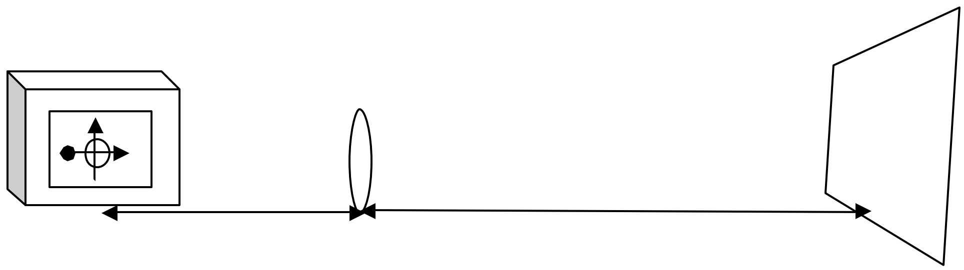
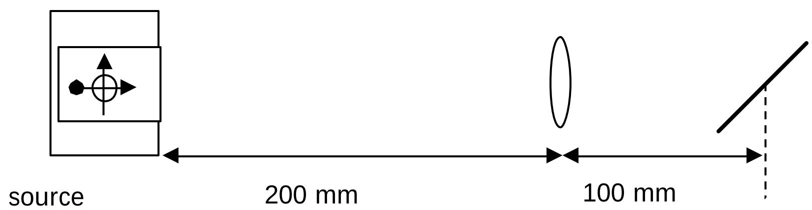
Physics 345 Pre-Lab 6

Images and reflection

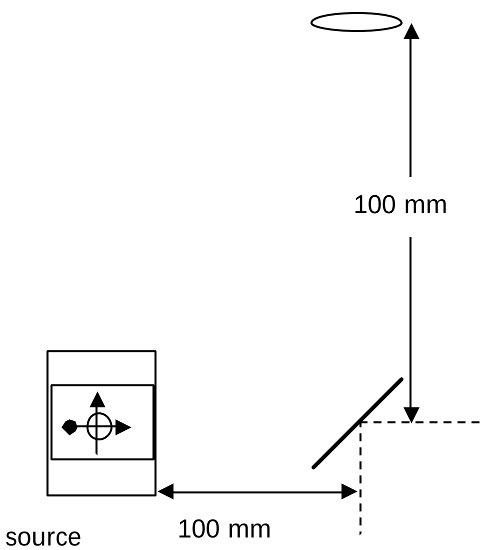
Imagine that you have an extended light source with two arrows, one horizontal and one vertical. A 150 mm fl lens is placed 200 mm from the lens.



A) How far from the source will the image form? Draw a picture of the image paying close attention to its orientation.



B) A mirror is now placed 100 mm from the lens at an angle of 45 degrees as shown in the diagram below. Determine the location of the image from the mirror and draw a careful picture of the image paying close attention to its orientation. Compare your results with those of the situation above. Explain how you arrived at your answer.



C) Suppose that the mirror were located 100 mm from the source and the lens located 100 mm from the mirror as shown in the diagram at left. Determine the location of the image and carefully draw a picture of the image. Compare your results with the previous results. Explain how you arrived at your answer.

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Place a 400mm focal length lens within 200mm from the light source. Keep the car with the 100mm lens next to the car with the video camera. Once more move these two cars together as one unit (as you did in the previous lab) until you see a focused image on the monitor. Where does the image form from the 400mm lens? How can you tell? What type of image is formed by the 400mm lens? How is the image of the test pattern oriented on the screen?

On the below sketch, show the distances between each of the elements and precisely indicate where images are formed.

Predict what would happen if we remove the 100mm lens from the current set up. Could we get a focused image on the monitor by simply changing the webcam position?

Remove the 100mm lens car from the rail and move the webcam backward and forward. Try to get a clear image on the screen. Resolve any differences with your predictions

Put the 100mm lens car back on the rail. Get a clear image on the screen keeping the 100mm lens car and the webcam car touching each other. Replace the 400mm focal length lens with a -25mm bi-concave focal length lens. Move the lens car with the -25mm focal length lens as close to the light source as possible. Where does the image form from the -25mm lens? Draw a sketch with measured values showing the spacing between each of the optical elements. What type of image is formed by the -25mm lens? How is the image of the test pattern oriented on the screen?

Introduction to Mirrors

The purpose of this portion of the lab is to familiarize you with positioning images and beams of light. You will be learning the impact that mirrors have on images. You will learn an iterative technique to position a laser beam. Many of these approaches are necessary when working with optics and lasers. Because you are going to be working with at least two dimensional setups, you will for the first time be using the optical table. As usual, care is necessary when setting up the optics. In all situations you should attempt to capture evidence of your observations using the translucent screen and the lensed quickcam. You will also be using quality mirrors and mirror mounts. Familiarize yourself with how the mirror mounts work and NEVER set the mirrors face down on the table.

Rightly or wrongly, we will not be addressing the issue of images formed using spherical mirrors. However, you are not to get the impression that spherical mirrors have no use. For example, spherical mirrors are often used under circumstances in which chromatic aberration may have a significant impact.

I. Set up the situations from the pre-lab and test your predictions. Describe your results

Reconcile your prediction with your observations.

II. Auto-collimation
Suppose that you wanted to have the light exiting a converging lens be collimated. How would you arrange the lens with respect to the source? Where would the image form in this situation? Explain. Describe a method to achieve this end.

One method to collimate light from a source is called auto collimation. Essentially, the lens is placed in a certain distance from the source and a mirror is placed some distance away from the lens. An image of the source should be formed on the source. Under what conditions can this happen? Explain.

Using the +150 mm F.L. lens, the 6-in. rail and cars, perform an auto collimation. The easiest method is to cover half the light source with an opaque screen.

