PhyzLab: Mirror Misunderstandings

an investigation of image formation with plane mirrors

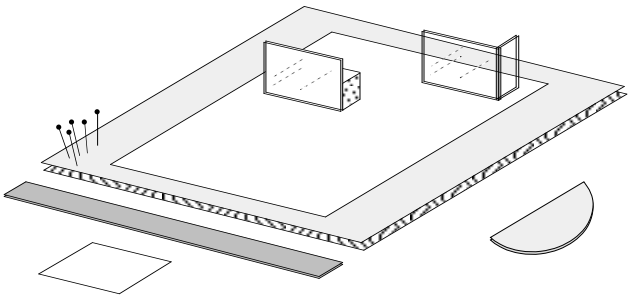
Based on "Where is the Mirror's Image?" by Dewey Dykstra and research by Lillian McDermott and Fred Goldberg.

• Purpose •

Mirror images are tricky things. Most people don't really understand them. Right now, you probably don't, either. After this lab, you probably will. (If not completely, at least better than you do now.) In part A of this investigation, you will determine the answer to the age-old question, "Hey! Where **is** that image in the mirror?" In part B, you will answer the somewhat simpler question, "Hey! Where can I see the image of an object **from**?" In part C, you will investigate the orientation of mirror images and the "coverage" or scope of a mirror. The lab will improve your understanding **only** if you follow the instructions, make appropriate predictions before observations, and give honest answers to the questions posed (don't try to outsmart the lab). If your predictions (which— incidentally—are made **before** observations are made) are wrong, it doesn't mean you are dumb. It means you will actually learn something by doing the lab. What a concept. If you try to outguess the question and the answer you really believe (but didn't record) is correct, then you really are phyzphoolish and should be locked up in phyzin' prison. Have I made myself clear? (Hmmm... Optically speaking, that's an interesting image to contemplate, eh?)

• Apparatus •

___ plane mirror attached to support block
___ 9"x12" corkboard (or equivalent)
___ several straight pins (SEE NOTE TO RIGHT)
___ 12" ruler
___ protractor
___ sheet of unruled white paper
___ index card
___ small transparent window with upright support
___ access to pinhole sheets: LINES OF SIGHT, MIRROR'S RANGE, and MIRRORULER



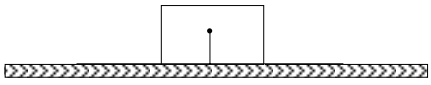
PLEASE STORE UNUSED PINS AS SHOWN ABOVE!

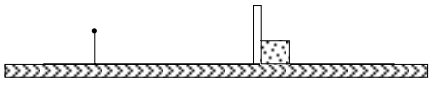
• Procedure •

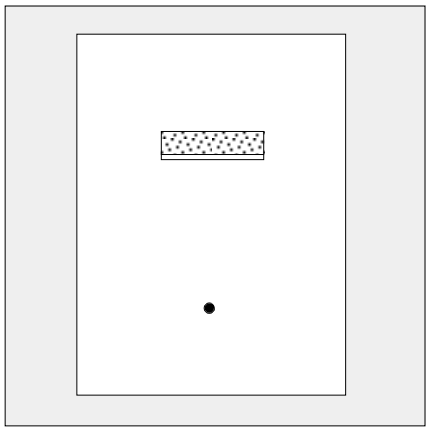
A. Locating the Image

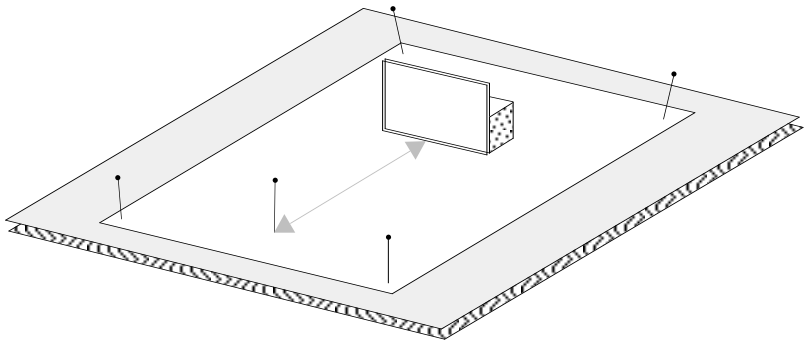
1. INITIAL IDEAS

a. Arrange the apparatus as shown below with the pin about 20cm from the mirror surface. Let each member of the group look at the image of the pin in the mirror. (Use plain white paper.)









