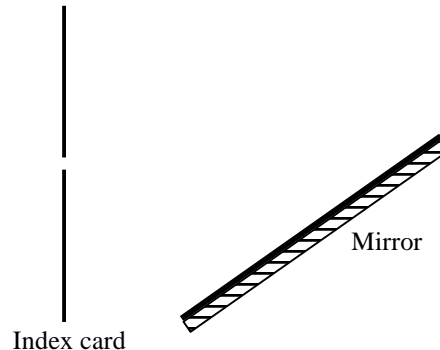


# How to tell where things are by looking

## I. A light bulb and a pencil

A. Imagine you had a small bulb, an index card with a narrow slit cut in it, and a mirror arranged as shown in the top view diagram at right.

Bulb  
○



1. Sketch the path that light would take through the slit. Show the beams that are incident on and reflected from the mirror. Draw arrowheads to indicate the direction that light travels.
2. Where would you place your eye to see the light bulb in the mirror? (The bulb that you see in the mirror is called the *image* of the bulb.)

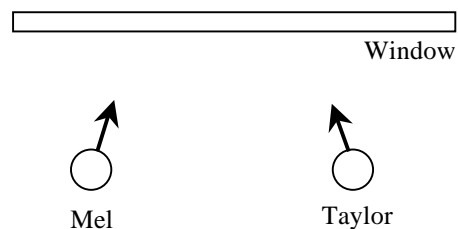
B. Imagine that instead of the bulb, you had a short pencil standing upright at the same location.

1. Where would you place your eye to see the image of the pencil? Sketch the path that light takes from the pencil to your eye.
2. Imagine you moved the index card down (away from the top of the page) by a small amount. Then where would you place your eye to see the image of the pencil? Explain your reasoning.

C. Often people object to the idea that light takes a path from the pencil to your eye, because “pencils don’t emit light.” How would you respond to this objection?

## II. Where you see things

A. Mel and Taylor are both looking directly at the same object through a large window. The direction that each of them is looking is indicated with an arrow in the diagram at right.



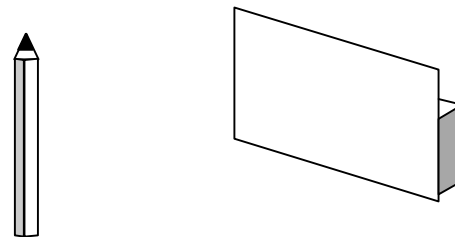
1. Where’s the object? How do you know?
2. Draw the location of the object as exactly as possible on the diagram. Write out in words the technique you use to do so. (This might seem a little silly at the moment, but we’re going to use it later.)

We will call this the “Mel and Taylor technique.”

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- B. Obtain a pencil and a mirror and place the pencil upright about 10 cm in front of the mirror. Place your head so you can see the image of the pencil in the mirror. Then move your head from side to side.



1. Where does the image appear to be located? Does its location change as you move your head from side to side?
  - i. In answering question 1, did you use the “Mel and Taylor technique,” or some other way of thinking? Explain.
  - ii. If you haven’t done so already, apply the “Mel and Taylor technique” to find the location of the image. Does it give the same answer as your other way? If not, try to reconcile the discrepancy.
2. Many people say the image of the pencil is on the surface of the mirror, whereas others say it’s behind the mirror. How can we decide which of these assertions is right?

- C. Obtain an enlargement of the diagram at right. The diagram shows an object near a mirror. An observer is free to walk along the line in front of the mirror.



1. On the enlargement, sketch the path that light would take from the object, to the mirror, to the observer at point B. You might want to use the ruler and the protractor that are on your table.
2. From which of the lettered points along the line could an observer see the image of the object? Explain your prediction.
3. Where is the image of the object located? Mark its location on the diagram and explain your reasoning.

Is your answer consistent with your answer in part B?



Check your work with a TA.

### III. Another image location technique

In this section you'll learn a particular technique for locating images. It's related to the "Mel and Taylor technique," but it's a little different.

- A. Close one eye and lean down in your chair so that your open eye is at table level. Have your partner drop a very 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. Keep your open eye at table level. After several tries, exchange roles with your partner.

1. Suppose that you placed your finger behind the piece of paper while trying to locate the piece of paper. Suppose that then you moved your head a little bit to the left. Would your finger then appear to be located *to the left of*, *to the right of*, or *in line with* the piece of paper?

What if, instead, you moved your head a little bit to the right?

What if you had placed your finger in front of the piece of paper rather than behind it?

2. Devise a method based on your answers to part 1 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. Describe your method to your partner, then test your method.

- B. The name for the method you described above is the *method of parallax*. Check your method with a TA if you want to make sure you're doing it right.

How is the method of parallax similar to the "Mel and Taylor technique"? How is it different?

- C. Obtain a mirror and two identical pencils. Place the mirror in the middle of a sheet of paper. Stand one pencil on its end about 10 cm in front of the mirror. We will call this pencil the *object pencil*.

On the paper, mark the locations of the mirror and the object pencil.

1. Place your head so that you can see the image of the pencil in the mirror.

Use the method of parallax to position the second pencil so that it is located in the same place as the image of the object pencil. Mark this location on the paper.

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2. Is the image of the pencil located *on the surface of, in front of, or behind* the mirror? Explain.

Would observers at other locations agree that the image is located at the place you marked?  
Check your answer experimentally.

3. Move the pencil so that instead of being in front of the mirror, it is off to the right side of the mirror. Find the new image location.

- D. Sum it all up now, taking into account the “Mel and Taylor technique,” the method of parallax, and other ideas that may have come up. *Where is the image of the pencil located?* Give your reasons for answering the way you do. Try to reconcile any inconsistencies.

### **IV. Reflections of a different kind**

The title of this tutorial makes it sound like it’s going to be a no-brainer, and certainly, you already knew a lot about finding locations by looking when you walked in the door. (Otherwise you probably wouldn’t have made it through the door in the first place.) So what did this tutorial do for you, if anything?



*Check your work with a TA.*