Once you have collimated the light suppose that you placed a +200mm lens approximately 100 mm from the +150 mm F.L. lens. Predict how you would expect the image to appear. Explain.

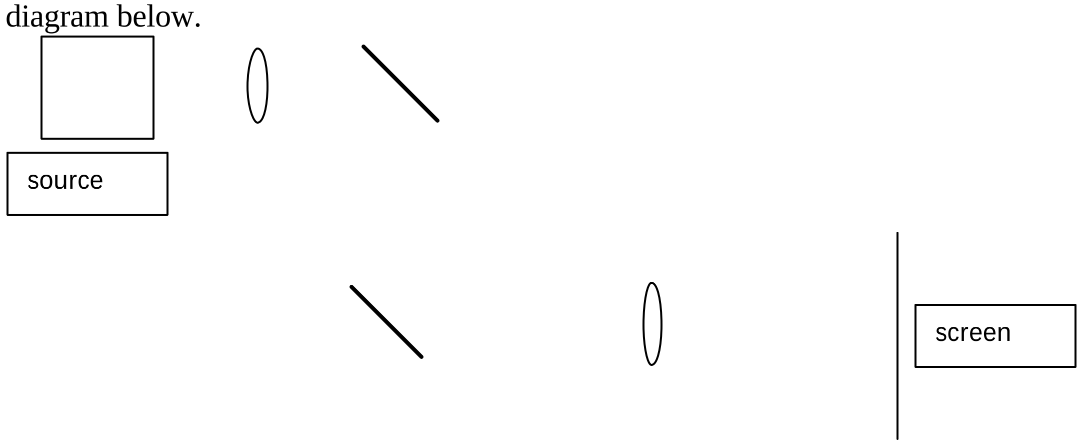
Suppose you moved the +200mm F.L. lens so that it was 500 mm away from the first lens. Predict how you would expect the image to appear. Explain.

Suppose that you replaced the +200 mm F.L. lens with a 100 mm F.L. lens. How would the image appear now? Explain.

Perform these three trials and reconcile the differences between observation and prediction.

III. Image positioning and distortion.

Suppose that you want to set move the light through two 90 degree angles as shown in the diagram below.



Predict the appearance of the image. Explain why you believe the image should appear this way.

Test your prediction being careful to keep the image at the same height throughout the test. Reconcile any differences between the prediction and your experiment.

Now imagine that you are trying to raise the image 5 cm from its original height. The first mirror is given a tilt upwards and as the light leaves the second mirror it is again parallel to the table, only 5 cm higher than before. How will the image on the screen appear?

Perform the test and reconcile any differences between prediction and observation.

IV. Image rotation

Occasionally it is necessary to rotate an image through 90 (270) degrees. How would this be possible?

Arrange the mirrors in such a way so the image is rotated by at least 90 degrees (270 degrees would be acceptable as well). How were the mirrors arranged?

What happens to the image if the mirrors are arranged so that the beam does not leave the second mirror perpendicular to the incoming beam?

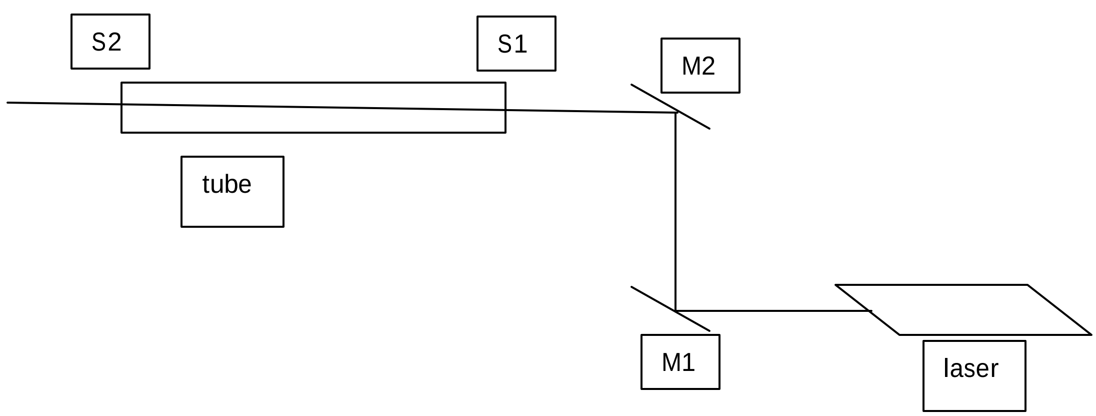
V. Laser alignment

In this section you will be working with lasers. Lasers are not toys and care must be taken to be sure of where the laser beam is going. You must always terminate the beam with some sort of beam stop. In this part of the lab, each of you should be setting up a laser individually so that you all get the "feel" of how to position the beam.

It is almost always preferable to position a laser beam using at least two mirrors. The reason for this is that it makes it possible to redirect the laser beam so that it can always be parallel to the working (table) surface. The two mirrors allow you to change horizontal and vertical positioning accurately.

For your first laser alignment task, you will have to get the laser through a 30 cm long, 1.3 cm diameter copper pipe. This pipe represents some sort of oven through which the laser beam must travel. Using two mirrors and the laser get the beam through the pipe without hitting the sides of the pipe.

The easiest way to perform the adjustments is through an iterative approach. Since you have two mirrors and two locations through which the light beam must pass you have to determine which mirror to adjust. Consider the drawing shown below. The best approach would be to adjust mirror M1 for the laser beam's location at S1 and mirror M2 for the laser beam's location at S2. Any other ordering of mirror adjustment will often result in an inability to get the beam to behave in a way that is reasonable. Why is that? Explain.



Final Task

Given the obstacle course you must position a laser beam through the three apertures with a minimum number of mirrors and in a minimum amount of time.