**Experiment 3: Periscope, Telescope, Microscope**

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**Abstract**

Briefly state the major goals and results of the experiment. For example: “A Michelson interferometer has been used to determine the difference in wavelength of the sodium D lines. A value of 5.9+- 0.2 A was found, which agrees with the accepted value.”

A pair of converging lenses are arranged in Telescopic and Microscopic orientations.

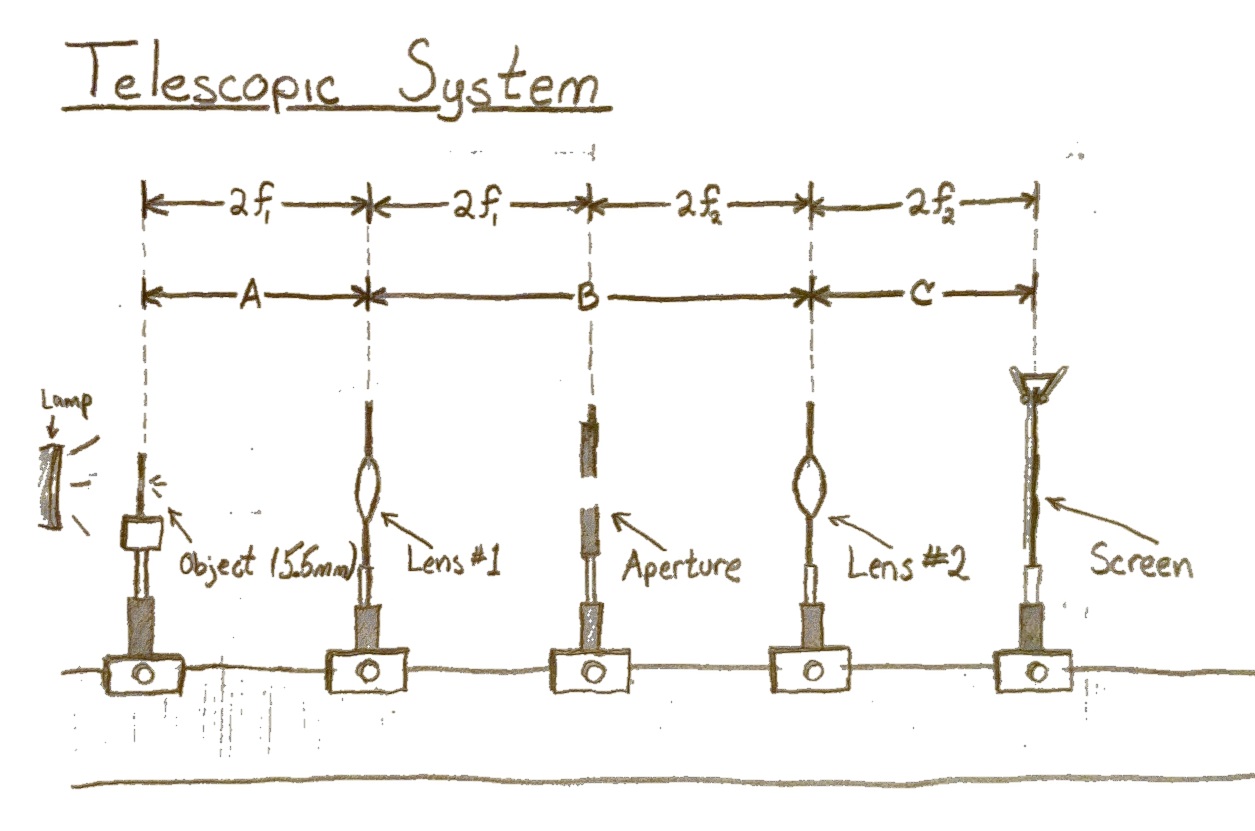
**Introduction**

This summarized the main ideas of the experiment and the conclusions of appropriate theory. A clear sketch of the experiment should be included.

