PhyzLab: Labyrinth of the Lens

an investigation of image formation by lenses

Based on "Images from Lenses" by Dewey Dykstra and research by Lillian McDermott and Fred Goldberg.

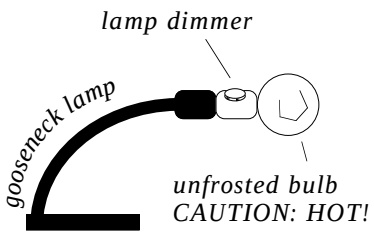
• Purpose •

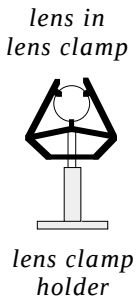
In this activity, you will explore the method by which a lens forms an image. This stuff is tricky. Trickier than pinholes! You'll get nothing out of this exercise unless you give thoughtful consideration to your predictions, make careful observations, and construct thorough conclusions.

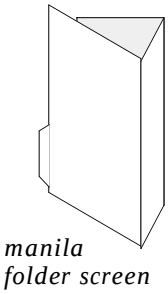
• Apparatus •

___ gooseneck lamp with lamp dimmer
___ 40W unfrosted bulb (4-sided filament)
___ converging lens *(f=+30cm)*
___ lens clamp
___ lens clamp holder (e.g. bunsen burner)
___ screen (e.g. propped-up manila folder)
___ 2 index cards (one with a punched hole)

Arrange your group so that you have a working space 1.5m x 3m (two tables end to end or in a T)



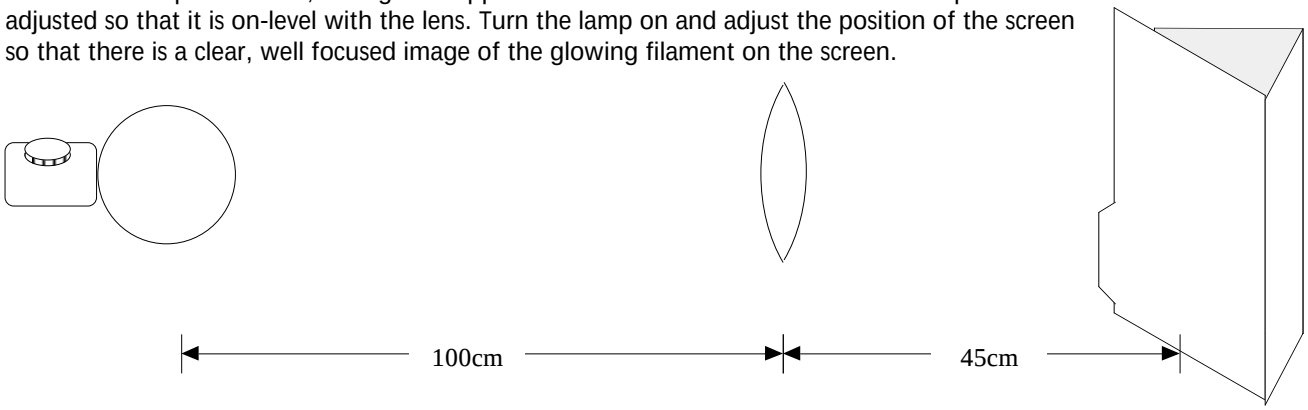




• Procedure •

1. INITIAL OBSERVATIONS

a. With the lamp turned off, arrange the apparatus as shown below. Note that the lamp has been adjusted so that it is on-level with the lens. Turn the lamp on and adjust the position of the screen so that there is a clear, well focused image of the glowing filament on the screen.



b. Allow each member of the group to view the image of the screen. Sketch the image on the diagram above. Draw the filament in the bulb, too. How does this image compare to one formed by a pinhole in size, focus, brightness, etc.?

c. Turn the light off.

2. LOOK MA—NO LENS

a. Prediction. What will happen to the image on the screen if the lens is removed? Will it flip right side up, get brighter or dimmer, go away, or what? Explain the reasoning behind your answer. ***Include a sketch that expresses your answer and explanation visually.*** *Discuss your answer with your group. Do all members agree? If there are alternate opinions, record them.*

b. Observation. When the group is pretty sure of its ideas, remove the lens. Turn on the light and record the results. **Include a sketch.**

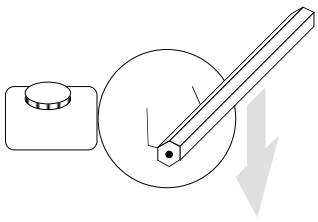
c. Conclusion. How do your observations compare to your prediction? Discuss the results with your group. Can the group explain any discrepancies between predictions and observations? If so, write the explanation; if not, write about the aspects that remain unclear.

d. Further conclusion. Do you need a lens to form the image on the screen? Explain the reasoning behind your answer. Discuss your answer with your group. Do all members agree? If there are alternate opinions, record them.

