Geometric Optics Lab 1a

Images formed by a converging lens.

Light source with arrow, optical bench, carriages and lens mounts, lenses, screen.

Procedure 1

1. Place a converging lens with a focal length of between 15 and 50 cm in a lens mount on a carriage near the center of the optical bench. The lens should remain at the center of the optical bench for most of this lab.
2. Place the light source on a carriage on one side of the lens and the screen on a carriage on the other side.
3. Place the light source as far away from the lens as possible. Move the screen until the images comes into focus on the screen. There will be a fairly wide range of image distances that yield an acceptable focus. This is due to spherical aberration. Namely, the outer edge of the lens does not focus the light rays to the same point as the center of the lens does.
4. Measure the length of the arrow used as the object and record it as the object size. Record the object distance, d_0, and the image distance, d_i, as well as the image size. The image and object distances should be measured from the center of the lens. Do this for at least ten different image and object distances.
5. Plot the image distance versus the object distance using Logger Pro. What is the shape of the curve? Is it linear?
6. Choose a value for the object distance that you have not used before. Read the image distance from the graph. See if your graph makes the proper prediction by placing the light at this object distance and the screen at the image distance. Is the image in focus?
7. Plot the data in a manner that yields a straight line. For a straight line, $y = mx + b$. Therefore, plot the inverse of the image distance (ordinate) versus the inverse of the object distance (abscissa). Determine the focal length from the intercepts with both the x-axis and the y-axis. Hint: relate $(1 / d_i) = - (1/ d_0) + (1 / f)$ to $y = mx + b$.
8. Calculate the magnification for each data point, using both the formula (magnification) = (image size) / (object size) and (magnification) = $- d_i / d_0$. Where should we put the object, in relation to the focal length, to get a magnified image?

Procedure 2

1. Now, put a large (2 inch diameter or more) fat (focal length less than about 10 cm) plano-convex or double convex lens on a lens mount on the optical bench and focus the image on the screen.
2. The f-ratio of an optical system is the (dimensionless) ratio of the focal length of the lens to the diameter of the lens. Calculate the f-ratio of your lens. If you don't know the focal length, you'll need to measure it.
3. Now put an aperture into the beam right next to the lens. This reduces the effective diameter of the lens to the aperture size. Record the f-ratio for the lens. What do you notice about the focus and the brightness of the image as the aperture size decreases?
4. Do a bit of research on f-ratio as it relates to photography. What does the f-ratio have to do with image brightness and depth of focus?

Geometric Optics Lab 1b

Images formed by a concave mirror.

Light source with arrow, optical bench, carriages and lens mounts, concave mirror, screen.

Procedure

1. Place a clean (use methanol) concave mirror in a mount on a carriage at the end of the optical bench. You will need to angle the mirror so that it forms an image on a screen that is slightly displaced to the side of the light source.
2. Place the light source as far away from the mirror as possible. Move the screen until the images comes into focus on the screen. Record the object distance, d_0, and the image distance, d_i, as well as the image size. The image and object distances should be measured from the vertex of the mirror. Due to spherical aberration and poor mirror quality, it will be difficult to obtain a sharp focus. You may determine a range of good focus and use the average distance.
3. Move the light source a few centimeters closer to the mirror. Find the new position of the screen where the image is in focus. Repeat this for at least ten different image and object distances. Include positions where the image is larger than the object.
4. Plot the image distance versus the object distance using Logger Pro. What is the shape of the curve? Is it linear?
5. Choose a value for the object distance that you have not used before. Read the image distance from the graph. See if your graph makes the proper prediction by placing the light at this object distance and the screen at the image distance. Is the image in focus?
6. Plot the data in a manner that yields a straight line. For a straight line, $y = mx + b$. Therefore, plot the inverse of the image distance (ordinate) versus the inverse of the object distance (abscissa). Determine the focal length from the intercepts with both the x-axis and the y-axis. Hint: relate $(1 / d_i) = - (1/ d_0) + (1 / f)$ to $y = mx + b$.
7. What is the radius of curvature of the mirror?