Geometrical Optics

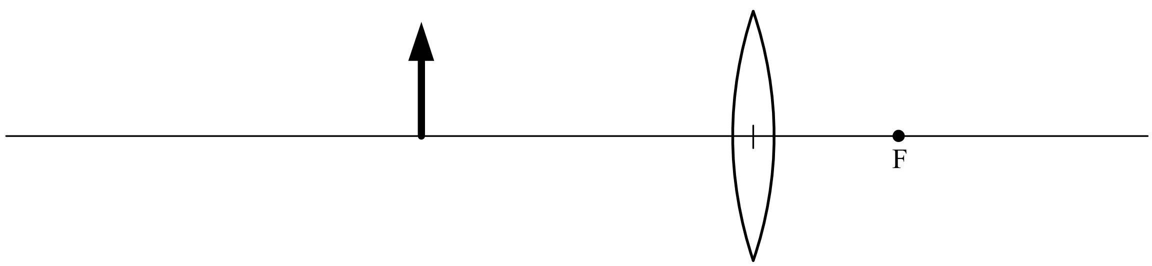
Name________________________________ ID________________________ TA________________

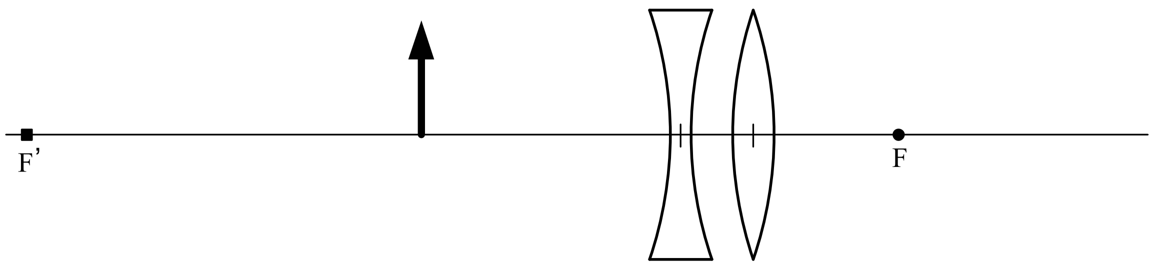
Partners____

Date______________________________________ Section____________________________________

Please do not scratch, polish or touch the surface of the mirror.

1. **Application of geometrical optics:**





2. **Real and virtual images:**

One easy method to find out whether the image is real or virtual is to find out whether you can obtain the image on a screen or not. If you have the image on the screen, it is called the real image. The virtual images cannot be seen on a screen. ***For this experiment, please answer following questions, and then show images to your TA.***

☑ **Convex mirror**
What images do you obtain, real or virtual, or both images? Describe how those look like.
(You are supposed to see only virtual images in the mirror. Make sure that you will not see any image on a screen, which is the real image.)

☑ **Concave mirror**
What images do you obtain, real or virtual, or both images? Describe how those look like.
(You will see both real and virtual images. Change the distance and use your hand as a screen. You will also see a virtual image in the mirror.)

☑ **Convex lens**
What images do you obtain, real or virtual, or both images? Describe how those look like.
(You will see both real and virtual images. Use a light source to see a real image. Look a magnified image through the lens, which is the virtual image.)

☑ **Concave lens**
What images do you obtain, real or virtual, or both images? Describe how those look like.
(You are supposed to see only virtual images. Look something through the lens. Make sure that you will not obtain any images on a screen.)

(Hereafter, please measure the maximum and minimum quantities and extract the uncertainty.)

3. The verification of the basic optics equations:

☑ **Plane mirrors (The law of reflection)**

	Angle of Incidence, θ_i	**Angle of Reflection, θ_r**
1	$\pm$	$\pm$
2	$\pm$	$\pm$

Are angles of incidence and reflection close each other?

☑ **Concave mirrors**

Focal length, f	**Radius of curvature using compass, R**

Does the equation $R=2f$ hold from your experiment?

How about a convex mirror? How do you obtain the focal length?

☑ **Snell's law**

Angle of Incidence ($\theta_i \pm \Delta\theta_i$)	**Angle of Refraction** ($\theta_t \pm \Delta\theta_t$)	**Index of Refraction** ($n \pm \Delta n$) For the rhombus

Is the index of refraction for the rhombus close to 1.5?

☑ **Convex lens**

	The distance between lens and light source	**Focal length of the convex lens** $(f \pm \Delta f)$
1		
2		

Does the focal length depend on the distance between lens and light source?

Design an experiment where you obtain the focal length of concave lens.

Lab Procedure for Geometrical Optics

Record your data in the data sheet and draw the tracing of light rays neatly so that you can explain them to your TA.

1. **Application of geometrical optics**

- **The TA will show you how to draw the light-ray lines. Then you will apply it to the pictures on the data sheet.**
  The purpose of this lab is to teach you an application of lenses. This is how a lens for nearsightedness works.