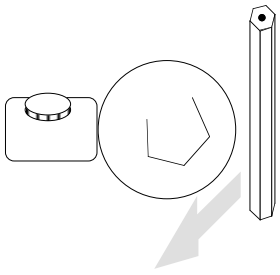
3. SO IS IT, LIKE, TOTALLY FLIPPED OUT?

a. Prediction/Interpretation of previous observations. Put the lens back in place so that you once again have a sharply focused image on the screen. Is the image flipped upside down? Is it flipped left and right? Explain the reasoning behind your answer. Discuss your answer with your group. Do all members agree? If there are alternate opinions, record them.

b. Observation. Hold a pencil horizontally over the front of the bulb. Lower it until it blocks part of the image of the filament. Move it downward past the filament, watching the image as you do so. (See diagram.) Record your results.



c. Observation. Hold a pencil vertically to the left of the front of the bulb. Move it to the right until it blocks part of the image of the filament. Move it to the right past the filament, watching the image as you do so. (See diagram.) Record your results.

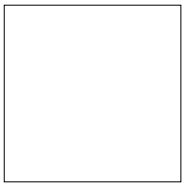


d. Conclusion. How do your observations compare to your prediction? Discuss the results with your group. Can the group explain any discrepancies between predictions and observations? If so, write the explanation; if not, write about the aspects that remain unclear.

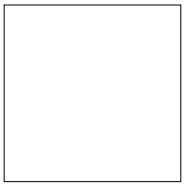
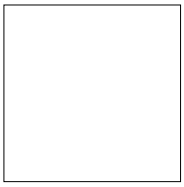
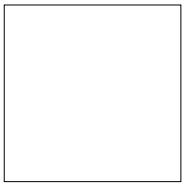
4. LENS HALFERS

a. Turn the light off or put the screen down.

b. Prediction. What would happen to the image if the top half of the lens were covered? Explain the reasoning behind your answer. **Include a sketch that expresses your answer and explanation visually.** Discuss your answer with your group. Do all members agree? If there are alternate opinions, record them.



c. More predictions. How would the image be different if the bottom half were covered instead? Right half? Left half? Sketch and label the image produced under each set of conditions.

d. Observations. When the group has recorded all predictions, carry out the following procedure.

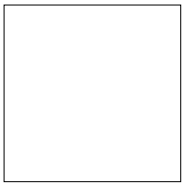
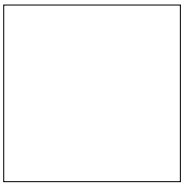
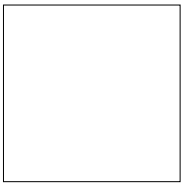
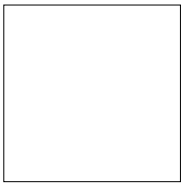
i. Turn on the lamp; adjust the brightness and screen position so that the image is bright (not blinding) and clear. Sketch the image below.

ii. Cover the top half of the lens with an index card. Comment on your results and sketch them below.

iii. Cover the top half of the other side of the lens. What difference does this make? (Don't sketch.)

iv. Cover different halves of the lens. Sketch the results below.

Sketches of observations (don't forget to label)

e. Continued observations. How much of the lens can you cover and still see an image? What happens to the image as you cover more of the lens?

f. Conclusion. How do your observations compare to your prediction? Discuss the results with your group. Can the group explain any discrepancies between predictions and observations? If so, write the explanation; if not, write about the aspects that remain unclear. Don't even think about writing, "We were right" here.

5. HOLEY LENSES!

a. Prediction. What would happen if the lens were covered entirely—except for a small hole? Will the image get larger, smaller, brighter, dimmer; will it be flipped, will it disappear, or what? Explain the reasoning behind your answer. **Include a sketch that expresses your answer and explanation visually.** Discuss your answer with your group. Do all members agree? If there are alternate opinions, record them.

b. Observation. When the group has recorded all predictions, carry out the following procedure.

i. Hold the card with the small hole-punched hole near the center of the lens. Record the results.

ii. Put the card on the other side of the lens with the hole near the center of the lens. What difference—if any—does this make?

iii. Move the card around so it covers different parts of the lens. What difference—if any—does this make?

iv. Move the card slowly from the lens toward the screen. What difference—if any—does this make?

c. Conclusion. How do your observations compare to your prediction? Discuss the results with your group. Can the group explain any discrepancies between predictions and observations? If so, write the explanation; if not, write about the aspects that remain unclear.

d. Continued conclusions. Does light from a specific part of the filament go through a specific part of the lens or does light from all parts of the filament go through all parts of the lens? Explain the reasoning behind your answer. **Include a sketch that expresses your answer and explanation visually.** Discuss your answer with your group. Do all members agree? If there are alternate opinions, record them.