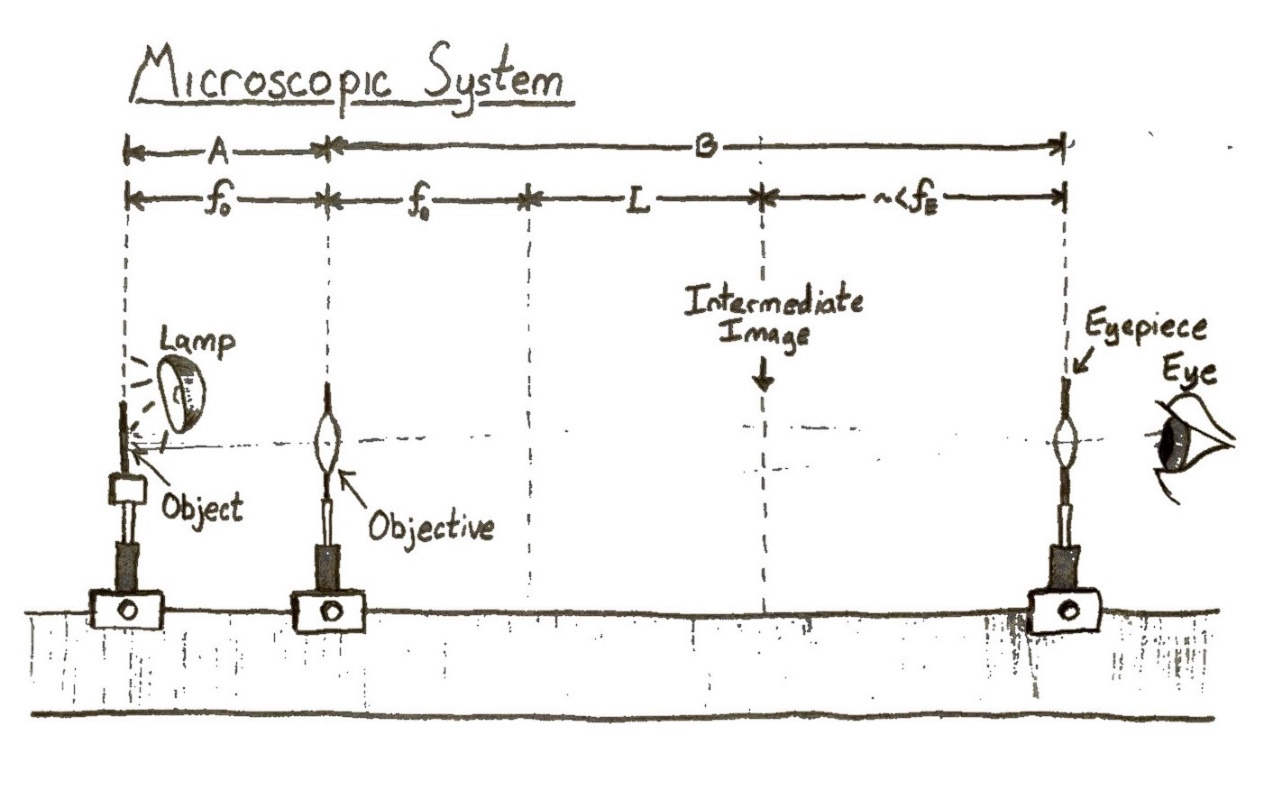
One can determine the focal length of a lens experimentally by arranging it in-between an object and screen such that an image is focused onto the screen, then measure the resulting distances and entering them into the Lens Equation.

A Telescopic system can be created by arranging one lens, an aperture, and a second lens in-between an object and screen such that an image is focused at the screen. Generally, the first lens in a telescopic system, the objective, serves as a collector of incoming rays. The eyepiece then serves to re-collimate the image to a diameter suitable for a pupil.

