) Insert the white screen in one of the holding clips and put it at the end of the optical bench (don't tighten it yet).

Procedure:

1) Turn on the light source (Halogen lamp).
2) Adjust the position of the screen to obtain a clear, clean, and sharp image on the white screen.
3) Tighten the clamp on the screen and use a ruler to read the value of B and record this value on a table.
4) Measure the distance between the lens and the white screen. That distance is b.
5) Repeat this experiment for the various values of g mentioned in the table below. Measure and record the values b and B in a table.

Observations

As shown in the table, for each value of g the values of the magnification calculated from b/g and B/G are very similar as expected.

Data

G =23mm

g/mm	b/mm	B/mm	b/g	B/G	f/mm
200	550	67	2.75	2.91	146.67
250	349	33	1.39	1.43	145.66
300	276	23	0.92	1	143.75
450	210	11.5	0.47	0.5	143.18
600	190	8	0.32	0.35	144.31
				Average of focal length:	144.71
2f = 289.42	290.57	24	1.004	1.0435	144.99

Calculations

b/g = A = magnification

Where 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

Where B is the height of the image and G is the height of the object.

Equation for focal length:

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

F = 1/ ((1/349) +(1/250) =145.66

Average focal length = sum of all focal lengths/5

Average focal length = 144.71 mm

Conclusion

The goal of this experiment was to determine the focal length (f) of the lens from the image distance b which is to be measured, the object distance g, and the magnification A of the image. Before doing the experiment, set the experiment by setting the halogen lamp at the 0 cm mark, the image 10 cm from the light source, set the +150 mm at a distance of 20 cm from the object. This distance is varying throughout the experiment. Put a white screen at the end of the optical bench. Turn on the light source. Adjust the position of the white screen until a sharp and clear image is observed. Measure the height of the image and the distance between the image and the lens. Repeat this experiment for different values of g.

Some sources of error may include:

1) The lenses may have imperfections and may be unclean.
2) Parallax error while taking measurements.
3) Misalignment of the lens on the optical bench

We learnt that a convex (converging) lens such as the one used in this experiment will produce an inverted real image or virtual magnified image of the object and this can be proved by conducting this experiment. If we were to repeat this experiment, we would make sure to read the measurements perpendicularly, clean the lens to see the image clearly.

Analysis questions:

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

   The image obtained was real and inverted.

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

   When the image distance is reduced, the image size also reduces. So, the image size is proportional to the image distance.

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

   When the object distance is increased, the image size is decreased. So, the image size is not proportional to the image distance.

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

   Both of these ratios are the magnification of the object. B/G is the magnification calculated from height. b/g

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

   The calculated focal length of the lens is 144.71 mm which is close to the theoretical focal length of 150 mm.

6) **For what object distance is the image reduced and for which is it magnified?**

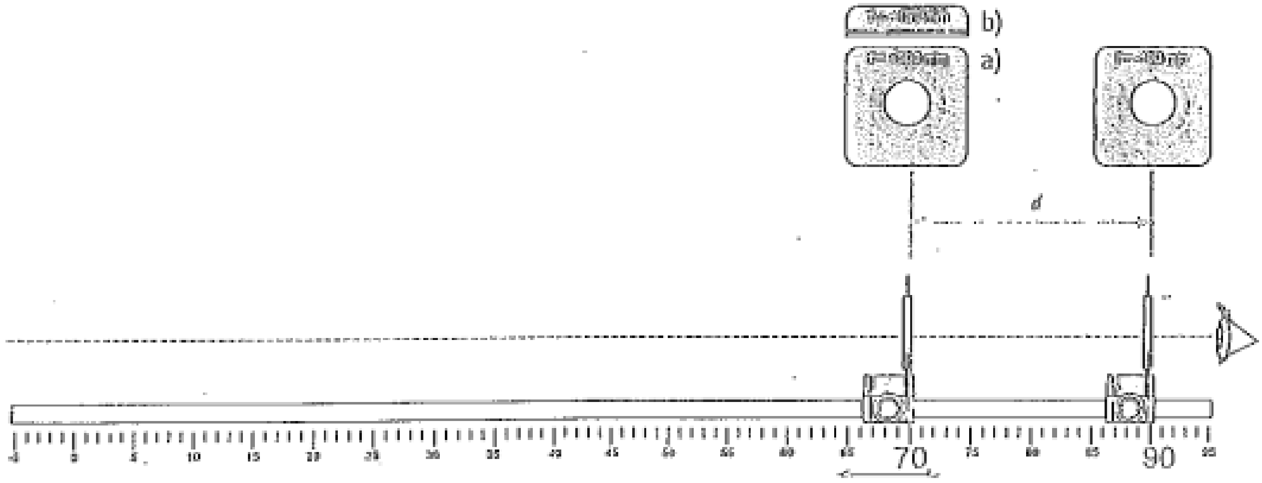
   If $g < 2f$ (289.42) then the image produced will be magnified.

