Physics Van Activity

Name: *SAMPLE* Date: ____________

V2.1

# Geometric Optics: Lenses

## Warm-up Activity

A. Obtain a ray box and a set of mirrors and lenses. Place the black mask at the front of the ray box so that a single ray emerges from the ray box.

   Describe the path of the light after it emerges from the ray box.

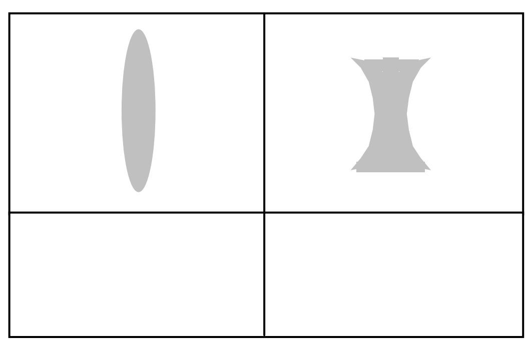
   Place different objects from the mirrors/lenses box in the path of the ray. For each object in the box, briefly describe what happens to the ray when it comes in contact with the object.

      Each object in the set can be classified as either a mirror or a lens.

      Describe what a mirror does to the light.

      Describe what a lens does to the light.

   In this activity we will focus on the properties of lenses. Reorient the mask on the ray box so that five rays emerge. In your set you will find a double convex lens and a double concave lenses (shown at right). The convex lens is called a converging lens while the concave lens is called a diverging lens. Determine which lens is which and label the lenses in the figure. (Hint: the terms converging and diverging should help.)



Call your instructor over and explain the labels you have used for the lenses.

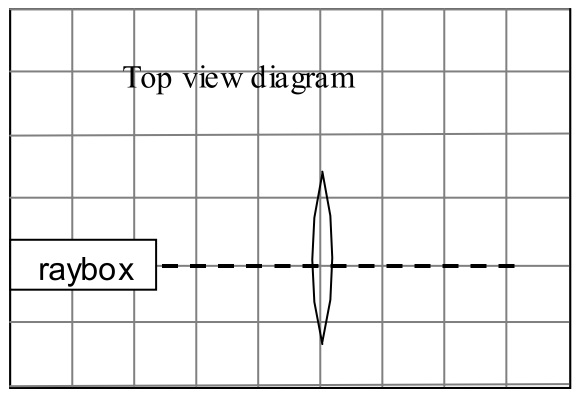
Adjust your ray box, by pulling on the end, so that the rays leaving the box are all parallel. .Ask your instructor if you need assistance with this.

Explain how you can tell whether the rays are parallel.

### The Convex Lens

In this part of the activity we will investigate some of the properties of the convex lens. Obtain a **circular convex** lens from your instructor.

A. Place the circular convex lens in front of the 5 parallel rays and trace the path the light takes on a sheet of graph paper. (You may want to raise the ray box and the sheet of graph paper so that the light strikes the middle of the lens and you can observe the light after it passes through the lens.) Sketch the path on the top view diagram shown at right.




B. The point at which the parallel rays intersect the principle axis is called the *focal point* of the lens.

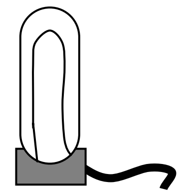
Mark the focal point of the lens on your graph paper with an X.

Try moving the ray box forward (still keeping it horizontal). Does the point at which the rays intersect the principle axis change?

The *focal length* of the lens is the distance from the center of the lens to the focal point. Determine the focal length of your lens and record the number below. Share your result for the focal length with your instructor.

**Image of the Filament Bulb**

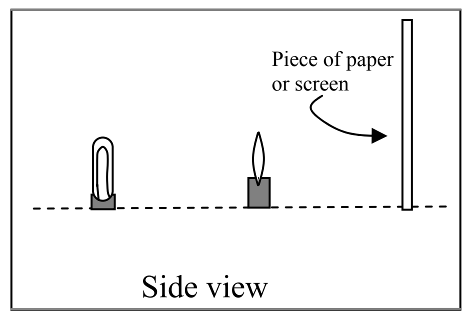
A. Obtain a long filament bulb. How is the light from this bulb different from the light from the raybox?



Place the long filament bulb in front of a lens as shown in the figure below right. In this experiment place the lens in the wooden lens holder.

B. Hold a piece of paper at different distances behind the lens and find the location of a sharp image of the long filament bulb.

Is the image of the bulb upright or inverted (consider top-bottom and left-right)?




What happens when you move the paper closer to the lens?

What happens when you move the paper farther from the lens?

Place the long filament bulb farther from the lens. Find the position where the screen will have to be placed so that a sharp image is formed.

**Coming up with a Rule**

We call the distance from the lens to the object (the long filament bulb) the object distance ($d_o$), and the distance from the lens to the image the image distance ($d_i$).

A. Place the object (the long filament bulb) at number of different positions. At each of these positions find the image distance by finding the position the paper would have to be placed so that a clear image is formed. Record your data in the space provided. (Recall that you have found the focal length for the bulb in first experiment.

| ***Object distance*** | ***Image Distance*** | ***Focal Length*** |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

B. Using your data above find the following quantities.

| $1 / d_o$ | $1 / d_i$ | $1 / f$ |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