To make the system Periscopic the distances used between the elements on either side of the first lens is and for either side of the second as seen in the image below. This makes the simplified values relevant in following equations: , , and . In our Periscopic system, the image becomes flipped in the intermediate image, then reverted back to the original orientation on the final screen. The goal of a periscope isn’t to magnify an image but allow it to travel some distance, as is done in submarine periscopes so views from above the surface can be seen by someone below.



Our microscopic optical arrangement has the same order of optical elements as the Periscopic but with different distances and no aperture. The first lens in a microscope is called the objective. It generates a real, inverted, and magnified intermediate image. This image is then magnified again, except into a virtual image, by the second lens. Using the Lens Equation in a compound fashion, we can describe the system and its magnification. Note that is the distance to the image plane from the second lens, and that a human eye—itself containing a lens—requires a different focus.



**Analysis & Discussion**

Present your results. Quantitatively compare your data with expectations. Error estimates must always be given. Do not recopy all the raw data for your report. Give examples and/or the range of the numerical values where appropriate. Present data by graphs as much as possible. Do the measurements within the error estimation agree with theory/ If not, can you suggest possible sources of the discrepancy.

The focal length of each lens was calculated using the Lens Equation and measured distances from the lens to the object on one side, and to a focused image on the other. Error analysis was done as seen below, and results tabulated below that.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Lenses |  |  |  |  |
| #2 |  |  | 20.46 |  |
| #1 |  |  | 15.36 |  |

The Periscopic System was arranged with the 15.36cm focal length lens first, and lens (2) second: resulting in distances of and . It was found that some extra adjustment from an initial setting of was required to get a sharp image at C. Entering these values into equation (3) returns a Magnification

. Which exactly matches the observed ratio in heights of our object to our image: both being 5.5mm—in other words, an agreeable magnification of 1.

Closing the aperture upstream from Lens #2 did decrease some bluring, but it seemed to mostly dim the image rather than sharpen it. Not until moving the aperture upstream farther still did we see any sharpening of the image. It was determined this ‘first order blurring effect’ is most likely due to the way transmitted light is effected by traveling through the edges of the first lens, and that this light can be limited by the aperture as it continues to travel along the optical axis with largest transverse distance relative to the other rays.

Our periscopic system was then made more telescopic by shifting Lens #2 upstream towards a distance from the intermediate image. Once at that distance, the exiting light would be fully collimated. If the distance is made shorter still, the light would begin to diverge.

By decreasing the distance of Lens#2 from the intermediate image, from 39.5cm to 22cm (). The Magnification became approximately 25 times larger, it appeared to be 13.75mm tall rather than 5.5mm.

Q1) The Closing of the aperture, or field stop, at a distance past lens #1 does decrease some blurring of the image. This is likely due to it excluding light which is getting around the lens in the first place. However, it was noted experimentally that by shifting this aperature further upstream, the image did get clearer. This was assumed to mean that rays coming in at greater , or transverse position, are blurring the image.

Q2) It was clear that moving the aperture closer to the objective lens that the image became sharper, implying that lens is the culprit for a lousy image.

Q3) Though there was some debate within our group about what was sharper rather than just less bright, I was left with the distinct impression that the field stop positioned closer to Lens #1 was optimal. This may be because it then limits not just stray incoming light, but also any aberrations due to light coming through at the edges of the lens, as the locations of our images do not change. These issues would otherwise have passed through the aperture if it was instead closer to Lens #2.

Q4) It was necessary to shift L2 because the human eye either can not, or struggles greatly, to see anything under the near point position of 25cm. By shifting L2 such that it’s distance from the intermediate image is decreased from , the light exiting the other side will become increasingly collimated as it reaches the distance . The source of most light we see with our eyes is at a very far (nearly infinite) distance.

Q5) The discrepancy between M and

**Conclusion**

A brief statement summarizing your results is required. Did you find what you expected? What improvements would you make if you were to repeat the measurements?