Lab 2
Lenses

Many experiments can be done with the PASCO Basic Optics System (PASCO, http://www.pasco.com/home.html, catalog number OS-8515C).

Quantitatively verifying the lens formula is simple: use the light source, a white screen, and a lens between the two as shown in Fig. 1. Find the conditions in which the cross-hair on the lamp appears well in focus on the screen. Use the ruler (part of the bench, shown in yellow in Fig. 1) to measure the object and image distance, and find the focal length using the lens law. This experiment works a lot better if the room is dark, as the lamp is not very intense.


Fig. 1

You can make a ray diagram in your notebook showing the parallel rays from the light source to the lens, and the rays converging on the screen. Mark f. How must one change the shape of the lens to shorten the focal length? Find a lens of this shape, measure the focal length as you did above, and report both in your notebook.

Measure the image size, compare it with the object size, then compare these with the magnification formula.

An interesting question of practical importance: how can we change the image size, for instance in a movie theater, without changing the image distance? Changing the image distance requires moving the projector booth or the screen: a costly construction project! Let's pretend the screen on our optical bench is the movie screen, and we want to produce a larger or smaller image on the screen without moving the lens. The solution is that we have to change the focal length of the lens. We now do an experiment to see how this works.

Take two lenses with two different focal lengths (lens 1 with larger f, lens 2 with smaller f). Adjust the image distance for lens 1 then replace it with lens 2. Keep the same image distance for both, that is, do not move the screen or the lens holder. Change the object distance by moving the light source until you get a focused image on the screen. Is the image larger or smaller? To understand why, use the fact that the focal length is smaller for lens 2. The lens formula tells you which way the object distance changes when you keep the same image distance. You could also simply use the fact that lens 2 bends the rays more than lens 1, thus requiring a smaller object distance.

Now use the lens formula to see what happens if you place the object closer than the focal length f. Try it!

Apertures

Is the entire lens used to form the image? Try covering part of the lens with a notebook. Is only part of the image being formed? Not at all! The only effect is less luminosity! This is why to see distant stars you need large telescopes: to increase their luminosity. Now try using the rotating, interchangeable apertures as shown in Fig. 2. You will see that the larger the aperture in front of the lens the greater the luminosity of the image on the screen.

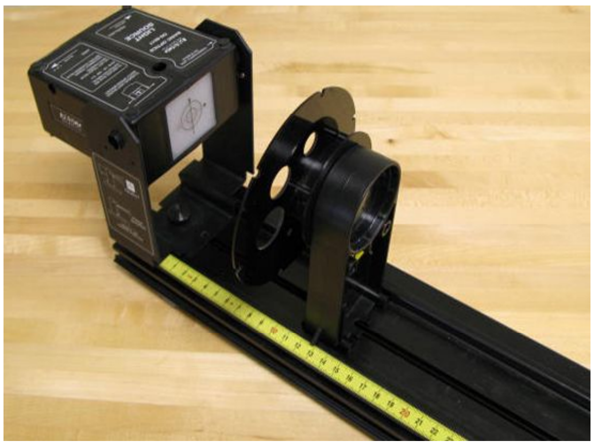

Fig. 2

Changing apertures, however, also has another effect: it changes the depth of field. While using a large aperture, move the white screen on which the image is formed backwards and forwards. You will see that if the screen distance is wrong the image goes out of focus very quickly. This corresponds to a small depth of field. Conversely, the dim image obtained with a smaller aperture, provides a much larger depth of field. This effect is widely used in photography: if you want to have a large depth of field to take a photograph of a nearby person and a far away mountain you need a small aperture, thus a large f-number (f-number = focal length/aperture diameter). Beware: this photo can only be taken in bright light, as a large f-number implies a small aperture, thus very little light on the film or CCD. If you have a tripod and can afford a longer exposure time without shaking a hand-held camera, you can also take this photograph at twilight.

Diverging lens

Find a diverging lens in your set of lenses. Try to use it to form an image on the screen: why doesn't it work?
Look at an object, such as your notebook, through the diverging lens. Try to figure out how far from the lens the image is located.
Measure object distance and image distance as well as you can.

Figure out the focal length of the lens from the lens formula.
Draw a ray diagram for your diverging lens, showing the location of the object and the image using the three easy rays.