Name ______________________________ Date _________

Partners ____

Images Formed by Converging Lenses: Lab #5

Objectives: to observe the image produced by one or by several converging lenses

Equipment:

Background: Light passing through a transparent lens is refracted (bent). Because of this an observer concludes that the light comes from the image of the object rather than from the object itself. If the refracted light passes through this image position then the image can be seen on a screen at that position. This is called a "real image." If the light only appears to come from the image position, then it is called a "virtual image" and cannot be seen on a screen. (An example of a virtual image is the image viewed in a plane mirror.)

Define: focal length:

Commutative:

Procedure:

A. Observing real images

Put the light source at one end of the optical bench. The coordinate system should go from the light source toward the first lens. (Note that the position numbers do not agree on the opposite sides of the optical bench.) Put the crossed arrow target (the object) 200 mm from the light source. Put the 75 mm convex lens 100 mm further along the bench. Set the viewing screen 300 mm further yet.

Sketch:

Move the screen until the image is as sharp as possible.

Record the object distance (lens to object) _________________

Record the image distance (lens to image) __________________

Is the image erect or inverted? _____________________________

The height of the object is ____________________

The height of the image is _____________________

Is the image magnified or reduced? ___________________

B. Observing without a lens

Remove the lens, leaving the object and the screen. Is the sharp image still visible on the screen? _________

Move the screen around. Can you find any position where a sharp image can be seen (except right at the object itself)? ______

C. <u>The effect of object distance on image distance</u>

Set the 75 mm lens 200 mm from the object. Move the screen until the image is sharp.
Record the object distance (lens to object) _________________
Record the image distance (lens to image) __________________

Is the image erect or inverted? _____________________________

The height of the image is ______________________

Is the image magnified or reduced? ___________________

Conclusion: As the object distance <u>increases,</u> the image distance ______________________,
so they are related (directly, inversely) ____________________

D. <u>The effect of object distance on image size</u>

By trial and error find the object distance required to produce an image <u>the same size</u> as the object using the 75 mm lens.
Record the object distance (lens to object) _________________
Record the image distance (lens to image) __________________

What is this image distance in terms of the focal length of the lens? _________________________

Is the image erect or inverted? _____________________________

The height of the image is ______________________

Conclusion: As the object distance <u>increases</u>, the image size _______________________,
so they are related (directly, inversely) ___________________

Use your data so far to fill in this table:

Part	Object distance, mm	Image distance, mm	Erect, inverted?	Image height, mm
A	100			
C				
D				

E. <u>Using the thin-lens equation to calculate the lens's focal length</u>

The "focal length" of a lens is the image distance of an object infinitely far away. We often use the sun as the infinitely far object, or even a light at the end of a long hallway. (This is hardly astronomical or mathematical infinity, is it?) The thin lens equation relates an image distance to its object's distance and to the lens's focal length.

Use your data from parts A, C, and D to calculate the focal length of your lens using

1/f = 1/s + 1/s’

where f = focal length of the lens, s = object distance (object to lens), s’ = image distance (image to lens). Record the inverse values to 7 decimal places.

Part	object distance, s, mm	Image distance, s’, mm	1/s	1/s’	1/s+1/s’=1/f	experimental f, mm
A	100					
C						
D						

Average experimental value of focal length f ___________________

The focal length written on the lens: ________________

Percent difference __________________________________ (You will try to explain this below.)

F. Virtual images

Place the 75 mm lens only 50 mm from the object. Can you find a position where the image is sharp? _____________

Now bend down and look through the lens at the object. Can you see a clear image? ____ Put your finger right by the object and look through the lens at it. Is it the normal size? ________ Since the image is on the same side of the lens as the object, you cannot put a screen there to see it. This is called a “virtual image.”

G. Application of the thin lens equation to calculate the image distance

Move the object close to the light source.

Replace the 75 mm focal length convex lens with the 150 mm focal length convex lens and put it 350 mm from the object.

Use the thin lens equation to predict the image distance _______________.

Use the screen held by hand to find the image distance for the sharpest image _____________

Calculate your percent difference. ________________________________

What range of object distances produces real images? (Consider from 0 to infinity.) __________

H. Systems of two lenses (far apart)

Place the 75 mm lens 200 mm from the object, and the 150 mm lens 340 mm further. Use the hand-held screen to find the image. If it is beyond the end of the optical bench you will need to use a meter stick to measure the final image distance (second lens to image) _____________.

Fill in these data in the table below. Calculate the first image distance s', the second object distance S and the second image distance S', then find the percent difference from your measured value of S'. Be careful about signs.
Now put the screen between the two lenses and locate the first image. Its distance from the first lens _______________. What is the percent difference from your calculated s'? ______________

I. <u>Systems of two lenses (far apart, reversed)</u>

Carefully remove the lenses from their holders and reverse them, keeping the spacings the same.

Use the hand-held screen to find the final image. If it is beyond the end of the optical bench you will need to use a meter stick to measure the image distance ______________.

Is the image formed at the same place in both cases H and I? __________________

Are lenses' positions commutative? ____________

J. <u>Systems of two lenses (close together)</u>

Place the 150 mm lens at position 100 mm from the object, and the 75 mm lens 100 mm further on. Use the hand-held screen to find the final image distance ___________.

For sections H, I, and J use the thin lens equation to calculate the intermediate and final image distances. Be careful about signs. Find your percent difference with the measured value of S'.

Part	first f, mm	s, first object distance, mm	s', first image distance calculated, mm	second F, mm	S, second object distance calculated	S', second image distance calculated	S' measured, mm	% diff.
H	75	200		150				
I								
J								

On the graph paper make a scale drawing of the optical bench for parts A, C, D, G, H, I, and J. Please use the same scale, 1 graph paper box = 50 mm in distance on the optical bench, and include the lamp, the object, and the lens for each case. Add the positions of the experimental images to your scale drawings. On your drawings for parts H, I, and J add the first <u>and</u> final image positions.

Discussion of errors:

Future work in this field: