O9a: Thin Converging Lenses

Introduction:

The refraction of light at the boundary between two mediums can be used to control the path light takes. It is from this refraction of light that scientist have been able to construct optical instruments, which are designed to control light in very precise ways. Lenses, for example, are optical instruments that utilize a transparent medium, such as glass, in order to refract light in an exact way, so as to form an image. The shape of the lens and its refractive index govern the characteristics of the image that the lens will produce.

For this experiment study the image characteristics produced by a thin converging lens, making use of an optical rail system of components. The data collected will allow for the determination of the focal length for a lens and also the magnification of the image produced by that lens. The relationships between the object distance, image distance, and image size will also be examined.

The first half of the experiment focuses on the distance and size of the image produced by a lens (Lens 3) in relation to its position. The second portion of the lab focuses on conjugate positions. Conjugate positions occur when the object position and image position remain fixed. With the image and object fixed and stationary, there are two lens positions that will produce a sharply focused image. These two lens positions are conjugate positions.

In order to help speed up the completion of this lab, a review of any physics textbook's discussion/summary of the chapter dealing with refraction, images, lens and other optical instruments is strongly suggested. Be sure to pay careful attention to the ***Thin Lens Equation*** and the ***Magnification Equation***.

Apparatus:

- Laser & laser holder
- Two meter optical rail
- 2 fixed filter mounts
- 6 Optical rail carriers, optical post holders, and optical posts
- 1 10mm double convex (DCX) lens & lens holder
- 2 25mm double convex (DCX) lenses & lens holder
- Crossed arrow target object and diffuser

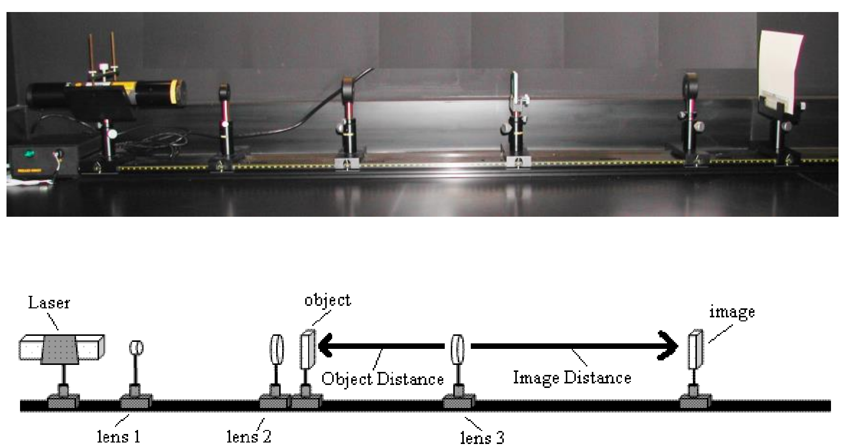

Figure 1

Before beginning, please see the laboratory personnel for instructions concerning the proper handling and care of the optical equipment. **Do not attempt to start this lab without checking with an instructor.**

Procedures:

Always wash hands before interacting with optics equipment. After having washed hands, verify that the equipment is set up the same as the diagram on the previous page. Also, be sure to check the positions of the Laser, Lens 1, Lens 2 and the Object, making sure that the positions are the same as those specified in Table 1 (posted on the wall above the equipment). It is not necessary to touch the Laser, Lens 1, Lens 2, or the Object at any point during the lab, unless the equipment is not set up to the specifications of Table 1. If needed, re-assemble the equipment so that it matches the diagram. Then ask a lab assistant to confirm that the setup is correct.

This lab experiment consists of two different sub-experiments: **Finding Image Positions** *&* **Finding Conjugate Positions**.

Finding Image Positions:

1. Move Lens 3 to the first position specified in Table 1.
2. Slowly move the image screen along the optical rail until the image of the target appears as sharply focused as possible.
3. Record the optical rail position of each optical component in the Data Table.
4. Use the millimeter scale on the image screen to estimate the size of the target circle's outside diameter (OD). This will be an approximate measurement. Record this measurement as the image size in the Data Table.
5. Repeat these steps for each Lens 3 position listed in Table 1.

Finding Conjugate Positions:

1. Move the image screen to the first position specified in Table 1. The object position will remain the same as before.
2. Slowly move Lens 3 along the optical rail until the image of the target appears as sharply focused as possible.
3. Record the optical rail position of each component and the approximate size of the image.
4. Without changing the position of the image screen, continue to slowly move Lens 3 further along the optical rail until the image again appears as sharply focused as possible, but at a different position from before.
5. Record all optical rail positions and the image size. The resulting image size for the second conjugate position will differ significantly from the image size of the first conjugate position.
6. Repeat these steps for the second image position listed in Table 1.

Experiment O9a: Table 1

Optical Component	Position (mm)
Laser	90.0
lens 1 *f* = +15.60 mm	235.0
lens 2 *f* = +400.0 mm	650.0
object (target size OD = 10.0 mm)	700.0
finding image positions	
lens 3 *f* = +150.0 mm	1250,1200, 1150,1100, 1050, 1000, 950, 940, 930,920, 910, 900, 890, 880
image	(Find for each the position where there is a sharp focus of the image.)
finding conjugate positions	
lens 3	(Find 2 positions that produce a sharp focus of the image for each image position.)
image	1325, 1450

Analysis:

First, it is necessary to calculate the object distance and image distance for all positions. Calculate the object distance and the image distance by making use of the positions of the Object, the Image, and Lens 3 recorded in the Data Table. The object distance and image distance should then be entered into the Analysis Table.

From these positions (object distance and image distance), it becomes possible to calculate the Focal length for Lens 3, by making use of the thin lens equation. Then calculate the magnitude of the magnification factor via the formula for magnification, using image distance and object distances. After calculating the magnification factor, calculate the theoretical image size by using the magnification factor and the object's original size.

Graph the image distance as a function of object distance. Also graph the image size as a function of object distance. It is recommended that MS Excel be used in order to create these two graphs. Include the appropriate asymptotes on each graph.

Experiment O9a: Thin Converging Lenses

Student Name____

*Lab Partner Name*____

*Lab Partner Name*____

Physics Course____

Physics Professor______________________________________

Experiment Start Date_________________________________

Lab Assistant Name	*Date*	*Time In*	*Time Out*

Experiment Stamped Completed

Data Sheets: O9a: Thin Converging Lenses

NAME: ___________________________ **DATE: ________________**

Laser position: ____________________
Lens 1 position: ___________________ ***f*** = _____________
Lens 2 position: ___________________ ***f*** = _____________
Lens 3 focal length: - - - - - - - - - - - - ***f*** = _____________
Object size: _______________________

Position (in mm)			Size (in mm)
Object	Lens 3	Image	Image (approx.)
Finding Image Positions:			
Finding Conjugate Positions:			

Analysis Sheets: O9a: Thin Converging Lenses

NAME: ______________________________ DATE: __________________

Distance (in mm)		Focal length	Magnification Factor	Image Size (in mm) (calculated)
Object	Image			
Finding Image Positions:				
Finding Conjugate Positions:				