Name________________________ Date______________

PHYS 1402 General Physics II

Geometrical Optics: Lenses

Equipment

Optics Bench
Light Source
Screen Plate
Dial Caliper
Convex Lens (+100mm)
Convex Lens(+200mm)
Concave Lens(-150mm)
Flashlight

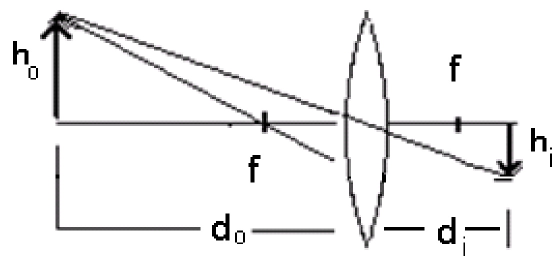

Figure 1 Real

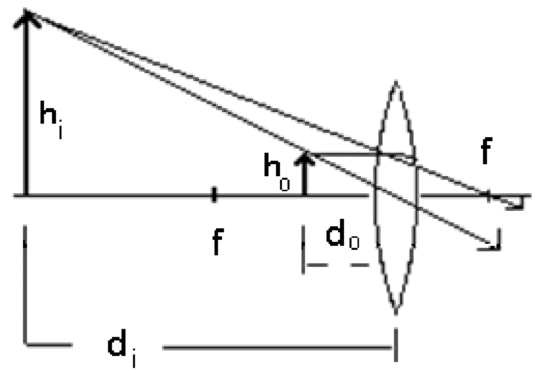

Figure 2 Virtual

Introduction

In this experiment you will work with various thin lenses. You will measure object distance, object size, image distance, and image sizes. Your results will be compared with theoretical calculations you will make using the lens equations.

Theory

A double convex (converging) lens produces a real or a virtual image from an object as shown in Figures 1 and 2 depending on whether the object distance is greater than or less than the focal length of the lens.

A double concave (diverging lens) produces a virtual image as in Figure 3.

Lens equations:

$$\frac{1}{d_0}+\frac{1}{d_i}=\frac{1}{f} \quad (1)$$

$$M=\frac{h_i}{h_0}=-\frac{d_i}{d_0} \quad (2)$$

$\mathbf{d_o}$ = object distance
$\mathbf{h_o}$ = object size
f = focal length
$\mathbf{d_i}$ = image distance
$\mathbf{h_i}$ = image size
M = magnification

Procedure

Find a focal length for each of the two converging (convex) lenses.

1. Mount one converging lens and the screen plate on the bench.
2. Aim the lens end of the optics bench out the window toward a streetlight or some other distant object (at infinite distance).
3. According to Equation (1), when an object is at infinite distance, $\mathbf{1/ d_o}$ = 0 and $\mathbf{d_i = f}$. Look at the screen and move the lens until a sharp image appears on the screen. It's easiest to hold the optics bench on your shoulder with your back to the window that way you can face the screen as you focus the image.
4. The image may be bright enough to see without turning off the room lights. Use the marks on the lens carrier to measure the focal length directly. This is your $\mathbf{f}_{measured}$.
5. Repeat 1 -4 for the second converging lens.

You are now ready to add the light source to the optics bench. Since the bench is marked like a meter stick, it helps to place the light source somewhere on the first half, with the lenses on the second half.

In the data tables that follow you will record the following four measurements for each of the two convex lenses:

1. Object distance
2. Image distance
3. Object height
4. Image height

Your four measurements will be taken in each of the following initial conditions:
1. Object distance greater than 2 times focal length
2. Object distance between 1 and 2 times focal length
3. Object distance less than 1 focal length

LENS 1	$\mathbf{f}_{measured}$	$\mathbf{d_o}$ (obj dst)	$\mathbf{d_i}$ (img dst)	$\mathbf{h_o}$ (obj ht)	$\mathbf{h_i}$ (img ht)	$\mathbf{f}_{calculated}$	**M**
$\mathbf{d_o > 2f}$							
$\mathbf{F< d_o <2f}$							
$\mathbf{d_o < f}$							

LENS 2	$\mathbf{f}_{measured}$	$\mathbf{d_o}$ (obj dst)	$\mathbf{d_i}$ (img dst)	$\mathbf{h_o}$ (obj ht)	$\mathbf{h_i}$ (img ht)	$\mathbf{f}_{calculated}$	**M**
$\mathbf{d_o > 2f}$							
$\mathbf{f< d_o <2f}$							
$\mathbf{d_o < f}$							

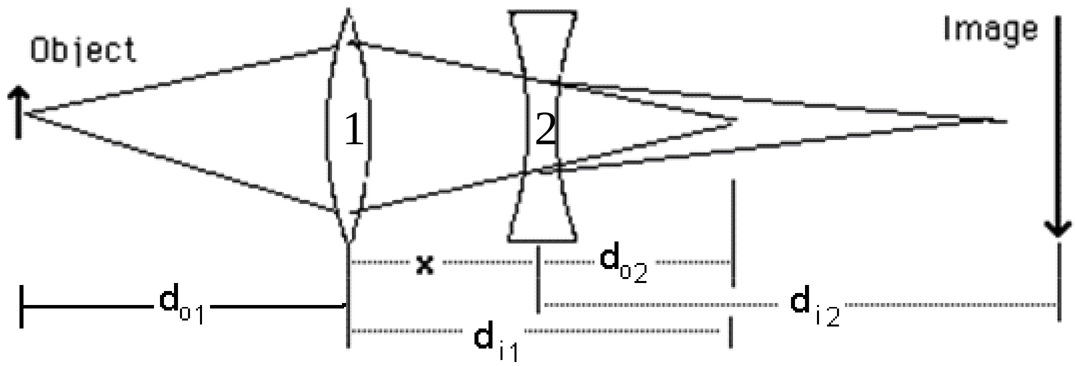

Figure 3 Finding the focal length of a diverging lens.

Diverging Lens Instructions
With a converging lens as far as possible from the object, project an image onto the screen. Record the object distance (**d_{o1}**) and image distance (**d_{i1}**). Insert a diverging lens between this image and the lens. The diverging lens will be inside the focal length of the converging lens and will use the Image from lens 1 as its Object. Do not move lens 1 but do move lens 2 (diverging) and the screen so as to form a new real image as in Figure 3. This is image distance **d_{i2}**.

Record the diverging lens distance (**x**) from the converging lens. Subtract **x** from **d_{i1}** (or measure directly using these two points on the optics bench scale) and record as **d_{o2}**. The object distance will be negative. The image distance of the combination is **d_{i2}**.

Diverging Lens					
d_{o1}	**d_{i1}**	**d_{i2}**	**x**	**d_{o2}**	**$f_{calculated}$**

Calculate **f** for the diverging lens using:

$$\frac{1}{f} = \frac{1}{d_{o2}} + \frac{1}{d_{i2}}$$