- **For people who like a challenge, you can think about the case for farsightedness.**
  For this, you have to use a convex lens.

2. **Real and virtual images**

- **Take the light source and mirrors and lenses.**

- **Use a screen to project the images.**
  Follow the data sheet. Using trial and error, find if the image is a real or virtual image.

3. **The verification of the basic optics equations**

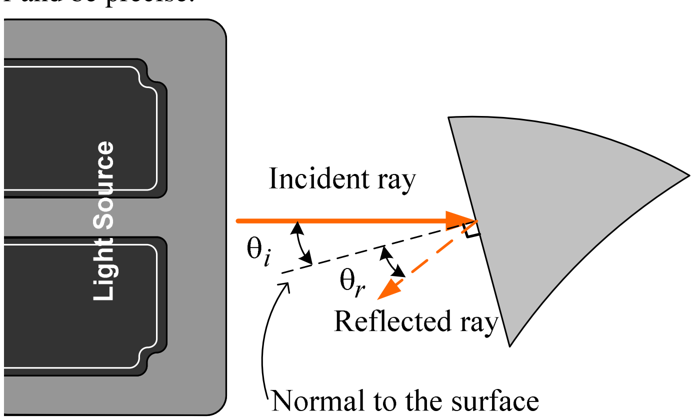
Plane mirrors (The law of reflection)

- **Place the ray box, label side up, on a white sheet of paper on the table shown below. Adjust the slit so one white ray is coming.**

- **Use the plane surface of the mirror.**
  Make an angle as shown below so that both the incident and reflected rays are seen.

- **Mark the position of the surface of the plane mirror. Trace the incident and reflected rays with arrows indicating the incoming and outgoing rays.**

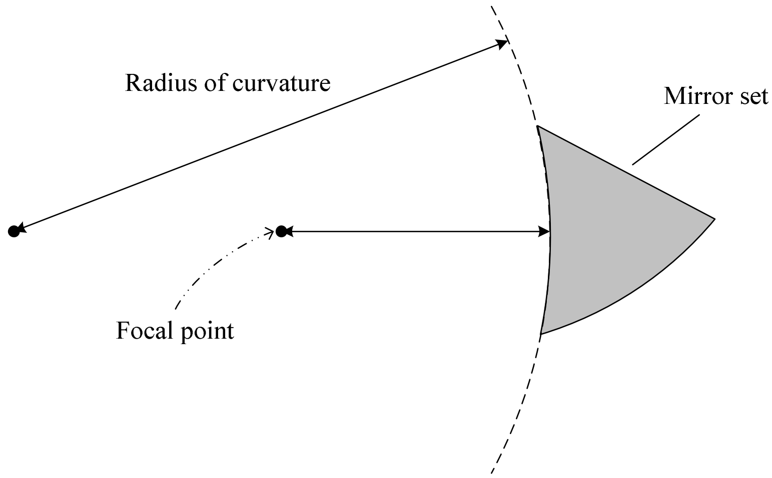
- **On the paper, draw the normal to the surface as shown below.**
  Use a protractor and be precise.



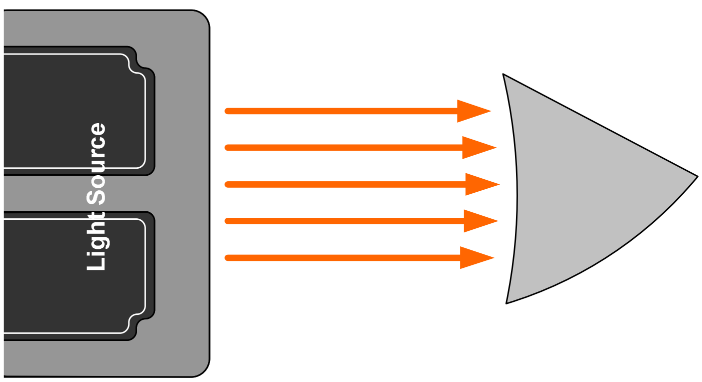
- **Measure the angle of incidence (θ_i) and the angle of reflection (θ_r).**
  Both of these angles must be measured from the normal of the surface.

Concave mirrors

- **The following figure explains a property of concave mirrors. The mirror focuses the incoming parallel rays of at the focal point. The focal length denoted as ‘f’ is one half of the radius of curvature of the mirror.**



- **Use five white rays from the ray box by adjusting the slit. Shine the rays straight into the concave mirror as shown.**
  Draw the surface of the mirror and trace the incident and reflected rays with arrows (to show the appropriate directions.)