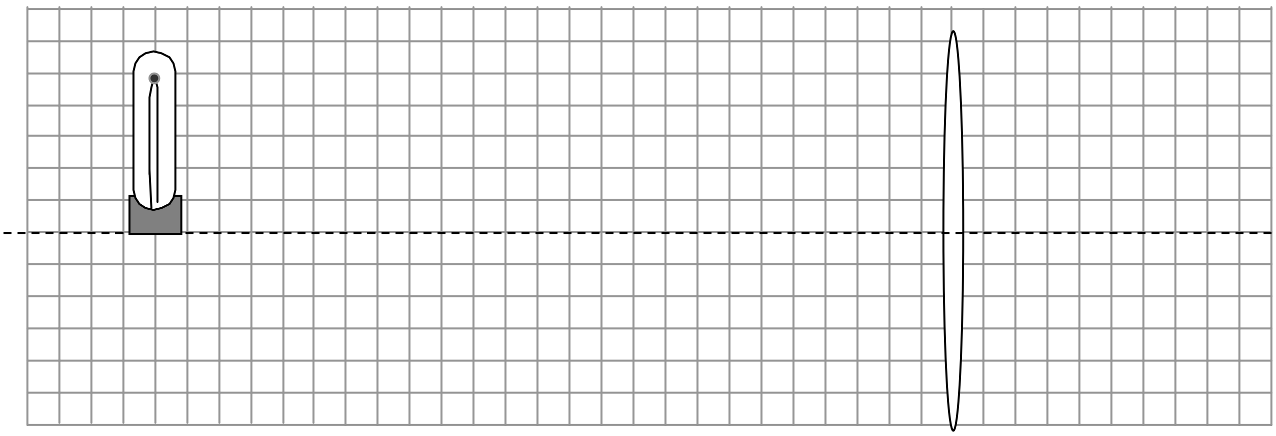
C. Do you notice a pattern based on your data in the table above? If so write out an equation relating $d_o$, $d_i$, and $f$. Hint: Look for patterns in the columns and across the rows.

Once you have an equation discuss the equation with your instructor. We call the equation relating $d_o$, $d_i$, and $f$ the *lens equation.*

**Principle Rays**

In order to predict the location of an image we can draw rays from the object to the screen using the path the light takes. In this exercise we will develop a model for the path of the light.

In the figure below, a scale diagram is shown with long filament bulb, a lens (with a focal length of 15 cm), and a screen. Each square in the grid represents 3 cm X 3 cm.



Place an **X** on both sides of the lens indicating the position of the focal point.

We will consider light from the top of the long filament (the point is shown on the diagram.) We know that light will travel in all directions from each point on the long filament but for our model we will first consider three of those rays called the *principle rays*.

Sketch the principle rays using the following rules (be sure to use a ruler):

*(Recall that light bends when it strikes the lens. For simplicity in our drawings we can bend all of the rays at the middle of the lens.)*

**Ray 1** *is drawn from the object (the top part of the filament) to the lens along a line parallel to the principle axis. At the middle of the lens this ray bends and travels in a straight path through the focal point.*

***Ray 2*** is drawn from the object through the focal point to the lens. This ray bends at the middle of the lens and continues along a straight path along a line parallel to the principle axis.

***Ray 3*** is drawn from the object along a line through the center of the lens and does not bend.

You should notice that all three rays meet in one location on the right side of the lens. This is the location of the image for the top part of our filament. To find out where the image for the middle of the filament would be you would apply the same technique. Do this using the middle of the filament.

Using the diagram above determine the distance from the lens to the image. Check your answer using the equation you have discovered. Were the two methods consistent with one another?

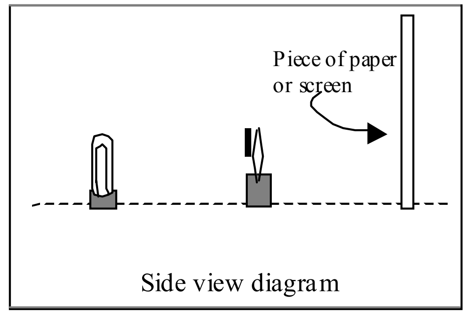
The Principle rays are the easiest to draw, but as we stated earlier there are rays traveling out in all directions from the bulb. Sketch more rays from the top part of the filament to the screen. (Hint: We know all light that passes through the lens from the top part of the filament must meet at the location of the top part of the image.

**Applying your ray model**

Use the ray model of light to answer the following questions. In each case first make a prediction and see if all group members agree. Try to account for your observations using the ray model of light.

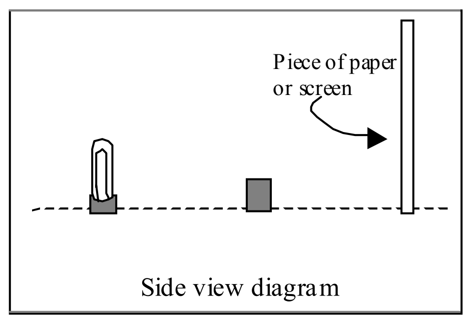
Predict how the image would change, if at all, if a piece of cardboard is placed so that it covers half the lens.

Test your prediction.



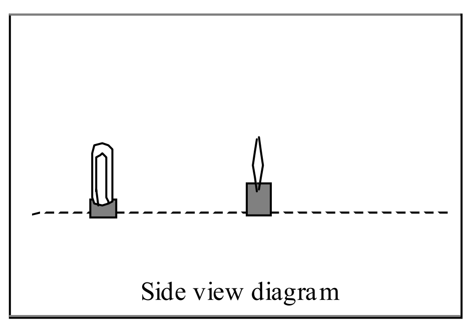

Predict how the image would change, if at all, if the lens were removed?

Test your prediction.




Predict how the image would change, if at all, if the screen were removed?

Test your prediction.



**Equipment**

# per group

Ray box with mask of different slits (1)
Set of mirrors/lenses for the ray box (1)
Double convex lens (1)
Plastic lens holders (1)
Wooden lens holder (1)
Whiteboard (large) (1)
Metersticks (1)
Long filament bulbs and sockets (1)
Graph paper (2)