Thin Lenses

Name_____ ID_____ TA_____

Partners_____

Date_____ Section_____

The object lamp might be hot. Exercise caution while using the lamp.

1. Finding the focal length of a converging lens:

The uncertainties for the focal length are given by:

Δ = |Max. focal length – Min. focal length| ÷ 2.

f = [Focal length (max.) +Focal length (min.)] ÷ 2 ⇐Average

Object distance d_o	Image distance (max.) $d_i + \Delta'$	Image distance (min.) $d_i - \Delta'$	Focal length (max.)	Focal length (min.)	Focal length $f \pm \Delta$
					±
					±
					±

2. Characteristics of real images formed by a converging lens:

Using a converging lens, measure different object distances that produce real images. In addition, measure the image magnification. (You should use the same unit!)

Object distance d_o	Image distance d_i	Object height h_o	Image height h_i (Multiply by – if the image is inverted.)	Magnification $M = h_i / h_o$ (direct)	$M = -d_i / d_o$ (distance ratio)

3. Finding the focal length of a diverging lens:

➢ Only the converging lens first *(Make a small image)*

Object distance d_{o1}: _____ Image distance d_{i1}: _____

❖ Magnification of the converging lens only

Direct measurement→ $M_1 = \frac{\text{Image}}{\text{object}}$ _____ (If the image is inverted, h_o will be negative.)

Distance ratio→ $-d_{i1}/d_{o1}$: _____

➢ After insert a diverging lens

Lens separation r :_____ Object distance $d_{o2} = r - d_{i1}$ _____

Image distance d_{i2} :_____

Focal length of diverging lens, $f = d_{o2}d_{i2}/(d_{o2} + d_{i2})$:_____(≈-15.0 cm)

❖Magnification of the diverging lens

$M_2 = -d_{i2}/d_{o2}$:_____ (only from the distance ratio)

❖The total magnification

Direct measurement→ $M = \frac{\text{Image}}{\text{object}}$ _____

Distance ratio→ $(d_{i1}/d_{o1})(d_{i2}/d_{o2})$: _____

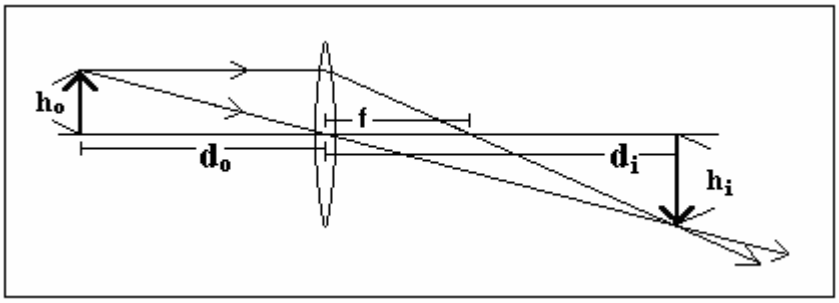
Questions:

- Does the experimental result of focal lengths for converging lens correspond to the value indicated on the lens within the uncertainty? (1 cm = 10 mm)
- For the second part, are the measurements of magnifications consistent between the direct measurement and the distance ratio?
- Did you get the experimental focal length for the diverging lens close to the indicated one?
- For the third part, is the measurement of magnification consistent? (The direct measurements and distance ratios are supposed to be the same.)

Lab Procedure for Thin Lenses

Please don't mix up the units. (1 cm = 10 mm)

1. **Finding the focal length of a converging lens**



- **Choose a place to put the converging lens.**
  The provided convex (converging) lens will be inserted between the light source (object) and screen.

- **By moving the screen, focus the image.**
  The object will be "circles and arrows" provided on the light source.

- **You will find a tolerance to focus the image by changing the place of screen slightly. Obtain the minimum and maximum image distances.**

- **After obtaining the image and object distances, calculate the focal length with the thin lens equation, and the uncertainty.**
  Thin lens equation: $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$. Maximum focal length: $f_{\max} = \frac{d_o \cdot (d_i + \Delta')}{d_o + (d_i + \Delta')}$, and

  Minimum focal length: $f_{\min} = \frac{d_o \cdot (d_i - \Delta')}{d_o + (d_i - \Delta')}$.

