6.2: Activities

Equipment

- transparent rectangular prism
- foam board & nails
- protractor & ruler
- optical bench with mounted light source, "object" (arrow) slide, lens, and projection screen
- meter stick

The General Idea

This lab comes in two parts, both of which involve solving a mystery using multiple methods that (should) concur on the answer. In both parts, it will be useful to have an understanding of the effects of parallax. An explanation for how to use parallax to find the position of an image is in the Background Material. For Part 1, the method of creating a ray trace using nails placed in the line of sight of the image is also discussed in the Background Material.

Part 1

In Part 1, you will experimentally determine the index of refraction of a transparent block, using three separate methods:

1. Use the nails-placed-along-the-line-of-sight approach to trace the path that the light takes from the object to your eye (through the block, of course). With a trace of a ray, the angles that the light bends at the two surfaces can be measured, and from that data (and the fact that the index of refraction of air is 1.0) one can use Snell's law to compute n for the block.
2. The next two methods involve finding the location of an image created when looking at an object through the block, and using the known image & object distances (and the appropriate equation) to compute the index of refraction. In both cases, the object (a nail) is placed in contact with one side of the block, so that the light only really bends at one block/air interface.
    - Find the image location using the nails-in-the-path-of-the-light from two different eye perspectives.
    - Find the image location using the parallax method (trial-and-error with another nail that you can move around).

[It should be noted that the formula for the image position of a refracting plane is actually *derived* from Snell's law, so these aren't exactly *independent* confirmation, but that's okay – they are a form of confirmation, and it's interesting to see them both in action.]

Part 2

In this part, light comes from the object and passes through a lens. We are not able to use nails to trace the path the light takes, but we can locate the image and use the object and image distances, along with the thin lens equation, to determine the focal length of the lens. This must be done in two distinctly different cases:

1. The image is located on the opposite side of the lens from the object. (Do at least three separate runs.)
2. The image is located on the same side of the lens as the object. (One run of this kind is sufficient.)

For locating the image, you have at your disposal the parallax method described earlier, and a screen onto which certain types of images may be projected.

Some Things to Think About

Part 1

- You will want to trace out the border of the block on the paper, both to make the later work easier, and so that you know where to place the block in the event that it moves off its original position while you are in the middle of taking data.
- When using the nails to trace the path of the light:
    - Please use a piece of paper, and *not* the styrofoam pad for drawing the rays.
    - Keep in mind that two nails are needed for any straight line you need to draw.
    - The last nail you place looks "fatter" than the previous nails due to perspective (it is closer to your eye), and the fact that it obscures those nails can make it difficult to align it accurately. It may help to look to the left and right of this nail, to see if the perspective with the other nails is symmetric. Moving your eye farther away should also help a bit.
- For the Snell's law portion:
    - Remember that θ is measured with the normal to the surface.

- There are *two* places where the light bends – you can use this extra data to potentially improve (or at least confirm) your result.

- For the image of the flat refractor portion:
  - Percentage uncertainties are reduced when the object & image lengths are longer.
  - You get the center-line ray trace (the one that passes straight through the block undeflected) "for free". Use it as a confirmation of two other rays.
  - Please don't put the sharp side of the nail against the block when doing the parallax location – scratching the surface of the block makes it less usable for future optics experiments.
- For both ray-trace-with-nails portions, include a photo of the traces you created in your lab report.
- As usual, make estimates of the range (uncertainty) of your length measurements, convert them to percentages, employ the weakest link protocol, and see if the two experiments agree.

Part 2

- You can start by "playing" with the lens to determine if it is converging or diverging. You should know some general characteristics of the two types of lenses that will allow you to make this determination.
- Whenever possible, using the screen and projecting the image onto it gives results that are more accurate and are easier to measure than using parallax. But you need to be aware of which circumstances make the use of a screen possible and which ones do not. When in doubt, think about *what is happening to the light*.
- As with Part 1, compute approximate uncertainties and use them to determine if your measurement is confirmed.

Lab Report

Craft a lab report for these activities and analysis, making sure to include every contributing group member's name on the front page. You are ***strongly encouraged*** to refer back to the Read Me as you do this, to make sure that you are not leaving out anything important. You should also feel free to get feedback from your lab TA whenever you find that your group is at an impasse.

Every member of the group must upload a separate digital copy of the report to their lab assignment in Canvas *prior to leaving the lab classroom*. These reports are not to be written outside the lab setting.
