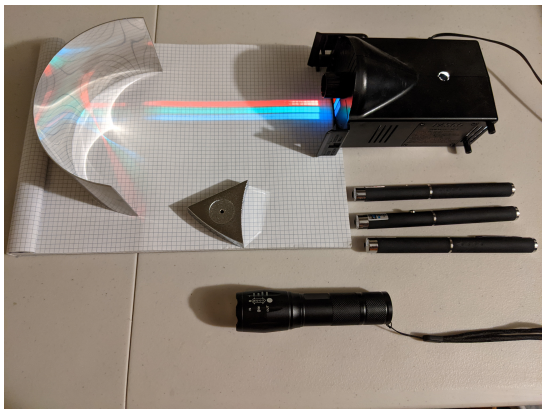
Lab 1

Focus on Uncertainty



Physical Models: Focal Length of a Mirror

Analysis Tools: Mean, Standard Deviation, Standard Deviation of the Mean, t-score

Experimental Systems: Large Concave Mirror, PASCO Optics Kit Mirror

Equipment: : Flashlight, multiple lasers, PASCO light source, dial caliper, protractor, stopwatch, graph paper

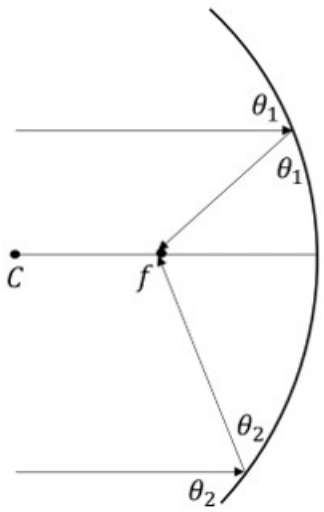
Safety Concerns: Please be careful not to look directly into any light sources or to shine them haphazardly at other groups! Be careful handling the glass mirrors since they could shatter. Absolutely do not use the "strobe" setting on the flashlights, since this may cause harm to others, including *epileptic seizures*.

Introduction

The goal of lab this week is to investigate the behavior of light reflected off a curved (cylindrical) mirror. In the Prelab Activity for this week, you were introduced to a proposal that related the focal point to the geometry of the mirror:

$$f = \frac{R}{2} \tag{1.1}$$

where f is the distance from the mirror along the central axis to the focal point and R is the radius of curvature. See the diagram and textbox on the next page for details.



Physical Model

In the picture C is the center of curvature, f is the focal point. The line going from C to the mirror is the "central axis."

The scientists' model has two claims:

1. All light rays incident on the mirror parallel to the central axis will be focused to a single point f.

2. If the radius of the mirror is R, then the location of f is such that the distance between f and the mirror is R/2. We write:

$$f = \frac{R}{2}$$

Part 1. Investigating the Model

Your goal in this part of the lab is to investigate the model to see how well it describes an actual mirror. Luckily, you'll be able to use a lot of the same tools and techniques as last week.

Quick Check: Let's first investigate qualitatively. Play around with the equipment available to you. Make sure to try out the following:

- The flashlight (try twisting the head to get different beams)
- The multiple different frequency lasers
- The PASCO light source (it has many different settings, make sure to try several!)

Hint: Light from a source far away from the mirror will hit the mirror approximately parallel.

Does the scientists' model seem at least somewhat reasonable? Discuss this with your partner and come up with a few points either in favor or against the model. Decide on a prediction.

Designing Your Experiment: Now design an experiment in order to quantitatively evaluate the scientists' proposed model. You're free to do this using any justifiable method and there isn't necessarily just one right way. Recall that there are two (related) claims you'll need to investigate:

1) Consider the model's first claim, which is that parallel light rays incident on the mirror are all focused through a single point on the central axis. With this in mind, come up with a strategy to answer the following question:

"When parallel light rays hit the cylindrical mirror, where do they cross the central axis?"

It's recommended that you try out parallel rays of different distances from the central axis and record their apparent focal points. For example you could make a table with columns like:

Distance of Ray(s) from Central Axis Apparent Focal Length

But it's up to you.

2) The model's second claim relates this to the geometry of the mirror. In order to evaluate this, you'll also need to know the radius of curvature of the mirror. As before, do this however you like, just make sure to minimize uncertainty with multiple measurements/precise tools as seems appropriate.

Recall that you can use the t-score method explained by your TA at the beginning of class to compare two measured values.

Refer to the lab rubric for a reminder of what else to consider and what to record.

Check in with Another Group: Briefly discuss your plans with another group. They may provide you with additional ideas and feedback. Note one similarity and one difference between your approaches.

Conducting Your Experiment: Go ahead and give it a shot. You can change your method around while you're at it, you don't need to treat your previous decisions as a contract. Just make sure to record any changes for sake of your eventual final writeup. Make sure all your data is labeled clearly with units, and that you keep track of uncertainty.

Above all, try to minimize uncertainty as much as you can! Take multiple measurements, use more precise equipment, etc. You want to be confident in what you find.

Forming a Conclusion: Does your data support the model's two claims? Does some data fit it better than others?

Check in with Another Group: Check back in with the same group you discussed things with before. How do your results compare? Note two similarities and/or differences between what you found, and use this to inform your proposals for future iterations.

Post your Results on the Board: On the board write a very brief summary of what you found in the spot listed for your table. For example, write what you found for $R/2$ and f, whether or not the model was accurate, and if there were any cases where the model failed.

Also, start thinking about possibilities for a next iteration of the experiment. You can refer to the flow chart for suggestion. Please wait for the TA before starting Part 2 though.

Part 2. Refining and Exploring

Once everyone has reported their results, your TA will lead a discussion. This will include spelling out some options for a second iteration of your experiment. *See also the flow chart* posted in the Canvas module for this lab for suggestions.

Remember that you'll need to list at least 3 possibilities for refinements in your Part 1 conclusion. Pick one of these and implement it.

Quick Check:Explore qualitatively, tinker, etc. to decide what you think of your new hypothesis and how best to test it.

Designing Your Experiment: Design an experiment like in Part 1, but this time to investigate your new hypothesis.

Check in with Another Group: Briefly discuss your plans with another group. They may provide you with additional ideas and feedback. Note one similarity and one difference between your approaches.

Conducting Your Experiment: Conduct the experiment as planned. As always, make sure to minimize uncertainty! And feel free to change your approach as needed, just be sure to record any changes.

Forming a Conclusion: What did your new approach reveal?

Check in with Another Group: Check back in with the same group you discussed things with before. How do your results compare? Note two similarities and/or differences between what you found, and use this to inform your proposals for future iterations.

A Final Question: What would you say about the scientist's model in summary? Was it totally correct or totally wrong? Neither?

Writing Up Your Lab Notes for Submission

Write up your notes for Part 1 and Part 2 in an organized way according to the rubric provided.