1988

Energy in Perspective Laboratory #10: Investigations in Optics

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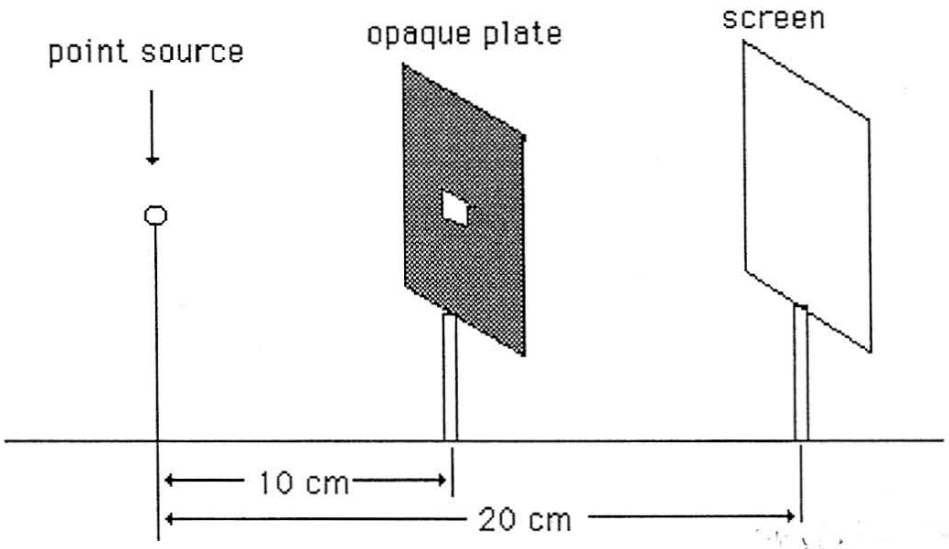
Investigations in Optics

Exploration #1:

In an old-fashion film-developing device, it is common to use an aperture to control the exposure area of a film. The following diagram is a simplified version. There is a point light source on the left side of the diagram. We place an opaque plate with a 1 cm square hole in its center and 10 cm away from the light source. Then we place a screen 20 cm away from the light source. The plate and the screen are facing the light source and all these objects are arranged in a straight line.



a) Sketch the bright area on the screen and estimate its SIZE. Explain your reasoning.

b) Assume you want to light an area of 25 cm^2. Where should you place the screen? Explain each step.

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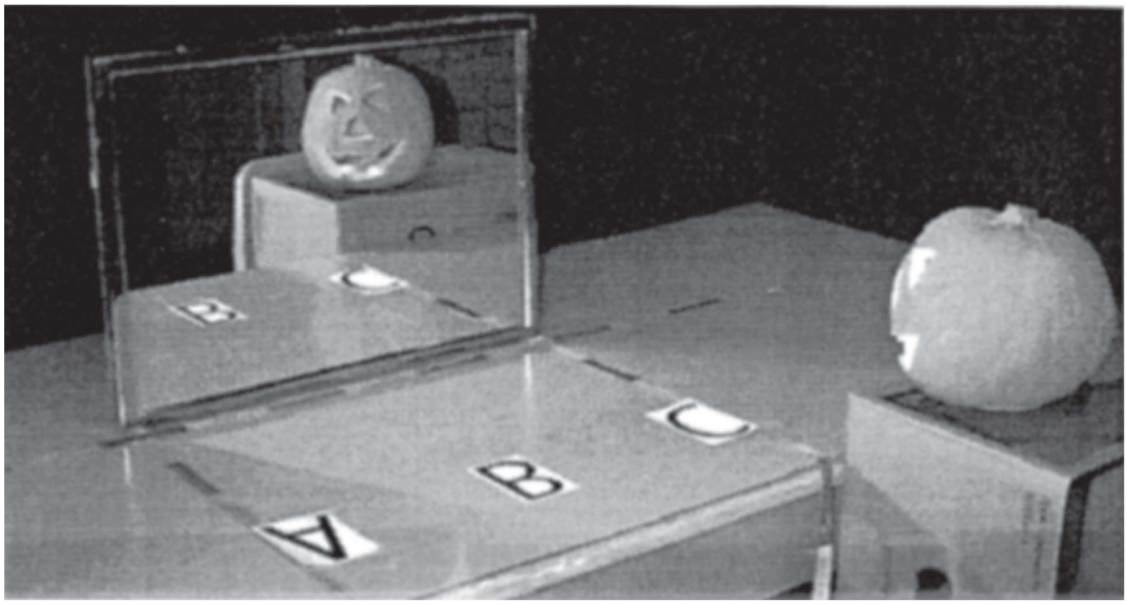
Exploration #2:



This Halloween picture was taken by Chris Moore, a famous digital photographer of Lincoln. His daughter Ella was asked to guess whether she could see the image of the pumpkin in position A, B and C. Without any knowledge of optics, she had to go to each position to check.

With your knowledge of optics, explain what you can see of the pumpkin in the mirror from each of the positions A, B, and C. Explain your reasoning using words and drawings as appropriate.

From position A:

From position B:

From position C:

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Station # 1
Looking at a hole on a wall.

What is the shape of the hole ?

