NAME Treepat Chantaurai

DATE 30 November 2021 Section J

**Report Sheet for Experiment 14: Geometrical optics**

Abstract

In conclusion, the geometrical reflection and refraction perspective of light rays in concave mirror and composite of lens(telescope and microscope) is investigated. Concave mirror will focus light from infinity to its focal length which the focal length can be determined by varying the finite distance of the objects and plot the inverse of that distance by the inverse of the formed image distance. The result shows only 0.2% deviation from the theoretical value. The magnification was found by two approaches consists of the ratio between the object over image distance and the ratio of their sizes. Result shows approximately 8.63% difference between the two methods. Furthermore, a composite of lens mimicking telescope is investigated. Both reveals an inverted images yet virtual since the rays do not focus on the screen. The magnification of the lens was found by two approaches, one deriving it from the distances of object, image, and the distance between the lenses. The other derives purely on the observation that is the ratio between the sizes of the image and the object. The results demonstrate a 6.26% and 18.10% error for the telescope and microscope, respectively. By swapping/changing the objective lens to a longer focal length one, a setup for microscope turns into telescope, the vice versa is also valid. The light ray for both experiments did cross and focus once in between the lens before creating a virtual image. The error for every experiment could potentially come from the imprecise measurement of the naked human eyes which might not be confident on where the light is perfectly focus and create the sharpest image, therefore, the focused distance might change.

Introduction and Theoretical Background

**Part I – Concave mirror**

For the light refraction and rays’ direction in concave mirror, the relationship between focal length(f), object distance(do), and image distance from the mirror(di) can be expressed as:

…eq(1)

And the magnification of the mirror is the ratio between distance or size of the image to that of the object.

**Part II – Telescope**

This is composed of two convex lenses demonstrated in the Figure 1 below. The magnification of such slope can be expressed as:

Diagram, line chart

Description automatically generated

Figure 1 depicts the lens components in the telescope

…eq(2)

**Part III – Microscope**

This utilized quite the same components like in telescope. However, unlike telescope that has long focal length of objective lens, microscope has short focal length lens on the objective side. This enables it to magnify small object at a very close distance. Its components and equation of magnification is listed below

A picture containing text, light, screenshot, power line

Description automatically generated

Figure 2 depicts the lens components in the microscope

Methods

**Part I – Concave mirror**

1. With 100mm concave mirror, align the half screen and adjust the distance until the light source is focus and record the position.
2. Set the experiment as shown in Figure 3, set the distance between the light source and the mirror to be 50 cm, align the half screen and adjust the distance until the light source is focus and record the position.
3. Repeat step 2 and change the distance to  45, 40, 35, 30, and 25 cm respectively.

A picture containing text, indoor

Description automatically generated

Figure 3 depicts the experimental set-up for concave mirror

**Part II – Telescope**

1. Set the experiment as shown in Figure 4 but swap the position of the long and short focal lengths lenses.
2. Observe the image through the eyepiece lens and move the objective lens until the image is clear.
3. Record the position and capture the image to determine the size of the image.

**Part III – Microscope**

1. Set the experiment as shown in Figure 4
2. Repeat step 6-7

A picture containing text, indoor

Description automatically generated

Figure 4 depicts the experimental set-up for Microscope

Results

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **do [cm]** | **di [cm]** | **Object size [cm]** | **image size [cm]** | **1/do [cm-1]** | **1/di [cm-1]** |
| 50 | 12.5 | 4 | 1.02 | 0.0200 | 0.0800 |
| 45 | 13 | 1.17 | 0.0222 | 0.0769 |
| 40 | 13.7 | 1.41 | 0.0250 | 0.0730 |
| 35 | 14.35 | 1.8 | 0.0286 | 0.0697 |
| 30 | 15.5 | 2.1 | 0.0333 | 0.0645 |
| 25 | 17.1 | 2.5 | 0.0400 | 0.0585 |

Table 1 summarizes parameters used in the experiments

Chart, scatter chart

Description automatically generated

Figure 5 depicts the linear relationship between inverse of object and image distances. Its y-intercept can be used to determine the inverse of the focal length of the concave mirror as described in equation 1.

