Circle your lab day and time.

Your name: ____________________

TA name: ____________________

Mon	Tue	Wed	Thu	Fri
8-10	10-12	12-2	2-4	4-6

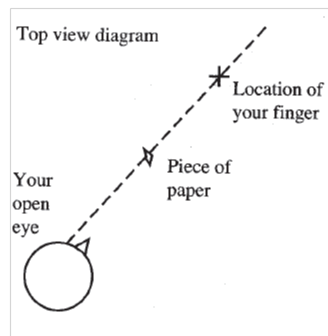
Lab 9: Mirrors

PART I: The Method of Parallax

A. Close one eye and lean down so that your eye is at table level. Have your partner drop a small piece of paper (about 2 mm square) onto the table. Hold one finger above the table and then move your finger until you think it is directly above the piece of paper. Move your finger straight down to the table and check whether your finger is, in fact, directly above the paper. Try this exercise several times, with your partner dropping the piece of paper at different locations. Afterwards exchange the roles.

- How can you account for the fact that when your finger misses the piece of paper, your finger is always either in front of the paper or behind it, but never to the left or to the right?

B. Suppose that you placed your finger behind the paper (as shown at the right) while trying to locate the piece of paper. Predict whether your finger would appear to be located *to the left of, to the right of,* or *in line with* the piece of paper if you moved your head:



- to the left
- to the right

Check your predictions and resolve any inconsistencies.

C. Suppose that you had placed your finger in front of the piece of paper rather than behind.

- Predict whether the paper or your finger would appear on the left when you move your head to the left.
- Check your answer experimentally and write down your observation.

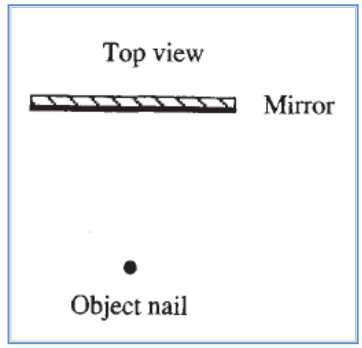
D. Devise a method based on your results from parts B and C by which you could locate the piece of paper. Your method should include how to tell whether your finger is directly over the piece of paper and, if not, whether it is in front of or behind the piece of paper.

- Discuss your method with your partner, then test your method and describe it below. Check your method with your TA.

We will refer to this method that you devised for locating the piece of paper as the ***method of parallax***.

PART II: Image Location

At your place you should have a small mirror and a few nails and pencils. Place the mirror in the middle of a sheet of paper. Stand one nail on its head about 10 cm from the front of the mirror. We call this nail the **object**.

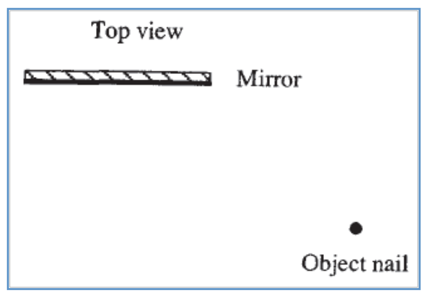


- On the paper, mark the locations of the mirror and the object (nail).

A. Place your head so that you can see the image of the nail in the mirror. Use the method of parallax to position a pencil so that it is located in the same place as the *image* of the object nail. Mark this location on the paper.

- Is the image located *on the surface of, in front of,* or *behind* the mirror? Please explain below.

- Would observers at other locations agree that the image is located at the place you marked? Let your partner check your answer experimentally.



B. Move the nail off to the right side of the mirror as shown.

- Is the image located *on the surface of, in front of,* or *behind* the mirror? Please explain below.

PART III: Ray Tracing

In the following experiments, you will determine the location of an object and its image by a different technique, called ***ray tracing***. This technique is based on a model for the behavior of light in which we envision light being either emitted in all directions by a luminous object (such as a light bulb) or reflected in all directions by a non-luminous object (such as a nail).