   If $g > 2f$ (289.42) then the image produced will be reduced.

7) **When are the image and object size equal?**

   From the table above, at $g = 300$mm, the magnification from both b/g and B/G are close to 1 which signifies that the image and object size are the same.

EXPERIMENT 2



Sample image of the experiment done

Purpose

The goal of this experiment was to construct a model of a Galileo telescope and determine the angular magnification and the required distance between the lenses as functions of their focal lengths.

Hypothesis

When looking through the Galileo telescope, it is expected that the image will be larger because the telescope magnifies the angle of vision that the object subtends at the eye of the observer.

Materials used

- Convex lens (+150 mm, +300 mm)
- Concave lens (-100 mm)
- Optical bench
- Lens holder

Procedure

Experimental set-up:

1) Set up the experiment by fixing the -100mm concave lens at the 90 cm mark.
2) Set the +300 mm convex lens at the 70 mm mark.

Procedure:

1) Adjust the +300 mm convex lens until a magnified and sharp image is seen through the lenses.
2) Measure the distance d between the ocular and the. Record this value in the table.
3) Repeat this experiment with a +150 mm convex lens.

Data

F_1 (mm)	F_2 (mm)	d (mm)	$F_1 + F_2$ (mm)	A	F_1/F_2
150	-100	45	50	1.5	-1.5
300	-100	203	200	3	-3

Calculations

$A = F_1/|F_2| = 150/100$

$F_1/F_2 = 150/-100$

Observation

As we can see from the table above, when F_1 increases, angular magnification also increases. When the distance between the light source and the lens (d) increases, the angular magnification also increases.

Conclusion

The objective of the experiment was to construct a model of a Galileo telescope and determine the relationship between the angular magnification and the required distance between lenses based on their focal lengths. The equipment used in the experiment included a convex lens, concave lens, screen, optical bench, and lens holder, while the procedure involved fixing the lenses at specific marks, adjusting them for a clear and magnified image, and measuring the distance between the ocular and objective, with this process repeated with a different convex lens.

Some possible sources of error may include:

4) The lenses may have imperfections and may be unclean.
5) Parallax error while taking measurements.
6) Misalignment of the lens on the optical bench.
7) Eye fatigue of the observer's eyes can cause inaccurate measurements.
8) Misalignment of the ruler when measuring B.

This topic is related to telescopes we studied in our class. Galileo's telescope used a convex objective lens and a concave eye lens, whereas modern telescopes use two convex lenses. Galileo recognized that a convex lens produced a mirrored image of a distant object on its opposite side, making the object appear larger when viewed from a distance. A problem we faced in the experiment was that the light source was very dim which may give inaccurate results. We then used a light source with a higher light intensity to obtain a clearer and sharper image.

We learnt that a convex (converging) lens can produce a real image which will be inverted and a virtual image which will always be upright. A real image is produced when the object is placed at a distance of more than the value of focal length from the lens itself. The image is always produced at the front of the lens and can be shown on a white screen. The virtual image is produced when the object is placed in front of the focal point. A concave (diverging) lens produces an image that is always virtual and reduced. If we repeat this experiment, we would make sure to read the measurements perpendicularly, clean the lens to see the image clearly.

Analysis question

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

   The image produced was upright and magnified (increased in size).

2) **What is the distance between the lenses that give a sharp image?**

   For the lens with focal length of 150 mm, the sharp image occurred at a distance 45 mm from the light source.

   For the lens with focal length of 300 mm, the sharp image was observed at a distance of 203mm from the light source.

3) **What is the relationship between the angular magnification A and the ratio $F_1/|F_2|$?**

   $A = F_1/F_2$.

4) **Which of the objective focal lens gives the greatest angular magnification?**

   +300 mm focal lens.

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

   The angular magnification of a telescope is directly proportional to the length of the telescope.