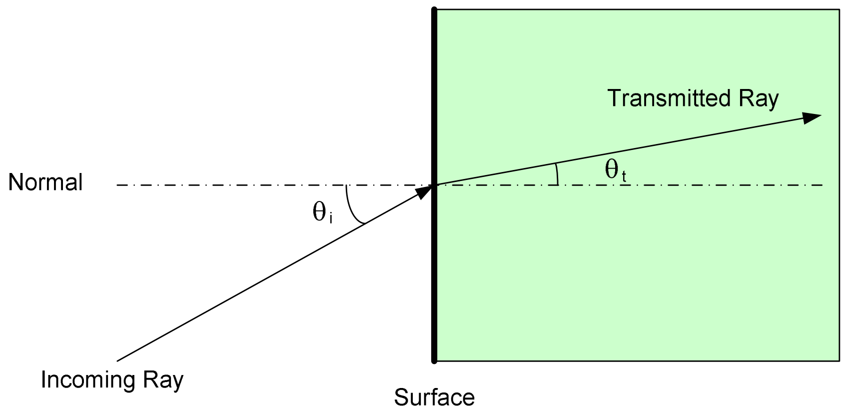


- **The place where the reflected rays cross each other is the focal point of the mirror. Measure the focal length, which is from the center of mirror’s surface to the focal point.**

- **Use the compass to draw a circle that matches the curvature of the mirror. Measure the radius of the curvature using a ruler.**

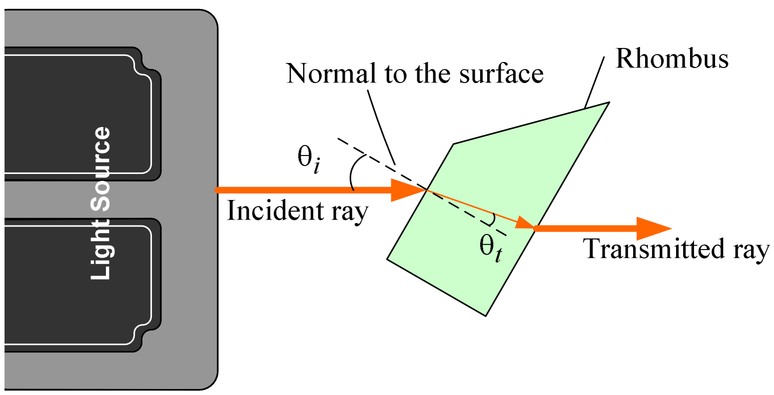
Snell's Law

- **For Snell's law, use the formula, $n_1 \sin\theta_i = n_2 \sin\theta_t$, where n is the index of refraction and the θ_i and θ_t are the correspondent angles.**



- **Place the ray box, label side up, on a white sheet of paper on the table. Use only one white ray by sliding the ray mask.**

- **Place the rhombus on the paper and position it so the ray passes through the parallel sides as shown below.**



- **Mark the position of the parallel surfaces of the rhombus and trace the incident and transmitted rays with arrows in the appropriate directions.**

- **Mark carefully where the ray enters and leaves the rhombus.**
  This is very important because the transmitted ray cannot be seen.

- **Remove the rhombus and on the paper draw a line connecting the points where the ray entered and left the rhombus.**
  Simulate this in your mind to avoid a carefree mistake.

- **At the point where the ray enters the rhombus, draw the normal of the surface.**

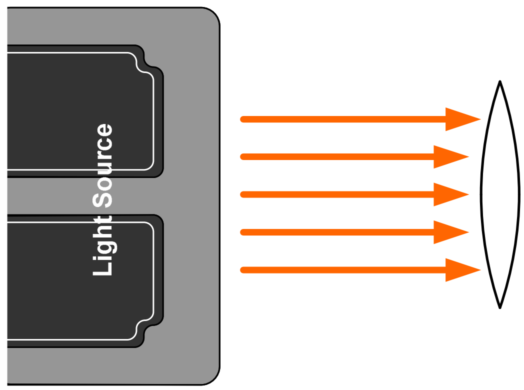
- **Measure the angle of incidence θ_i and angle of refraction θ_t with a protractor. Both of these angles must be measured from <u>the normal line</u>. Determine the uncertainties for the measurement.**

- **Calculate the index of refraction for the rhombus by using the given equation. It should be close to 1.5.**
  The rhombus is made of Acrylic which has an index of refraction of 1.497.

Reference: for light of wavelength 486 nm in a vacuum (blue), 1.491 for wavelength 589 nm (green), and 1.489 for wavelength 651 nm (red). Notice that in general for visible light, the index of refraction for Acrylic becomes larger with increasing frequency.

<u>Convex lens</u>

- **Place the ray box on a white paper. Using the five white rays from the ray box, shine the rays straight into the convex lens.**



- **Trace around the surface of the lens and trace the incident and transmitted rays.**

- **With the lens removed, mark the center of the lens.**

- **Find the focal point of the lens.**
  You may see the fuzzy interval around where the focal point should be. Mark the boundaries of this interval to set your limits on the uncertainty and take the center of the interval to be your focal point.

- **Measure the focal length, which is from <u>the center of the lens</u> to the focal point. Don't forget to determine its uncertainty.**

- **Choose a new distance and repeat the above step to see if the focal length changes.**