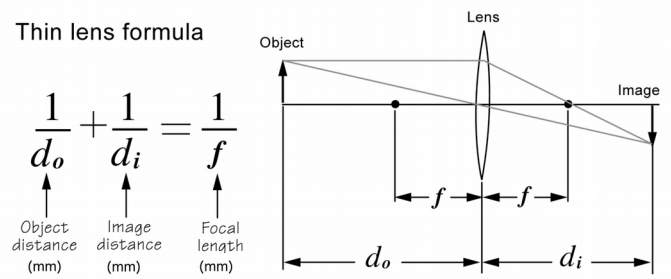
PURPOSE[1]

In this lab you will explore how single positive lenses forms an image. You will use the thin lens formula. It is summarized in the figure to the left. In addition the magnification of the image is $m=-\frac{d_i}{d_o}$ Note that the unit most commonly used is millimeter which is abbreviated *mm*. In the next few weeks you will see that this formula works for real and virtual images and negative focal length lenses.



You will also explore how the lens on a webcam functions and make an “Image Finder” using the webcam with an external lens.

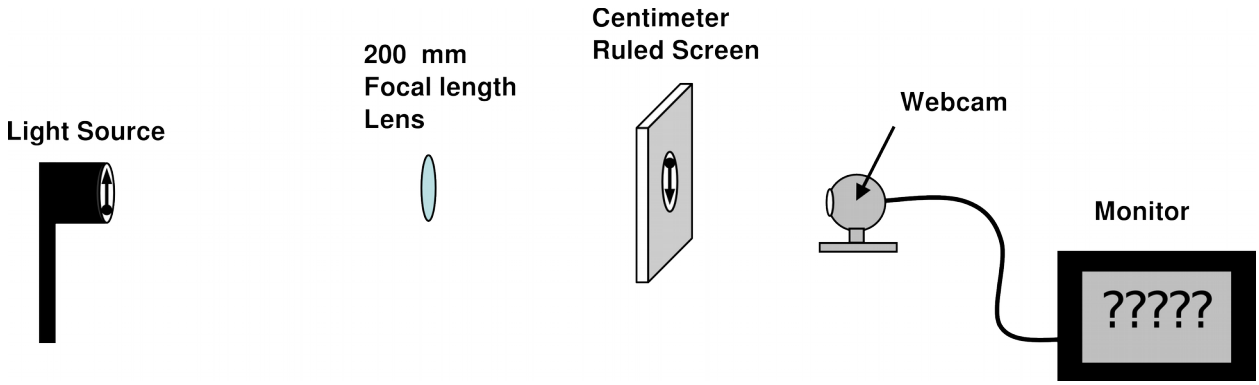
SECTION 1 – 200MM LENS

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

Equipment: Optical rail, optical rail carts, light source with test pattern, lens holder, lens set, webcam with adjustable and removable lens, optical posts, post holders and a computer.

Set up the equipment as shown below. Make sure that the monitor and the webcam face the same direction (otherwise you could get confused by the orientation on the monitor). Turn on the light source with the test pattern. Next put a 200mm focal length lens in a lens holder on a post and a post holder. Align the light source and the lens exactly 600mm apart. It is very important that the lens' faces are nearly perpendicular to the light path. Move the screen until you see a clear image on the ruled 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.

Do the distances agree with that predicted by the thin lens formula?



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

1 © T.T. Grove & M.F. Masters 2007, 2008 – Modified by M.E. Huster 2015

Now remove the centimeter ruled screen. Can you 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 20 cm away from the former position of the webcam. Can you see the image?

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

SHOW YOUR ANSWERS TO YOUR INSTRUCTOR BEFORE PROCEEDING

SECTION 2 – COVERING A LENS

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 – WHEN A BLURRY IMAGE BE FIXED?

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 you use another lens to correct the problem and form a clear image?

Using the previous setup, move the screen so that the picture on the monitor is slightly blurry. Predict whether it is possible to see a clear image on the monitor screen by simply repositioning adjusting the webcam’s lens.

Without moving the light source, the 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?

Now, remove the ruled-screen without moving anything else. Now try getting a clear image by adjusting the web-cam lens. Explain what you observe.