b. Where is the image of the pin located? When you look at the **pin**, you focus your eyes on the pin: 20cm in front of the mirror. Where do you focus your eyes when you look at the **image** of the pin in the mirror? Show the location on each of the diagrams above by drawing a star at the location of the image. Draw a star on each of the four diagrams. Describe as clearly as you can the reasoning for your answer (and argue against alternate image location selections). Do you agree with other members of your group? If not, what opinion(s) do they hold?

2. SIMULTANEOUS FOCUS

a. i. Hold an upward-pointing finger about 20cm in front of your nose. Hey, not **that** finger! Now focus on it. Notice that everything in the background is out of focus.

ii. Now focus on something in the background. Notice that your finger is now out of focus.

iii. Can you focus your finger and the background at the same time? The word "focus" here does not mean "see," it means "focus," as in, "bring into sharp resolution." ___Yes ___No

iv. Look at two of your partners sitting side by side across the table. Notice that you **can** focus on both of them at the same time.

v. What does it mean if you **can't** focus on two things in your line of site at the same time?
___The objects are approximately the same distance away from you.
___The objects are at significantly different distances away from you.

vi. What does it mean if you **can** focus on two things in your line of site at the same time?
___The objects are approximately the same distance away from you.
___The objects are at significantly different distances away from you.

b. i. Put a fingerprint (or small piece of tape) on the surface of the mirror.

ii. With the pin about 20cm from the mirror and your eyes about 30cm from the mirror, look at the image of the pin in the mirror.

iii. Focus on the image of the pin, then focus on the fingerprint, and then focus on the actual pin. Continue switching your focus from the pin image to the fingerprint to the pin.

c. Can you **focus** on the image of the pin and the fingerprint at the same time?

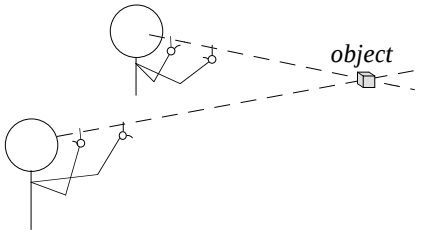
d. Can you **focus** on the image of the pin and the actual pin at the same time?

e. What do your observations here tell you about the location of the image of the pin?

f. Is this finding consistent with your prediction? If not, describe the differences and the possible reasons for the discrepancy.

~~3~~3. POINTING THE WAY

The previous activity indicates the relative position of the image but it does not give a specific location. The following activity will. Find a stationary object in the room. Look at it with only one eye open. Now hold up one finger and "block out" the object with your finger. Align a finger from your **other** hand with the object and your first finger. Your two fingers define a line of sight. The object lies along that line. But how far is the object from you? You could find out by defining another line of sight from a different angle. **The object is located where the two lines intersect.**



a. Concept question. If you traced several lines of sight to the image of the pin and they crossed at or near some point, what would that tell you about the location of the image? If you don't know how to answer read the passage above again.

b. Observation. Create points for several lines of sight to the image of the pin by the following method.

i. Attach the LINES OF SIGHT pinhole sheet to the corkboard. Align the mirror as indicated on the sheet and tape it down. (Note: is the reflecting surface of your mirror its front or back surface? For most mirrors, a layer of glass covers the reflective surface, thus it is the back surface that reflects; front surface mirrors are more expensive and less common.) Make certain the reflecting surface of the mirror is **always** in the right place.

ii. Place the **object** pin in its place as indicated by the instructions on the LINES OF SIGHT sheet.

iii. Push a **second** pin into the sheet at the circled X marked "1."

iv. Next, push a third pin into the sheet in the L-shaped gray region so that the third pin is aligned with (blocking) the X_1 **pin** (not its image) and the **image** of the original pin. A properly placed third pin for the X_1 alignment will be in the bounded section of the gray region. Have the other members of the lab group check to see if they agree on the placement of the pins.

