

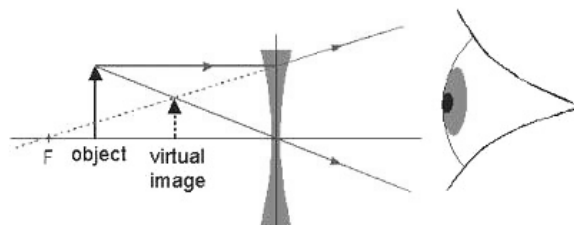
LAB 15. RAY OPTICS: IMAGES OF CONCAVE LENSES

AP PHYSICS II

Driving Question | Objective

If a virtual image is the result of intersecting non-real refracted light rays, how can you determine its location without being able to project the image itself onto a screen?

You will attempt to determine the location of a virtual image using methods of parallax and multi-lens optics.



Conduct Your Experiment

Before going into this experiment, it is necessary to review basic optics properties. When dealing with multiple lenses, it would make sense that the light from the object passes through the first lens and forms an image (real or virtual). It is this image that the second lens “sees”, not the original object. So in application, we can treat the image of the first lens as the object of the second lens.

Object 1 → Lens 1 → Forms Image 1

Image 1 = Object 2 → Lens 2 → Forms Image 2

Materials and Equipment

- Light Source
- Optics Bench
- -150 mm lens
- +200 mm lens
- Viewing Screen

Experimental Design

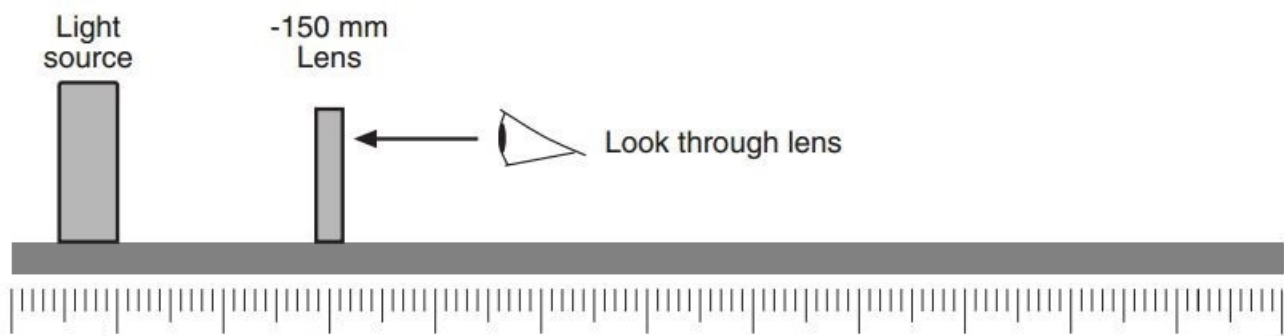
1. Place the light source (image side) somewhere near the beginning of the bench, but not at the 0 cm mark (example: 10 cm or 15 cm).

Chosen Light Source Position: 15 cm

2. Place the -150 mm lens on the bench at a position greater than 150 mm, but less than 300 mm away from the light source.

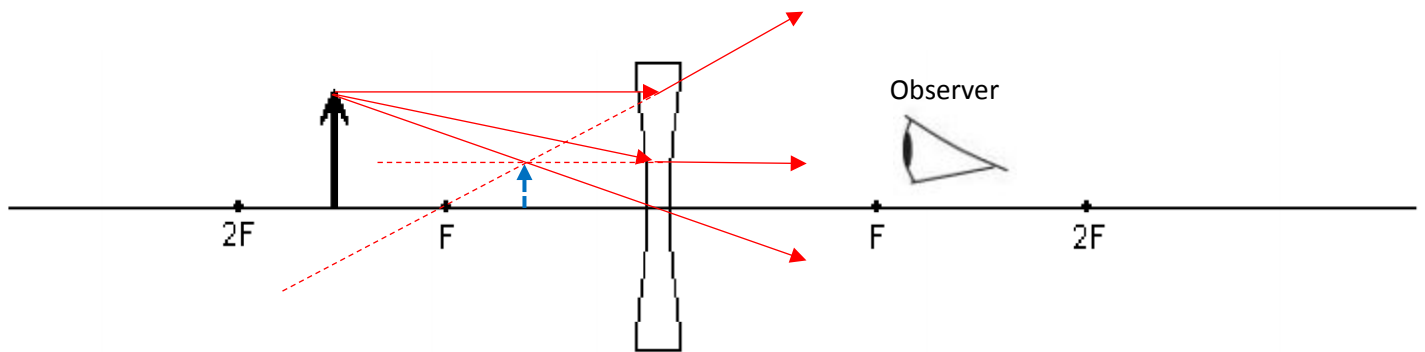
Chosen $f = -150$ mm Lens Position: 35 cm

3. Record the object distance d_{o1} in Table 1 on page 35.



4. Looking through the lens toward the light source, describe the image. Is it upright or inverted? Smaller or Larger? Upright, smaller
5. Is the image closer or farther to you than the object? Is the image real or virtual? How do you know? It is closer, and Virtual, because it is a concave lens, and therefore the rays never intersect.