SECTION 4 – THE LENS OF A WEBCAM

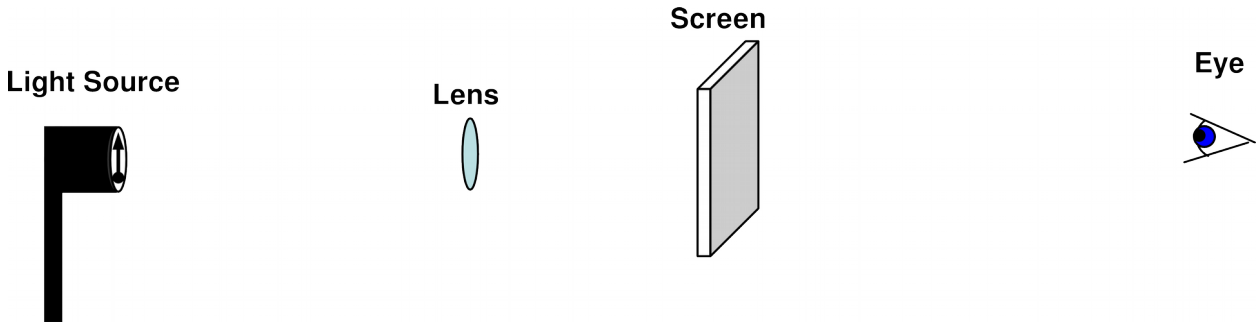
In this section you will explore how the optics of a webcam function. What does the lens in front of the webcam do? What will happen if we remove it? For the rest of the exercise you will be using the webcam *without* the lens. Remove the webcam lens by unscrewing it. (Place it in a drawer of your cabinet.) Aim the webcam without the lens at various objects in the room. Can you see a clear picture on the monitor screen? Explain how you can get a clear picture on the monitor using this webcam set-up or explain why you believe it can’t be done.

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. Move the webcam along the optical rail. Can you ever see a clear image on the monitor? What is its orientation? Since a single lens makes an inverted image on a screen, how do you explain the image on the monitor?

BEFORE PROCEEDING, SHOW YOUR RESULTS TO YOUR INSTRUCTOR!

Back up the webcam. Move a screen toward and away from the webcam along the rail. Find the location where you can see an image of the source pattern on the screen. Carefully note where you must hold the screen.

Place your eye at the indicated position shown below and observe the orientation of the image on the paper.



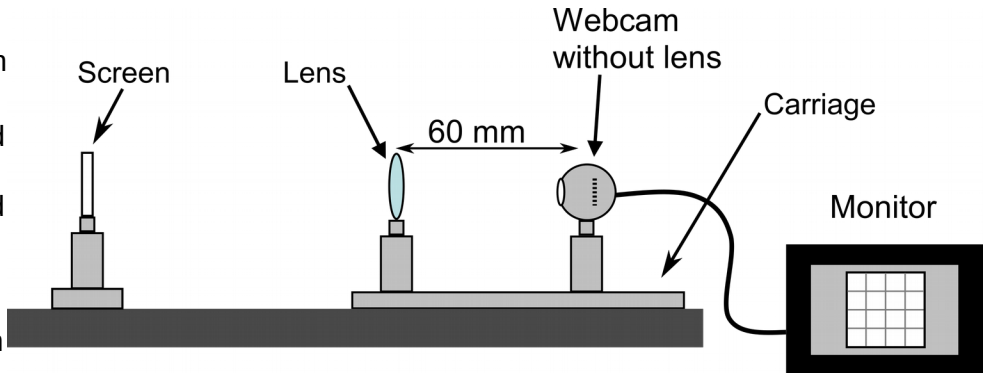
Draw a sketch of the source's orientation and the image's orientation you see.

Now remove the screen and 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 screen you used above?

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

SECTION 5 – MAKING A WEBCAM *IMAGE FINDER*

- Mount a 50 mm lens on a post and a post holder and attach it to a carriage.
- Remove the web cam lens and mount the webcam on the carriage. Adjust the lens and the sensor of the webcam so they are lined up and 60 mm apart. Note that the sensor is *inside* the webcam housing.



- Use the screen with the centimeter grid and move the carriage until you have a sharply focussed image of the screen on the webcam monitor. Make sure everything is securely attached to the carriage.
- Measure the *Image Finding Distance* for your carriage by measuring the distance from the front of the carriage to the screen. Also measure an uncertainty to this distance. Write distance with uncertainty on a label and stick it to the carriage.
- Test your Image Finder by using it to measure the distance to some other objects and verify this distance.
- The screen is calibrated with a centimeter grid. Capture a webcam image and measure the number of pixels (with uncertainty) of a one centimeter length. Also record this calibration on the label.

TASK 1 – USING THE *IMAGE FINDER* TO FIND A REAL IMAGE

Set up the source and a 200 mm lens with 500 mm between them. Predict the image distance and magnification. Show your predictions to the instructor before proceeding.

Predicted d_i and m:

Now measure the image distance and magnification with uncertainty using the Image Finder. Comment on your results.

TASK 2 – USING THE *IMAGE FINDER* TO FIND A VIRTUAL IMAGE

Set up the source 67 mm from the 200 mm lens. Predict the image distance and magnification. Show your predictions to the instructor before proceeding.

Predicted d_i and m:

Now measure the image distance and magnification with uncertainty using the Image Finder. Comment on your results.

When you are finished, leave the carriage set up. You will be using these for the next several labs!