Diverging Lens

Purpose:

To locate the virtual image produced by a diverging lens with the help of a converging lens. We will investigate the validity of the lens equation for diverging lens.

Equipment needed:

-Optics Bench
-75 mm Focal Length Convex Lens
-Crossed Arrow Target
-Viewing Screen.
-Light Source
-150mm Focal Length Concave Lens
-Component Holders (3)

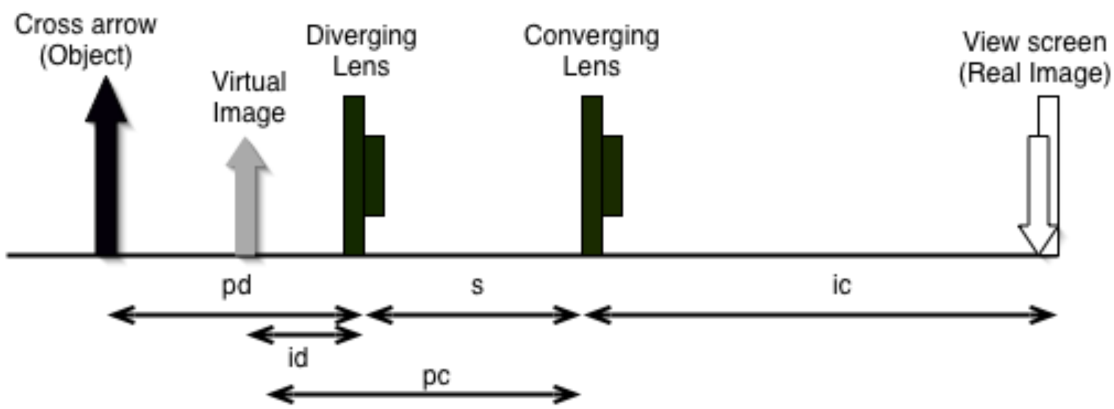

Figure 1

Notation:

id: image distance of the diverging lens
pd: object distance of the diverging lens
fd: focal length of the diverging lens
s: separation between the two lenses
ic: image distance of the converging lens
pc: object distance of the converging lens
fc: focal length of the converging lens

Introduction

We learned in class that diverging lens forms only virtual image on the same side of the lens as the object. We also learned that both the converging lens and diverging lens obey the lens equation. Recall that a converging lens has positive focal length while a diverging lens has negative focal length. The lens equation is given by:

$$\frac{1}{i} + \frac{1}{p} = \frac{1}{f}$$

How can we confirm experimentally that the virtual image produced by a diverging lens indeed obey the lens equation? We certainly cannot use the view screen to locate the image because a virtual image will not project on a screen. We need a trick.

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In this experiment we will use a converging lens to track down the position of the virtual image produced by a diverging lens. Basically, the converging lens can converge the light from the virtual image (as if it is an actual object) and project it on a screen. Then from the image distance of the converging lens, we can use the lens equation[1] to deduce where the virtual image is.

Equations:

Here is how you can find the image distance of the virtual image:

Step (i): $\frac{1}{ic} + \frac{1}{pc} = \frac{1}{fc} \Rightarrow \frac{1}{pc} = \frac{1}{fc} - \frac{1}{ic} \Rightarrow$ From this you can calculate pc

Step (ii): $|id| + s = pc \Rightarrow |id| = pc - s \Rightarrow$ From this you can find $|id|$

Note that id is negative for the virtual image, so you should put $id = -|id|$

Step (iii): You can now compare id above with the prediction of the lens equation:

$$\frac{1}{id} = \frac{1}{fd} - \frac{1}{pd} \Rightarrow id = \left(\frac{1}{fd} - \frac{1}{pd}\right)^{-1}$$

Procedure:

1. Set up the equipment as shown in Figure 1 *without the diverging lens*. Turn on the light source and slide the lens toward or away from the crossed arrow, as needed to focus the image of the cross arrow onto the view screen.
2. Now put the diverging lens in place (anywhere between the cross arrow and the converging lens). The image on the screen should now be out of focus.
3. Move the screen so that the image is focused again. Do you have to move the screen towards or away from the light source in order to find a clear image? Use the lens equation to explain why.

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4. Without moving the diverging lens, measure pd, ic and s.
5. Follow Step (i) and Step (ii) in the calculation section to use fc, ic and s to calculate id and record your result in Table 1.
6. Without moving the diverging lens, move the converging lens and the view screen to get a second (and different) reading of ic and s, repeat step 5 to calculate id again.
7. Average the previous two results for id from step 5 and step 6 to get $\langle id \rangle$ and compare it with the calculation using the lens equation as shown in Step (iii).
8. Repeat steps 3 to 7 for five different positions of the diverging lens to complete Table 1.

[1] We have already verified the lens equation for the converging lens last week.

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Data:

Table 1

<table>
<tr><th>pd</th><th>s</th><th>ic</th><th>pc</th><th>id</th><th>$\langle id \rangle$</th><th>$\left(\frac{1}{fd}-\frac{1}{pd}\right)^{-1}$</th><th>Percentage difference</th></tr>
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All lengths above are measured in *mm*.

fd =______________ fc =______________