v. **If this is the first time through, secure a "phyzblessing" from the instructor before continuing.**

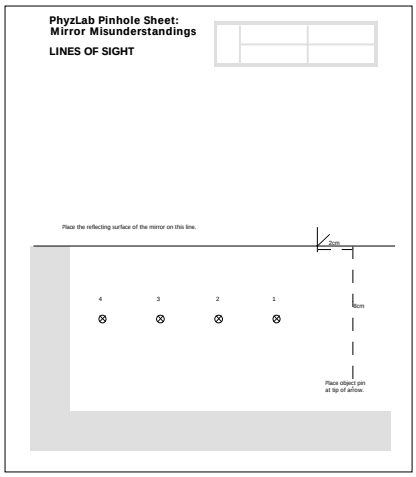
vi. Put your initials and a subscript matching to the X number you were using (e.g. DB_1) next to the pinhole created by the pin in the L-shaped gray region. The X pin and the gray region pin define a line of sight to the image of the original pin.

vii. Move the pin at X_1 to X_2. Let the next member repeat the alignment process describe above.

viii. Each member of the group must repeat this process until the group has a total of four separate sets of pinholes (one for X_1, one for X_2, and so on).

ix. Remove all pins and the mirror from the sheet. Circle all labeled pinholes.

c. Prediction. BEFORE drawing the actual lines of sight, answer the following question. Where will the lines of sight meet? Discuss your answer with the other members of your group? If not, what opinion(s) do they hold?



d. Observation. Trace the lines of sight. Align a ruler along two corresponding lines of sight pinholes (e.g. X_1 and DB_1) and draw a line that extends across the full length of the sheet. Don't stop the line until you reach an edge of the sheet! Make sure that the line passes through the centers of both pinholes. Each member of the group must draw the line of sight he or she arranged.

e. Sketch. Make a scale drawing of your lines of sight on the figure to the right.

f. Conclusion. The original pin was 2cm to the right and 8cm in front of the reflecting surface. Where did the lines of sight meet, and what does this tell you about the image? Is your observation consistent with your prediction? If not, describe the differences and the possible reasons for the discrepancy.

4. IMAGE LOCATION CONCLUSIONS
a. Where is the image of the pin located?

b. Cite evidence to support your conclusion from sections 2 and 3 of the lab.

c. Did the light that forms the image of the pin come from the location of the image you stated in question 4.a above? If not, where did it come from?

5. SEEING IS BELIEVING
a. Reassemble the LINES OF SIGHT sheet using the transparent window instead of the mirror. Put the object pin in its place and put a second pin at the intersection of the lines of sight you drew.

b. Look at the window as if it were the mirror and you were aligning a pair of lines of sight pins. You should be able to see a faint image of the object pin **reflected** from the window and the intersection pin **through** the window. The reflected image of the object pin is difficult to see since the window reflects only a small percentage of the light incident upon it. To see the reflected image more clearly,

i. place an opaque, light-colored ruler next to the pin. If you can see a reflected image of the ruler, the reflected image of the pin is right next to it (whether you can see it or not).

ii. obtain a gooseneck lamp. Arrange it so that the light from the lamp illuminates the object pin, thereby increasing the brightness of its reflection.

c. The reflected image of the object pin should appear close to the intersection pin seen through the window.

d. Observation. Can you focus the reflected image of the object pin and the intersection pin at the same time? (If you can see only the reflected image of the ruler, can you focus on it and the intersection pin at the same time?)

e. Observation. While looking at the reflected image of the object pin and the intersection pin through the window, tap a finger up and down on the object pin. What do you see? Each member must do this.

f. What do these observations tell you about the location of the reflected image of the object pin? Do these observations support or contradict your finding in part A.4.a above?

