THIN LENSES

OBJECTIVE

To verify the thin lens equation, $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$, and the magnification equations $m = h_i/h_o = -d_i/d_o$.

THEORY

In the above equations, d_o is the distance between the object and the center of the lens, d_i is the distance between the image and the center of the lens, h_o is the object height, h_i is the image height, and f is the focal length of the lens.

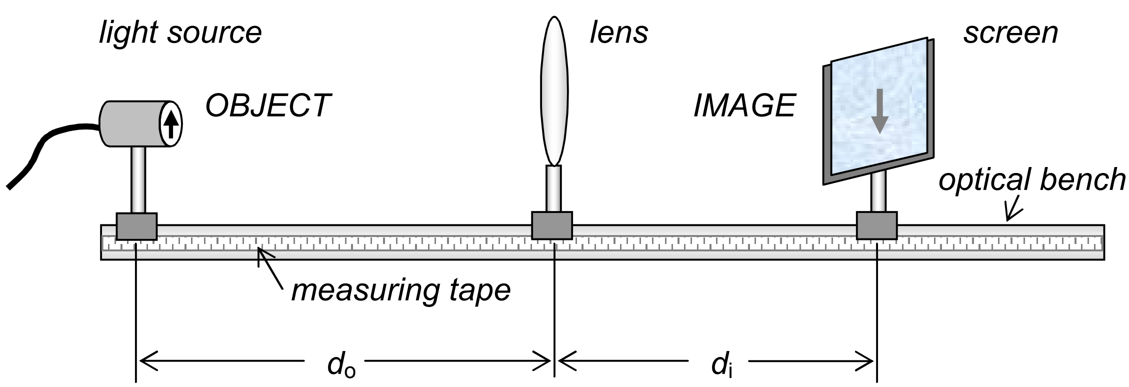
EQUIPMENT

Optical bench, convex lens, concave lens, lens holder, light source ("the object"), smoked glass screen, pointers for virtual image determination, plane mirror, mirror holder

SET-UP AND PROCEDURE

PART I – Estimate Focal Length of Convex Lens

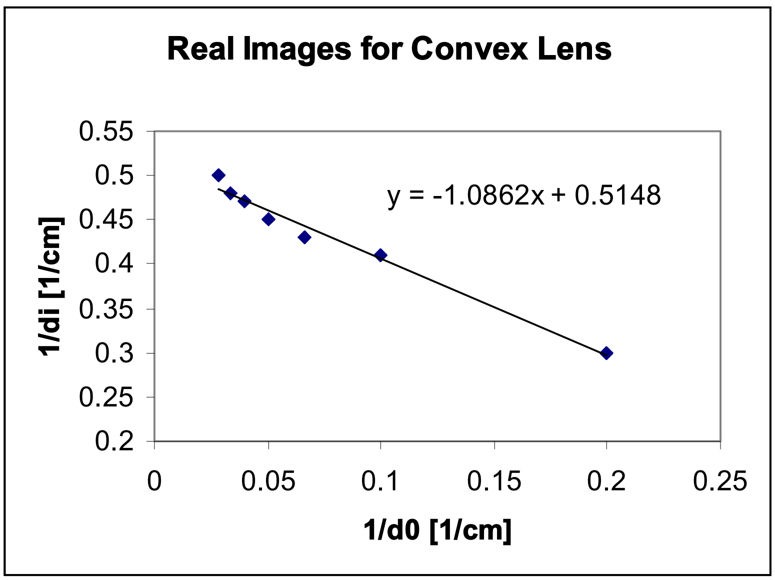
1) Mount your light source to the optical bench and plug it in. Move your lens as far as possible from the source.
2) Place the screen on the opposite side of the lens and move it until you see a clear image of the arrow.
3) While holding the lens and screen stationary, measure the distance between the two. This is your best estimate of the focal length. Record your answer on your data sheet.



