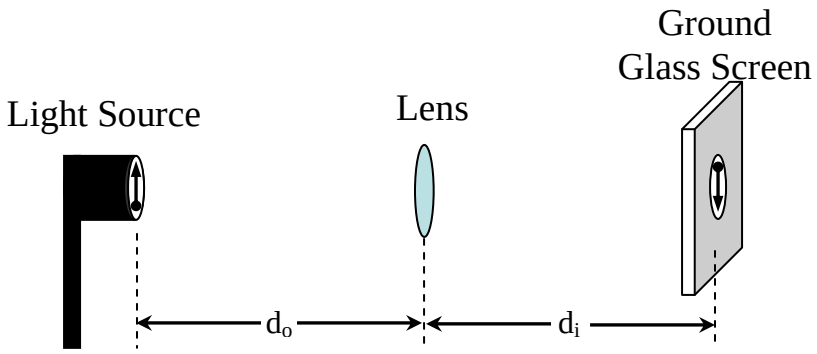
Physics 345 Pre-Lab 4 Single Converging Lens

Consider this lens set-up (**drawn to scale**) where an image is projected on a ground glass screen.



1) Is the image distance greater than, less than, or equal to the focal length? Explain how you can tell.

2) Is it possible to determine the ratio between the focal length and the image distance? If so, find it and explain your reasoning. If not, what additional information is needed to find this ratio?

3) How would the image change if we blocked just the LOWER half of the lens with opaque cardboard? Explain your reasoning.

4) Would there still be an image if we removed the ground glass screen? Explain your reasoning. What sort of experiment could one perform to check your prediction?

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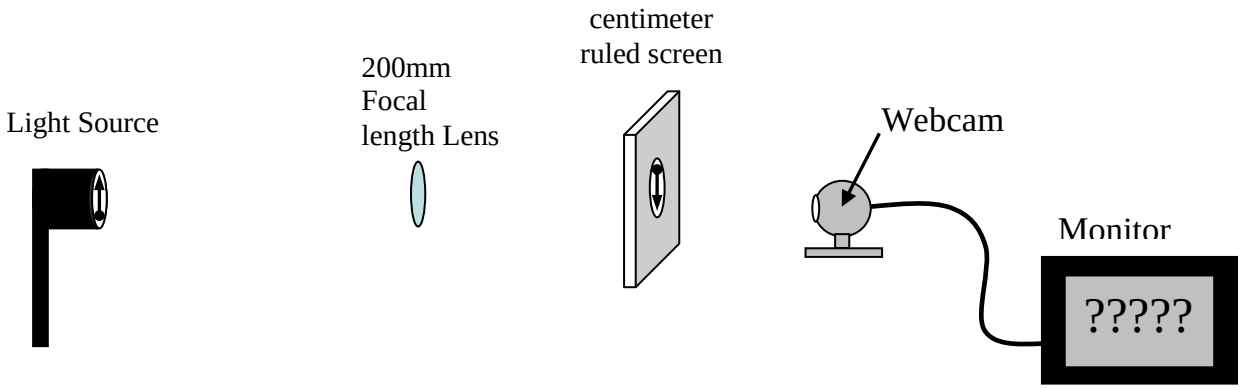
Section 1

In this section you will explore the issue of how a image forms on a screen.

Equipment: Optical Rail, optical rail carts, light source with test pattern, lens holder, lens set, ruled screen, webcam without lens, webcam with lens, optical posts, post holders and a computer.

Set up the equipment as shown below. Make sure that the monitor and the webcam's opening face the same direction (otherwise you could get confused by the orientation on the monitor). Attach the light source with the test pattern on an optical rail cart. Next put a 200mm focal length double convex lens in a lens holder. Connect the lens holder to an optical cart using a post and post holder. Place the two optical rail carts on the optical rail such that the light source and the lens are exactly 600mm apart. It is highly important that the lens' faces are nearly perpendicular to the light beam path. Move the screen until you see a clear image (on the screen). Then add the webcam and adjust the webcam's lens so that a clear picture of the image (on the ruled screen) appears on the monitor.



Without experimental testing, predict if the image would still be present if the white screen were removed? Explain your reasoning.

Now remove the centimeter ruled screen. Can one see an image on the monitor?

Take a picture with the webcam to provide evidence as to whether the screen is necessary for the image to form.

Now remove the webcam. Put your eye at the approximate position of the webcam. Look at the lens from this eye position. Can you see the image?

Now move your eye approximately 10 cm to the side (perpendicular to the optical rail). Can you still see the image?

In light of your evidence, is a screen necessary for an image to form? Resolve any differences with your prediction on page 2.