B. Defining the Range of Mirror Image Observation

1. WHERE CAN YOU SEE IT FROM?
Now that you have a better understanding of where the image is, try to determine where you can be while looking into the mirror to see the image.

a. Obtain a MIRROR RANGE pinhole sheet. Cover your mirror with the index card.

b. Consider the diagrams below. They represent an overhead view of a pin near a mirror.

i. From which positions (indicated by circles) can the image of the object be seen? In other words, if your eye was located at any/all of the circles, could you look into the mirror and see an image of the pin? Darken the positions from which a mirror image of the pin could be seen and cross out positions from which an image could not be seen.

ii. What explanation can you give for your selection? Discuss your answer with the other members of your group. Do you agree with the other members of your group? If not, what opinion(s) do they hold?

c. Follow the instructions on the MIRROR RANGE pinhole sheet to test your predictions. Record your observations on the diagram below.

2. WHAT LIGHT FROM YONDER MIRROR BOUNCETH?

a. What is the path of the light that forms the mirror image of an object? Copy the findings shown on the previous diagram to the diagram below. Show as accurately as you can the path followed by the light from the pin seen as a reflection by the eye. (How did the light get from the pin to the eye at each of the darkened positions?) The light starts at the pin, reflects from the mirror, and travels to the observable location. But where does the light reflect from the mirror? To determine this, do the following.

i. With a pin in the object position (black circle, white X) and another in a viewing position (white circle, black X), view the reflected image of the object pin aligned with the viewing position pin.

ii. Hold a pencil vertically on the front surface of the mirror. Move it left or right until it blocks the reflected image of the object pin. Push the pencil down at that location so it makes a mark on the paper.

iii. Draw a line from the object pin to the pencil mark in front of the mirror. Draw another line from the pencil mark to the viewing position. That is the path taken by the light from the pin to the viewing position.

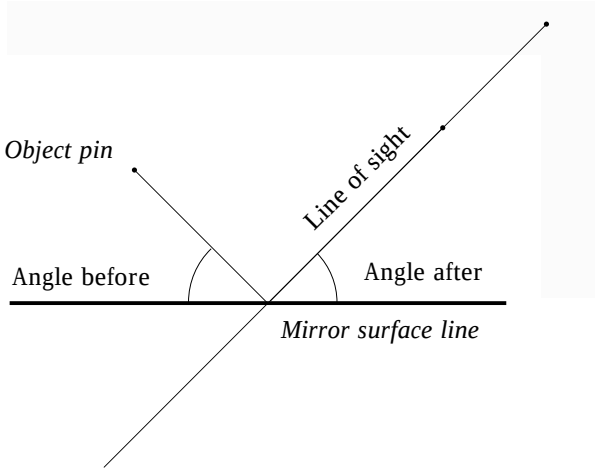
b. On your LINES OF SIGHT sheet (not the MIRROR'S RANGE sheet), draw the following line. Connect the point at which a line of sight intersects the mirror surface line to **object pin's** pinhole. Do this for each line of sight.

c. Discuss the resulting pattern with your group. Does this pattern strengthen or weaken your finding in A.4.c above? Would you like to make any modifications to your answer in A.4.c?

3. A LAW OF REFLECTION?

a. Is there a pattern to the angles formed between the incoming light and the mirror and those formed by the outgoing light and the mirror surface? discuss your answer with the other members of your group. Do you agree with the other members of your group? if not, what opinion(s) do they hold?

b. Using a protractor, measure the incoming and outgoing angles for each line of sight drawn on the LINES OF SIGHT sheet. Record these values on the table below.



Ray	Angle before mirror	Angle after mirror
1		
2		
3		
4		

c. What pattern—if any—can you see between the angles formed between the incoming light and the mirror and those formed by the outgoing light and the mirror surface (within significant difference limitations)?

C. Characteristics of mirror images

1. MIRROR, RORRIM?

a. Cover the mirror with the index card.

b. Prediction. Does the mirror reverse up and down (y-axis)? Does the mirror reverse left and right (x-axis)? Does it reverse forward and backward (z-axis)? Discuss your answer with the other members of your group. Do you agree with the other members of your group? If not, what opinion(s) do they hold?

c. Observation.

i. Now remove the index card and look at your image in the mirror. Point toward the ceiling. Does your image point toward the ceiling?

ii. Point to the side of the room to **your** right. Identify the direction you're pointing: __N __S __E __W. Does your image point in the same direction (to the side of the room to **your** right, in the direction selected above)?