|  |  |
| --- | --- |
| Calculated magnification (by sizes) | 0.684 |
| Theoretical magnification (by distances) | 0.625 |
| %ifference in magnification | 8.63 |

Table 2 summarizes calculated and theoretical magnifications of the concave mirror

|  |  |  |
| --- | --- | --- |
|  | Telescope | Microscope |
| Position of objective lens [cm] | 70.5 (long focal) | 45.3 |
| Position of eyepiece lens [cm] | 112 | 76 (long focal) |
| Position of screen [cm] | 0 | 25 |
| Observed magnification | 3.05 | 3.69 |
| do,1 [cm] | 70.5 | 20.3 |
| di,1 [cm] | 27.92 | 19.71 |
| do,2 [cm] | 13.58 | 10.99 |
| di,2 [cm] | 112 | 51 |
| Calculated magnification | 3.27 | 4.51 |
| %difference in magnification | 6.62 | 18.10 |

Table 3 summarizes the calculated and theoretical magnifications of telescope and microscope experiments.

The calculation of information shown in Table 2 can be demonstrated as follows:

* Calculated magnification = do/di = 17.1 cm / 25 cm = 0.684
* Theoretical magnification = sizeo/sizei = 2.5 cm / 4 cm = 0.625
* %Difference in magnification = (0.684 – 0.625)/0.625 x 100 = 8.63%

The calculation of information shown in Table 3 can be demonstrated as follows:

Telescope

* Calculated magnification = 27.92/70.5 x 112/13.58 = 3.27
* %Difference in magnification = (3.27-3.05)/3.05x100 = 6.62%

Microscope

* Calculated magnification = 19.71/20.3 x 51/10.99 = 4.51
* %Difference in magnification = (4.51-3.69)/3.69x100 = 18.10%

Discussion

In Part I, from the first observation, a light source from an infinite distance will form a focused dot image at the focal length of the concave mirror, at 10 cm which matches the spec of the mirror of 100mm. Furthermore, with finite distances, the image is inverted and real since the light actually intersects and can be seen even without a screen. By fitting the inverse of object distance to the mirror and the inverse of the image distance, the obtained y-intercept will be the inverse of the focal length. The magnification is negative and can be determined by two routes including the ratio between the distances of object over image, or the size of object over image. The difference between these two approaches is around 8.63%. The error might be contributed from the imprecise measurement of the focus point of our eye which might find slightly blurred point a focus one.

In both part II and part III, the images are inverted and virtual since the rays do not actually focus and form image on the screen. Magnification calculated from the distances compared to the one from the sizes(observation) are 6.26% and 18.10% for the telescope and microscope, respectively. The error is as well the imprecise observation of human eyes mentioned above. Furthermore, for the microscope, the focal length of objective lens should be shorter since its distance to the object is very small. Light will consequently focus once in between the two lenses. On the contrary, longer focal length of objective lens is used in the telescope and focus like in the microscope.

Conclusion

In conclusion, the geometrical reflection and refraction perspective of light rays in concave mirror and composite of lens(telescope and microscope) is investigated. Concave mirror will focus light from infinity to its focal length which the focal length can be determined by varying the finite distance of the objects and plot the inverse of that distance by the inverse of the formed image distance. The result shows only 0.2% deviation from the theoretical value. The magnification was found by two approaches consists of the ratio between the object over image distance and the ratio of their sizes. Result shows approximately 8.63% difference between the two methods. Furthermore, a composite of lens mimicking telescope is investigated. Both reveals an inverted images yet virtual since the rays do not focus on the screen. The magnification of the lens was found by two approaches, one deriving it from the distances of object, image, and the distance between the lenses. The other derives purely on the observation that is the ratio between the sizes of the image and the object. The results demonstrate a 6.26% and 18.10% error for the telescope and microscope, respectively. By swapping/changing the objective lens to a longer focal length one, a setup for microscope turns into telescope, the vice versa is also valid. The light ray for both experiments did cross and focus once in between the lens before creating a virtual image. The error for every experiment could potentially come from the imprecise measurement of the naked human eyes which might not be confident on where the light is perfectly focus and create the sharpest image, therefore, the focused distance might change.

Reference

1. Lab manual titled “**Ch10.** **Measuring the earths magnetic field”**from Department of Physics on KLMS