Why might a physics instructor want to use a screen to demonstrate an image to a large number of students?

SHOW YOUR ANSWERS TO YOUR INSTRUCTOR BEFORE PROCEEDING

Section 2

In this section you will explore the effect on an image when part of the lens is covered with opaque material.

Using the same experimental setup as in sections 1, place the centimeter ruled screen back on the optical rail so that you can see a clear image on it.

For the current optical set-up, predict what we would see on the monitor if we covered the right side of the lens? Fully explain your reasoning.

Using a small piece of paper, cover the right side of the lens and observe the picture on the monitor screen. Resolve any differences you might have between this observation and your previous prediction.

Section 3

Suppose we use a single lens to form an image. However, we place the screen at the wrong location. Obviously this will result in a "blurry image". Can one use another lens to correct the problem and form a clear image?

Move the screen so that the picture on the monitor is blurry. Predict whether it is possible to see a clear image on the monitor screen by simply repositioning adjusting the lens on the webcam.

Without moving the light source, 200mm lens, or the ruled-screen try to get a clear of the test pattern on the monitor by adjusting the webcam lens. Can this be done? Using your knowledge of lenses, explain why you might expect this result?

Section 4

In this section you will explore how the optics of a webcam function. What does the lens in front of the webcam do? What will happen if we remove it?

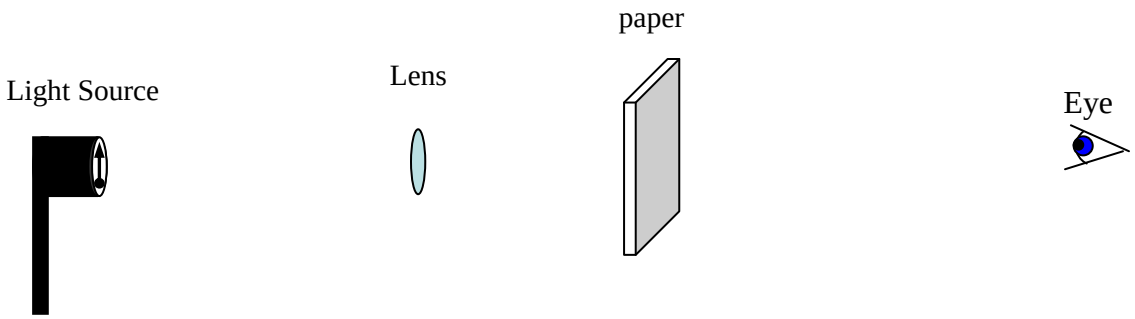
For the rest of the exercise you will be using the webcam **without the lens**. Aim the webcam **without the lens** at various objects in the room. Can you see a clear picture on the monitor screen? Explain how one can get a clear picture on the monitor using this webcam set-up or explain why you believe it can't be done.

Attach the webcam (without a lens) to an optical rail cart using a post holder. Make sure the light source with the test pattern is turned on and that the rail cart with the 200mm focal length lens is still on the optical rail. Separate the light source and lens so that they are 600mm apart (if they are not already there). Move the webcam along the optical rail. Can you ever see a clear image on the monitor?

BEFORE PROCEEDING, SHOW YOUR RESULTS TO YOUR INSTRUCTOR!

Back up the rail cart with the webcam on it. Moving a piece of paper back and forth, find the location where you can see an image on the paper. Carefully note where you must hold the paper.

Place your eye at the indicated position shown below and observe the orientation of the image on the paper. Draw a sketch of the image's orientation and the object's orientation.



Now move the webcam back to the position where a clear image is seen on the monitor. Observe the orientation of this picture. Where is the webcam located with respect to the piece of paper you used above?

Is the image you see on the monitor the same as you saw on the piece of paper? Why do you think it happens this way?

Make a prediction of what you think will happen to the picture on the monitor if you turn off the light source? Explain your reasoning.

Now turn off the light source. Resolve any differences you might have between this observation and your previous prediction.

Shine a flashlight beam on the test pattern on the light source (light source still off). Does this improve or worsen the contrast of the picture seen on the monitor? Why might this happen?

Use a black cloth to cover the lens and the webcam while still allowing an optical path between these two devices. Does this improve or worsen the contrast of the picture seen on the monitor? Why might this happen?

Task 4

Using **multiple lenses** (not counting the one in front of the webcam) it is possible to form an upside down image of the light source on the monitor. Determine a method in which you could do this on the optical rail. Show your plan to your instructor before proceeding. You are NOT allowed to solve this problem through trial and error.

Follow your plan and see if you accomplished the goal. Resolve any differences with your plan and the test.