6. WHAT'S THAT UP ON THE MOVING SCREEN?

a. Turn the light off or put the screen down.

b. Prediction. What happens to the image when the screen is moved closer to the lens? Will it get larger, smaller, brighter, dimmer; will it be flipped, will it disappear, or what? Explain the reasoning behind your answer. **Include a sketch that expresses your answer and explanation visually**. Discuss your answer with your group. Do all members agree? If there are alternate opinions, record them.

c. Observation. When the group has recorded all predictions, carry out the following procedure.

i. Attach a piece of paper to the viewing surface of the screen.

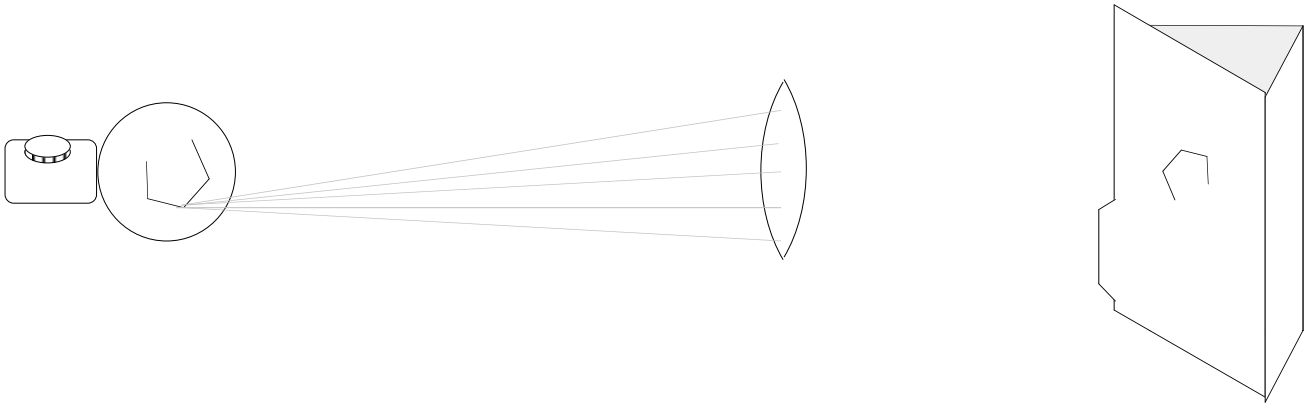
ii. Turn on the light and trace the image.

iii. Move the screen closer to the lens. Record the results (include a sketch).

d. Conclusion. How do your observations compare to your prediction? Discuss the results with your group. Can the group explain any discrepancies between predictions and observations? If so, write the explanation; if not, write about the aspects that remain unclear.

e. Continued conclusion. Is the image in sharp focus for all distances from the screen, or is there a sharp image only at one specific point?

f. Continued conclusion. What is the light that forms the image "doing" as it travels from the filament to the screen? For instance, what happens to several rays of light that come from the apex of the filament and strike the lens at different places? Consider the diagram below; complete it based on what you think is happening.



7. LOOK MA—NO SCREEN!

a. Prediction. Is there a place from which you could view the image **in your eye** instead of on the screen? Explain the reasoning behind your answer. **Include a sketch that expresses your answer and explanation visually**. Discuss your answer with your group. Do all members agree? If there are alternate opinions, record them.

b. Observation. When the group has recorded all predictions, carry out the following procedure.

i. Use the dimmer to reduce the brightness of the filament so that you can view it comfortably through the lens.

ii. Position the lens about 1m from the light and stand about 1m behind the lens. Look at the filament through the lens. Each member of the group must do this.

iii. When you view the filament through the lens, are you viewing the actual object or an image of the object? How can you tell? Discuss this with the group and record your answer with an explanation.

c. Continued observations. Locate the position of the image you are seeing with your eyes. Each member of the group must do this.

i. While you are still in the same position, have a lab partner place a piece of plain white paper between you and the lens so that the image of the filament is in sharp focus on the paper.

ii. Have your partner move the paper partly out of the way so that you can see half the image on the paper and half through the lens.

iii. Can you focus on the image on the paper and the image through the lens at the same time?

iv. Move your head from side to side. Does the image through the lens remain aligned with the image on the paper? If not, how does it move relative to the image on the paper?

v. With the lens 1m from the light and your eyes 65cm or so from the lens (so you can see a focused image of the filament through the lens, try to focus on the lens itself and then the image you see through the lens. The light should be turned down to a dull orange glow. Put a fingerprint on the lens to help in focussing on the surface of the lens.

vi. Can you focus on the lens surface and the image at the same time?

d. Conclusion. Can you see the image without using the screen? If so, where should your eye be to see the image? Discuss this with the group and record your answer with an explanation. **Include a sketch that expresses your answer and explanation visually**.

e. Continued conclusion. What is the location of the image you see through the lens? Is it behind the light, at the light, between the light and the lens, at the lens, between the lens and your eye, or at your eye? Cite the lab evidence behind your answer. **Include a sketch that expresses your answer and explanation visually**.