Optical Systems

PROBLEM

How are the properties of images determined?

INTRODUCTION

Geometry and scale drawings can be used to analyze optical systems. Rays of light are represented by lines. Virtual rays are represented by dotted lines. Images form where the rays leaving a point on the object come together again. The images are real when actual light rays meet and virtual when virtual rays meet.
In this investigation, you will: predict where images form with lenses using ray diagrams.

MATERIALS (*per group*)

Clear filter with letter *F*; Dark blue lens; Flashlight and holder; Laminated sheet; Light blue lens; Ruler or straight-edge; Water soluble marker.

PROCEDURE

1. Place a filter with the letter *F* on a flashlight, and place the flashlight in a holder.Shine the flashlight (with the letter F filter attached) horizontally on the laminated sheet. Shine the light at a distant wall at least 5 meters away. If one is not available, affix a piece of white paper to the wall as your projection screen.

2. Set the light blue lens about 35 cm away from the light.. Slowly move the lens toward the light until you see a sharp image of the "*F*" on the wall or screen. Have one group member check the projected image closely while the lens is slowly moved to find the exact place the lens needs to be to make it come into focus.

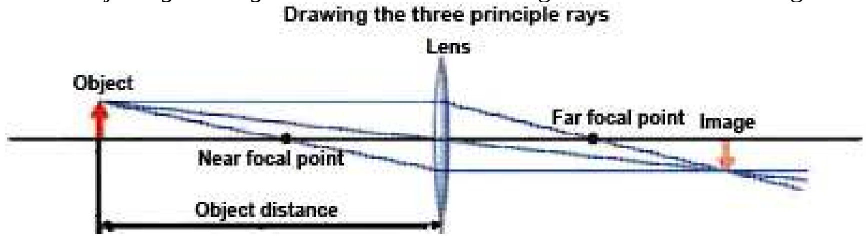
3. When you have the image in sharp focus, measure the object distance and image distance and record them in Table 1. The object distance is measured from the front of the light to the middle of the lens. The image distance is measured from the middle of the lens to the front of the screen.

4. Fill in the rest of Table 1. For image orientation, record whether the image is inverted. For image height, measure the height of the image with a ruler to the nearest millimeter. The magnification is the image height divided by the object height (the height of the letter F on the filter cap is the object height).

5. Next, try projecting the image at a wall or screen that is farther away. Go even farther away for a third trial. (Hint: You will only be able to get a clear image if the separation between the lens and the screen is more than four times the focal length of the lens.) Record your data in the Table *Projecting an Image with a Lens*.

6. Using the laminated graph sheet and a fine-point, water-soluble marker, make a scale drawing showing the positions of the object and lens from the first trial in Table *Projecting an Image with a Lens*. You must decide how many cm each box on your grid will equal, and record it on the next page. Keep that value throughout the exercise. Measure and mark the near and far focal point of the light blue lens (you found this value in the previous investigation). Draw an arrow for an object at an object distance that corresponds to your first trial in Table *Projecting an Image with a Lens*. Your drawing should look like the diagram below (without the rays).

Drawing the three principle rays



7. Draw three rays from the tip of the arrow (as shown on the previous page) using these rules: [1] A ray parallel to the axis is bent to pass through the far focal point; [2] A ray passing through the near focal point emerges parallel to the axis; and [3] A ray passing through the center of the lens is not deflected at all.

8. Measure the image distance from your drawing, and the height of the image (length of the image arrow from the optical axis to the tip). Record your measurements in the Table *Results from Ray Diagrams*. Compare the measured distances and calculated data.

CALCULATIONS

Record the scale for each box . . . . ____________________

Fill in the table *Results from Ray Diagrams* by counting the number of boxes and multiplying by the scale

OBSERVATIONS

Projecting an Image with a Lens				
Object dist (cm)	**Image dist. (cm)**	**Image orientation**	**Image height (mm)**	**Magnification**

Results from Ray Diagrams				
Object dist (cm)	**Image dist. (cm)**	**Image orientation**	**Image height (mm)**	**Magnification**

CONCLUSIONS

1. What happens to the magnification as the image is projected further away? ____________________

2. Why is the image oriented as it is? ____________________

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3. How do the image heights and magnifications in the ray diagrams compare to the actual measurements? Which are more accurate?

What are the sources of error? ____________________

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