- **Repeat the above two more times.**

2. **Characteristics of real images formed by a converging lens**

- **Use only the converging lens.**

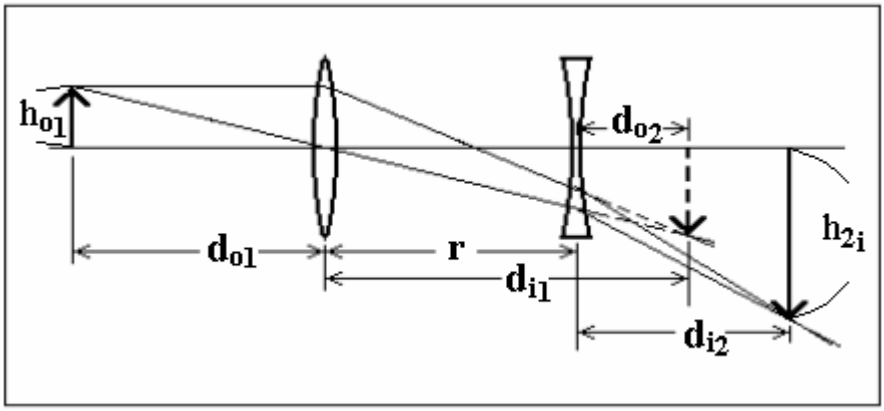
- **This time you will choose any location for 3 time measurements. But the purpose is to measure the magnifications of the screened images.**

- **After focusing the image, measure the diameter of the circle as the object, and the same circle on the screen as the image.**
  The diameter of the image ÷ the diameter of the object is the magnification.

- **At the same time, measure the object and image distances, and calculate the ratio.**
  This result is also the value of the magnification. You will compare this with the above result.

- **Repeat this 2 more times, but in different locations.**

3. **<u>Finding the focal length of a diverging lens</u>**



- **First focus an image only with the converging (convex) lens.**
  Write down the object and image distances. Also measure the magnification.

- **Insert the diverging (concave) lens between the convex lens and screen.**
  The separation between two lenses shouldn't be large. That makes the result inaccurate.

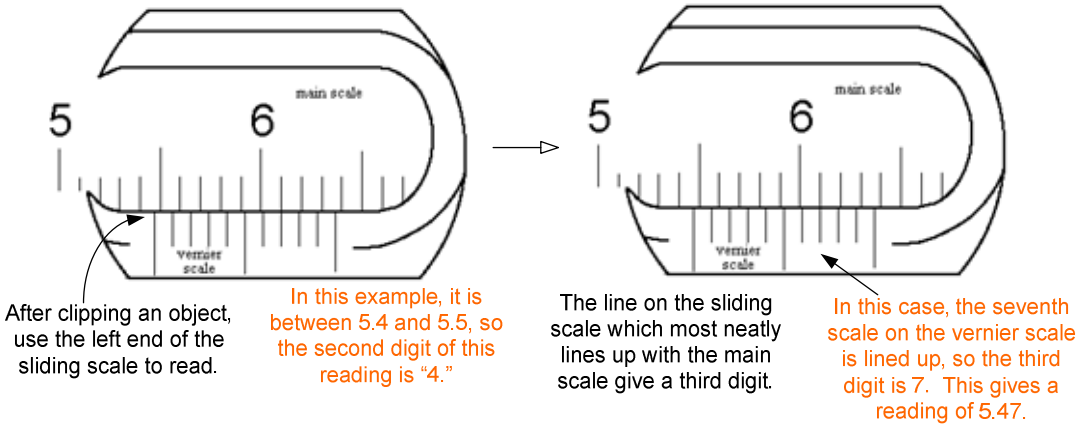
- **By adjusting the screen, focus the image.**
  You can just follow the data sheet to write down the measurements.

  - **To confirm the results, calculate the focal length of the diverging (concave) lens and the total magnification.**

4. **<u>Lab report</u>:** For your discussion, please answer the questions on the data sheet.

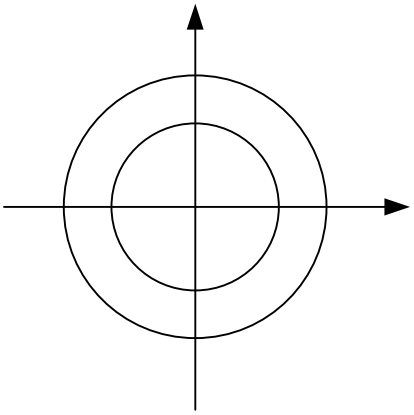
References

- How to use a caliper



- How to find the object height

On the light source, you find circles and arrows.



You can measure either the length of an arrow or the diameter of a circle as follows.