What is the relationship between the size of a shadow formed on a screen and the distance of the shadow from the light source. You will need: an optical bench, two light sources (lamps, a mask with a hole, and a screen to view the hole.
Start with the mask about 10 cm from the light source(a standard light bulb) and the viewing screen about 20 cm from the light source. How big is the image of the hole that is formed on the screen? Make a table as follows:

Distance of hole	Distance of wall with hole	Size of hole on wall

Complete the table using at least 6 different positions of the viewing screen (remember to keep all other variables fixed!).
Next, move the mask so that it is about 20 cm from the light source and make a new table like the one above.

Now change the light source to the bulb with the reflecting base, tip the bulb horizontal so that most of its light travels toward the hole in the mask. Repeat the two investigations as above, i.e. with the hole at 10 cm from the light and with the hole at 20 cm from the light.

What is the relationship between the size of the hole on the wall and the distance from the light sources to the wall ?

Graph size of the hole on the wall vs distance of the wall from light source. Is it linear? Should you graph it on Cartesian graph paper or log-log graph paper?

How do the results for the two different light sources compare ?

Find the relationship between the area of the hole on the wall and the distance of the wall from the light source from your graph.

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Station # 2

It's all done with Lenses!

Can you determine the relationship between the object distance (*o*) and the image distance (*i*) for a lens? How does the size of an image depend upon the size and location of the object with respect to the lens ?

For this study you will need: An optical bench, two lenses, a light source with object mask (object), and a screen for viewing the image.

a) Place one lens in the mount and position it about midway on the optical bench.

b) Measure the image distance (lens to screen) for at least 6 different object distances (lens to object).

c) Complete the following table:

object distance (*o*)	image distance (*i*)	image size	object size	sum *i+o*	product (*i*)(*o*)	$\frac{\text{image size}}{\text{object size}}$

d) Repeat this procedure using a different lens.

Are there any similarities and differences between the two lenses?

Be prepared to graph the product of object distance times image distance[(*i*)(*o*)] vs their sum [*i*+*o*] for your write up and determine the relationship between those two quantities.

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Station # 3

It's all done with Mirrors!

Determine the relationship between the position of an object and its image formed by a mirror. You will need: a plane (flat) mirror, a cardboard base, several sheets of newsprint, a push pin, and several straight pins.

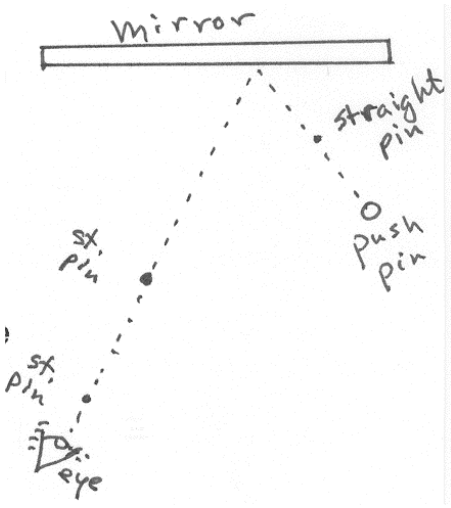
a) Stack several sheets of newsprint (one for each of you) on a cardboard base.

b) Set a plane mirror with stand on top of the sheets and approximately in the center.

c) Make several pin pricks through the newsprint to locate the front of the mirror on the sheets for later reference.

d) Pick a spot in front of the mirror and off near one edge and embed the push pin through the newsprint and into the cardboard base.

e) View the image of the push pin from a spot in front of the mirror and determine its location by lining up two or three straight pins between your eye and the image. (Where does the image of the push pin seem to be?)



f) Draw a line along the straight pins. These are called rays and represent the path of light from the object to the observer (you!). Where do these rays appear to come from? Where do they actually come from? g) Remove the mirror and extend the lines behind the mirror position until they cross. Draw the path light actually takes in going from the push pin to your eye.

h) Repeat steps d through g for at least two more spots in front of the mirror. (At what position(s) can you no longer see the image?).

i) Repeat steps a through h with the push pin at least three different distances from the mirror.

The distance the object (push pin) is from the mirror is called the object distance (o) and the distance the image is from the mirror is called the image distance (i). Make a table of i and o and compare the two.

What conclusions can you make about the position of the object and the image?

Now try your hand at curved mirrors!

a) Place the curved mirror near one edge of the newsprint.

b) For at least 6 different positions of the push pin (object) find the location of the image.

c) Fill in the following table and be prepapred to draw a graph for the write up. Data table

object distance (o)	image distance (i)	i+o	(i)(o)

Explain how you draw rays for the curved mirror based on what you learned with plane mirrors and find the location of the image.

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Write-up:

I. Purpose
II. Describe the procedures for collecting data
  A) Shadows {**Looking at a hole on a wall.**}
  B) Plane and curved mirrors {**It's all done with Mirrors!}**
  C) Lenses{**It's all done with Lenses!}**
III Discuss results

Answer all of the questions asked on the hand-out pages in this section of your write-up!!!

  A) Shadows

Include a graph of the size of the hole on the wall versus distance of the wall from the light source

Be sure to include your discussion of the differences in the results for the two different light sources.

  B) Plane and curved mirrors

Include a graph of the product of the image distance times the object distance versus the sum of the image distance and the object distance. Is this graph linear on any kind of graph ?

  C) Lenses

Include a graph of the product of the image distance times the object distance versus the sum of the image distance and the object distance. Is this graph linear on any kind of graph ?

IV Conclusions

How do the results of these investigations compare with what you wrote as answers to the pre-laboratory questions ?

V Raw data pages