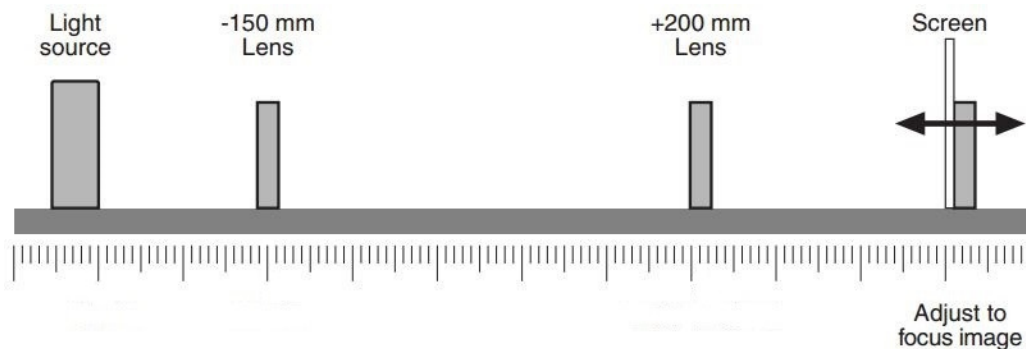
6. Using what you know about ray tracing at this point, does the location of the image match your prediction? **YES**



7. Does your Ray Trace Diagram confirm your hypothesis of the relative location of the image with respect to the object from Procedure #5? **Yes**

Now that you have an *approximate* location of the image, we will be attempting to find the *exact* location experimentally.

8. Place the +200 mm lens on the bench anywhere a distance greater than 200 mm from the -150 mm lens.
9. Record the +200 mm lens position: **60 cm**
10. Place the viewing screen behind the +200 lens and slide the screen to a position where a clear image is formed on it.
11. Record the screen position: **109 cm**



12. Is the image you see on the screen real or virtual? How do you know?

It is a real image because the greater focal length of the convex lens causes the light rays to ultimately bend inwards, after passing both lenses's, and intersect on the screen.

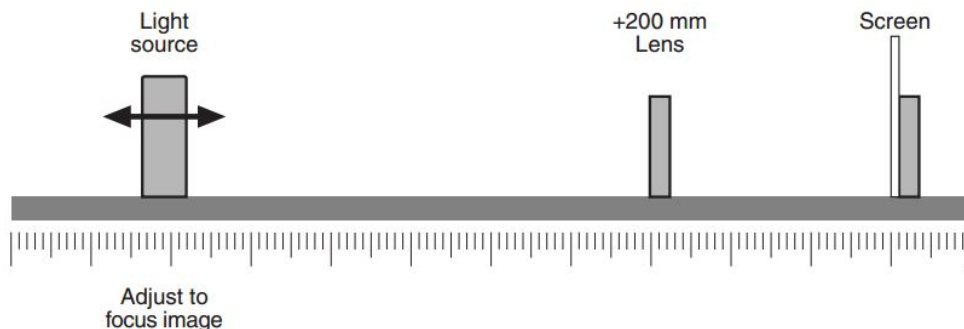
13. The image you see on the screen is the "*image*" from the +200 mm lens. But what acts as the +200 mm lens' "*object*"?

The virtual image that we see through the 150mm lens.

14. Remove the -150 mm lens from the bench. What happens to the image on the screen?

It goes out of focus.

15. While leaving the +200 mm lens and Screen in place, attempt to get your image back by moving the light source around to a new position.



16. Once you have formed a clear image on the screen, record the new position of the light source: **26.6 cm**

Analysis

We will be making a comparison between the experimental image distance and calculated image distance.

1. How do you think this new position of the Light Source compares to the position of the virtual image formed by the -150 lens. Why?

They are the same, because they need to be the same distance from the 200mm lens, to end up focused on the screen.

2. Record the distance between the chosen position of the -150 mm lens (Procedure #2) and the position of the light source from Procedure #16 as d_{i1} Experimental.

$d_{i1} = -8.4 \text{ cm}$

3. Calculate the virtual image distance d_{i1} (the distance between the $f = -150 \text{ mm}$ lens and the virtual image) using the Thin Lens Formula $\frac{1}{f} = \frac{1}{d_{o1}} + \frac{1}{d_{i1}}$. Record this value in the table below for d_{i1} Theoretical.

-8.57 cm

4. What do you notice about the sign of d_{i1} Theoretical? What do you think this means?

Negative, because the virtual image, and the light source in step 16, was behind the 150mm lens position

5. Calculate the magnification and record it in Table 1 below. $M_1 = -\frac{d_{i1}}{d_{o1}}$ using your experimental values.

Table 1: Negative Lens Info.

d_{o1}	20 cm
d_{i1} Experimental	-8.4 cm
d_{i1} Theoretical	-8.57 cm
M_1	+ .42

Analysis

- ❓ 1. How do you know that the final position of the light source is identical to the position of the virtual image when the negative lens was on the bench?

We know this because the image is focused on the screen, at the same distance from the 200mm lens. Therefore, the object distances must be equal.

- ❓ 2. In step 5, you predicted the position of the virtual image relative to the light source. Was your prediction correct?

Yes, there was about a .17 delta between the two.

- ❓ 3. Is M_1 positive or negative? How does this relate to the appearance of the image?

A positive magnification means that the virtual image is not inverted, but rather upright.

- ❓ 4. Calculate the % error of the calculated and measured position of the virtual image.

1.98%

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