iii. Point toward the side of the room you are facing (toward the mirror). Identify the direction you're pointing: __N __S __E __W. Does your image point in the same direction?

d. Cover the mirror with the index card. Obtain a piece of transparent material with some writing on it. Hold it a few centimeters in front of the covered mirror so that you can properly read it.

i. Prediction. What will the mirror image of the writing look like?

ii. Observation. Uncover the mirror and observe the mirror image of the writing. Does the mirror reverse the writing?

iii. Can someone on the opposite side of the table from you—looking over the mirror—properly read the writing?

iv. Hold the writing so that the person across the table from you can properly read it.

Can you properly read it now?

Does the mirror reverse the writing?

e. Conclusion. Does the mirror reverse up and down (y-axis)? Does the mirror reverse left and right (x-axis)? Does it reverse forward and backward (z-axis)? Discuss your answer with the other members of your group. Do you agree with the other members of your group? If not, what opinion(s) do they hold?

2. HOW MUCH WILL THE MIRROR TAKE IN?

a. Prediction. If you are 160cm tall, what is the length of the shortest mirror you could use to see your entire body? Discuss your answer with the other members of your group. Do you agree with the other members of your group? If not, what opinion(s) do they hold?

b. Attach the MIRRORULER sheet to the corkboard. Place the mirror on the appropriate mark and tape it down.

c. Measure the width of the mirrored surface. Mirror width = _____.

d. Place the edge of the ruler in the indicated first location. Place a pin at 0cm.

e. Look at the mirror image of the pin and move your head to the right until the mirror image is at the right edge of the mirror. Push a pin into the ruler line so that it blocks the mirror image of the 0cm pin.

f. Where along the ruler is the second pin? Mirror image range width = _____.

g. On the MIRRORULER sheet, draw a little dude as follows: The little dude's head is at 0cm on the ruler line; the little dude's feet are where the second pin is on the ruler line. The little dude can see its entire body in the mirror!

i. How tall is the little dude?

ii. How does the little dude's height compare to the "height" of the mirror (mirror width measure in part C.3.c above.)

iii. What is the length of the shortest mirror a little dude could use to see its entire body if the little dude had a height h?

h. Conclusion. Is your observation consistent with your prediction? If not, describe the differences and the possible reasons for the discrepancy.

3. BACKING UP

a. Prediction. Can you see more of yourself in the mirror if you back away from it? Could a larger little dude see its entire body in the mirror if it stood farther from the mirror? (This is the same question phrased two different ways.) Discuss your answer with the other members of your group. Do you agree with the other members of your group? If not, what opinion(s) do they hold?

b. Place the edge of the ruler in the indicated **second** (more distant) location. Place a pin at 0cm of the **second** ruler line.

c. Look at the mirror image of the pin from behind the second ruler line and move your head to the right until the mirror image is at the right edge of the mirror. Push a pin into the second ruler line so that it blocks the mirror image of the 0cm pin.

d. Where along the ruler is the second pin? Mirror image range width = _____.

e. What is the height of the tallest little dude that could see its entire body in the mirror from this distance?

f. The second ruler line is _____times farther from the mirror than the first ruler line. How many times taller is the second little dude compared to the first?

g. Conclusion. Is your observation consistent with your prediction? If not, describe the differences and the possible reasons for the discrepancy.

4. SEEING MORE OF YOURSELF?

a. Prediction. If you look into a mirror that is near, you can see a certain amount of yourself. As you move farther from a mirror, can you see more of yourself, less of yourself, or the same amount of yourself? Discuss your answer with the other members of your group. Do you agree with the other members of your group? if not, what opinion(s) do they hold?

b. Observation.

i. Hold the mirror about 10cm from your face. Center the reflected image on your eyes. Notice how high above your eyes and how low below your eyes you can see in the reflected image. How much can you see? Can you see your entire head?

ii. Slowly move the mirror away from your face. When your arms are fully extended, the mirror will be up to eight times farther from your face than it was initially. Now how much can you see? Can you see your entire head?

c. Conclusion. Is your observation consistent with your prediction? if not, describe the differences and the possible reasons for the discrepancy.