A. Turn the sheet of paper over (or obtain a new sheet of paper). Stand a nail vertically at one end of the piece paper. Place your eye at table level at the other end of the piece of paper and look at the nail. Use a straightedge to draw a ***line of sight*** to the nail, that is, a line from your eye to the nail. Repeat this procedure to mark lines of sight from three other very different vantage points and *then remove the nail.*

- How can you use these lines of sight to determine where the nail was located?

- What is the smallest number of lines of sight needed to determine the location of the nail?

B. Turn the sheet of paper over (or get a new sheet of paper). Place the mirror in the middle of the sheet of paper and place a nail in front of the mirror (about 10 cm away). On the paper, mark the locations of the mirror and the nail.

- Draw several lines of sight from your eye to the *image of the nail*. How can you use these lines of sight to determine the location of the image of the nail?

- Use the method of parallax to determine the location of the image of the nail. Do these two methods yield the same location of the image (to within reasonable uncertainty)?

C. (Did you mark the location of the mirror and the object nail?) Remove the mirror and the object nail. For the one eye location that you used in part B, draw the path that light takes from the *object nail to the mirror*. Draw an arrow head on this line segment to indicate the direction that light moves along that part of the path.

- On the basis of the path of light from the object nail to the mirror (drawn in part C) and the corresponding line of sight from your eye to the image of the nail (drawn in part B), predict the path that light takes after it is reflected by the mirror.

- Repeat the steps above for other eye locations used in part B. Use a protractor to formulate a rule that you can use to predict the path light takes after it is reflected by a mirror and write it down in the space below.

D. Place a nail at the location of the *image of the object nail.* Illustrate the path of light from that nail to your eye for the same eye locations as in part B.

- How is the diagram for this situation similar to the diagram that you drew in part C?

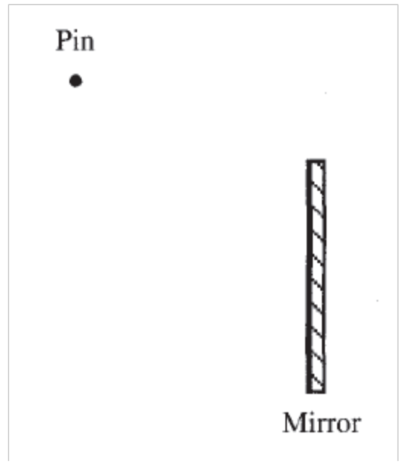
- Is there any way that your eye can distinguish between the two situations?

PART IV: An Application of Ray Tracing

In this last part, use a straightedge and a protractor to draw rays as accurately as possible.

A. First Reflection

- On the diagram at right, draw one ray from the pin that is reflected by the mirror.
- If you were to place your eye so that you were looking back along the reflected ray, what would you see?
- From one ray *alone* do you have enough information to determine the location of the image? If not, what can you infer about the location of the image from only a single ray?



B. Second Reflection

- On the same diagram above, draw a second ray from the pin that is reflected by the mirror and that would reach the observer at a different location.
- What can you infer about the location of the image from this second ray *alone*?
- How can you use the two rays that you have drawn to determine the location of the image?
- Is there additional information about the image location that can be deduced from three or more rays?

C. Image Location

- Determine the image location using the method of ray tracing from part III. (If it is necessary to extend a ray to show from where light appears to come, use a *dashed* line.)

- Does the light that reaches the observer actually come from the image location or does this light only *appear* to come from that point?

- What is the smallest number of rays that you must draw in using ray tracing to determine the location of the image of an object?

- How does the distance between the mirror and the image location compare to the distance between the mirror and the pin?

The diagram that you drew above to determine the image location is called a ***ray diagram***. The point from which the reflected light appears to come (i.e. the location of the pin that you saw when you looked in the mirror) is called the ***image location***. An image is said to be ***virtual*** when the light that forms the image does no actually pass through the image location. An image is said to be ***real*** when the light that forms the image does pass through the image location.

When drawing ray diagrams, use a solid line with an arrow head (⟶) to represent a ray, that is, a path that light takes. Use a dashed line (-----------) to extend a ray to show from where light *appears* to come in order to distinguish such a line from an actual ray.