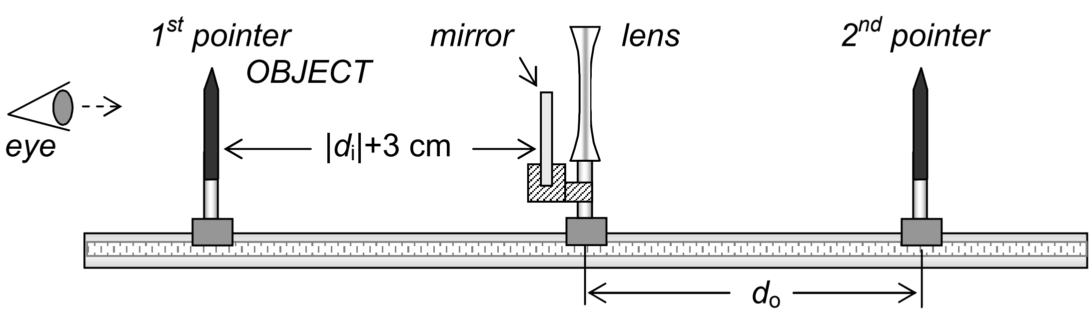
PART II – Real Images with Convex Lens

1) Assemble your apparatus as shown above. The light source should be placed at the end of the optical bench. Measure the height h_o of the object (i.e. the length of the arrow) imprinted on the light source and record it on your data sheet.
2) Place the convex lens at least two focal lengths away from the object (i.e. $d_o > 2f$).

3) Adjust the position of the screen until you get a sharp inverted image. Measure the height h_i of the image (i.e. the length of the arrow) and its distance d_i from the lens.
4) Calculate the magnification in two ways using $m_h = h_i/h_o$ (experimental) and $m_d = -d_i/d_o$ (theoretical). Find the percent error.
5) Repeat Steps 2 – 4 for six different object distances $d_O > f$.
6) Use Excel to plot your data. Let the horizontal (x) coordinate be $1/d_o$ and let the vertical (y) coordinate be $1/d_i$. Add a trend line and record its slope and vertical (y) intercept on your data sheet. The theory predicts a slope of –1 and a vertical intercept $1/f$. Compute the percent errors.
7) Print out your graph. It must have a title, a label for each axis, and the equation for the trend line. A good example is shown below.



PART III – Virtual Images with Concave Lens



1) Remove the light source and the screen from the optical bench. Position the concave lens at the center of the bench (see diagram above).
2) Record the focal length printed on the lens box. If the box is not available, ask your lab instructor for this value.
3) Place the first pointer beyond one focal length of the convex lens ($d_o > f$). Record d_o on your data sheet.

4) Position your eye as shown in the diagram to see the virtual image of the first pointer in the mirror.
5) Move the second pointer to a position behind the mirror such that, *when you move your eye from side to side, the first pointer, the image in the mirror, and the second pointer always remain aligned*. (This is the *parallax* technique.) Measure the distance between the second pointer and the mirror which equals $|d_i| + 3$ cm. Record $d_i = -|d_i|$ on your data sheet.
6) Repeat Steps 2 – 4 for three different object distances $d_o < f$. Note that this data set will be less accurate than the real image set. You do not have to measure the object and image heights.
7) Use Excel to plot your data. Let the horizontal (*x*) coordinate be $1/d_o$ and let the vertical (*y*) coordinate be $1/d_i$. Add a trend line and record its slope and vertical (*y*) intercept on your data sheet. The theory predicts a slope of –1 and a vertical intercept $1/f$. Compute the percent errors.
8) Print out your graph. It must have a title, a label for each axis, and the equation for the trend line.

ASSIGNMENT: due by the end of the lab period
Each group must submit a completed data sheet with the two graphs stapled to it.

Name ______________________________ **Date** __________

Partners ____

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THIN LENSES DATA SHEET

PART I – Estimate Focal Length

Focal length = ____________________ cm

PART II – Real Images with Convex Lens

Height of object h_o = ____________________ cm

Focal length of lens f = ____________________ cm

d_o [cm]	d_i [cm]	h_i [cm]	$m_h = h_i/h_o$ *experimental*	$m_d = -d_i/d_o$ *theoretical*	% error

$$\% \text{ error} = \frac{|experimental - theoretical|}{theoretical} \times 100$$

From Excel equation of trend line:

	theoretical	experimental	% error
Slope	– 1		
Vertical Intercept	$^1/f$ =		

PART III – Virtual Images with Concave Lens

Focal length from lens box f = – ____________________ . (theoretical value)

d_o [cm]	d_i [cm]

From Excel equation of trend line:

	theoretical	experimental	% error
Slope	– 1		
Vertical Intercept	$^1/f$ =		

QUESTIONS

1) Why is the distance between the mirror and the first pointer equal to $|d_i|$ + 3 cm instead of simply d_i?

2) Can a convex lens produce a virtual, reduced image? (Yes/No) Explain your answer.