Student Name: ______________________________ Date: _______________

Activity 1

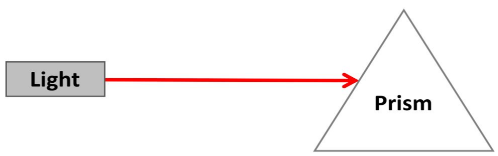
Prisms vs. Lenses

Aim:
Understand how light behaves when crossing from one material to another. Compare the effects of light traveling through a prism and lens.

Materials:			
Laser	Flashlight	Prism	Convex Lens

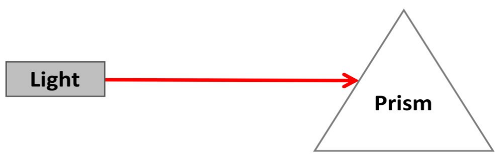
Prediction: What do you think happens when light travels from one material, like air, into another, like glass, plastic, or water?

Draw a line to **predict** the direction of the light coming out of the prism.

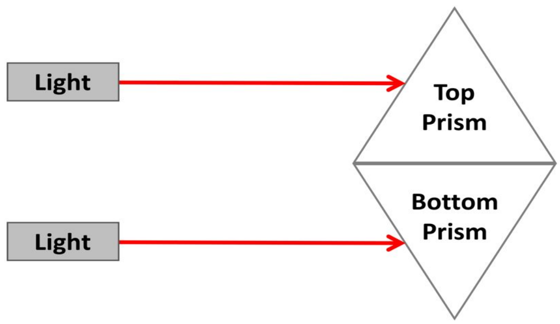


Why do you think this will happen?

Experiment: Set the prism near the edge of a table pointing it towards a wall or hold a piece of paper in front of it so you will be able to see where the light goes. Shine the light straight through the prism and **draw** on the diagram where the light goes.

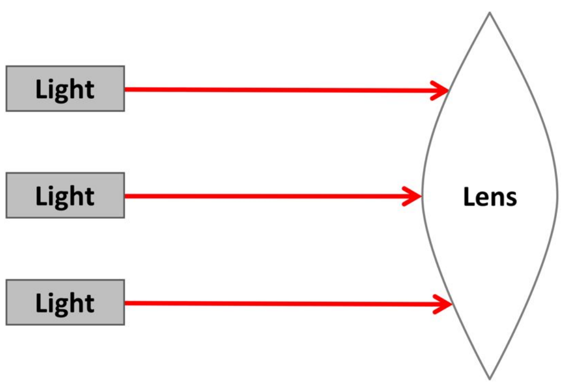


Prediction: Based on your previous observations, **draw** what you would happen to light going through two prisms stuck together, one right-side up and one upside down



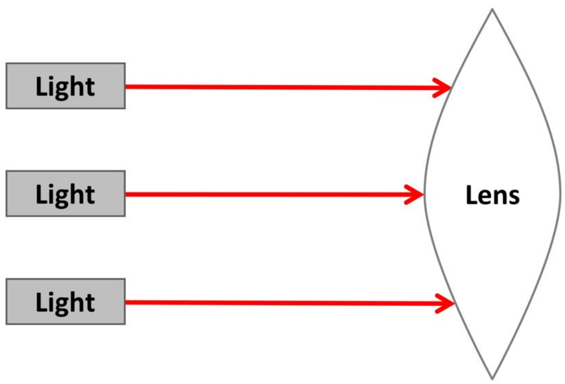
Prediction: A lens is a curved piece of material designed to bend light in a specific way. The shape of a lens called a "convex" lens resembles two prisms stuck together, but is curved smoothly. Make one final prediction and **draw** what you think should happen to the three light rays traveling through the convex lens in the picture below.

Hint: Keep in mind what you predicted for the prisms above! Does the light bend towards the thin part or the thick part? What might happen if it goes straight through the middle?



There are different types of lenses. Some will **spread** light going through, and some **focus** it to a spot. What will a convex lens do?

Experiment: Aim the light towards a wall or a piece of paper and put the lens directly between the two, with the light shining through the lens. Move the lens back and forth from near the light to near the wall or paper. Can you focus the light to a spot (or a small image of the light bulb)? **Draw** what happens to the light rays that pass through your lens:



Conclusion

A convex lens will ____________________ light.

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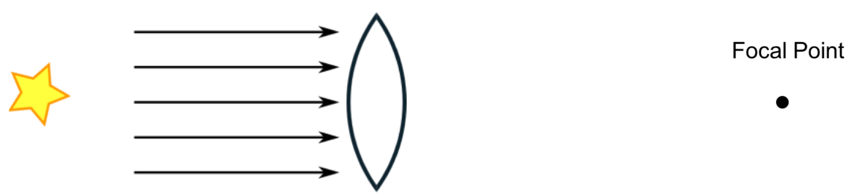
Activity 2

Measuring the Focal Length

Aim:
Measure the focal length of three different convex lenses.

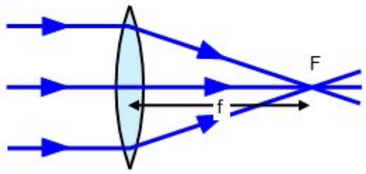
Materials:		
Light (window or flashlight held far away)	3 convex lenses	Meterstick or tape measure

A convex lens focuses parallel light to a point. This point is called the **focal point** of the lens. **Draw** the lines to show what happens when parallel light rays pass through a lens.



The focal length of a lens is the distance from the lens to the focal point. **Label** the focal length on the diagram above.

Method for Measuring Focal Length
Start with lens #1. Have one person hold the lens far (more than one meter) from the light source so that the light source shines through the lens and onto your blank surface.
Move the lens closer and farther from the blank surface until you focus an image of the light source onto the blank surface. The lens is focused when the image is as bright and crisp as possible. For some of the lenses, you may have to ask a partner to look at the image from the side. **Make sure the lens is always closer to the blank surface than it is to the light!**
Hold the lens at this point of best-focus and use a meter stick or the ruler inside your microscope to measure the distance between the center of the lens and the image on the surface. This is your focal length. Record your length in the diagram below.



Lens #1 focal length (f) = ______ cm

Repeat the experiment with the the other lenses and record below.

Lens #2 focal length (f) = ______ cm

Lens #3 focal length (f) = ______ cm

Questions:
Compare your lenses by filling in the table below:

	Lens #1	**Lens #2**
What is the focal length?		
Appearance of image? (small? big? sharp? fuzzy?)		
Shape of lens? You can touch the lens with your fingers -- are some of them rounder than others?		
Use each lens as a magnifying lens. How does the object appear with each?		

Conclusion

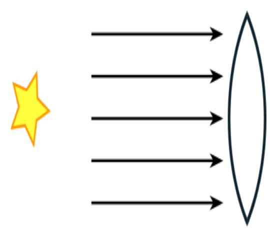
The focal point is where

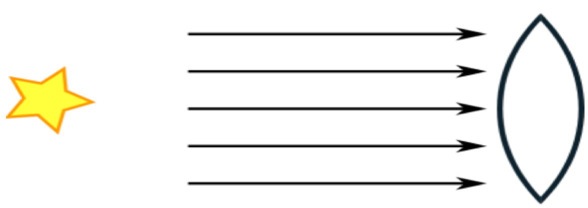
____

____

A more rounded lens will have a __________________________________ **focal length than a flat lens.**

Sketch focal points and draw in lines to show what will happen in the two differently shaped lenses below:





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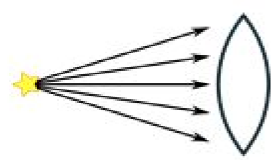
Activity 3

Making a microscope

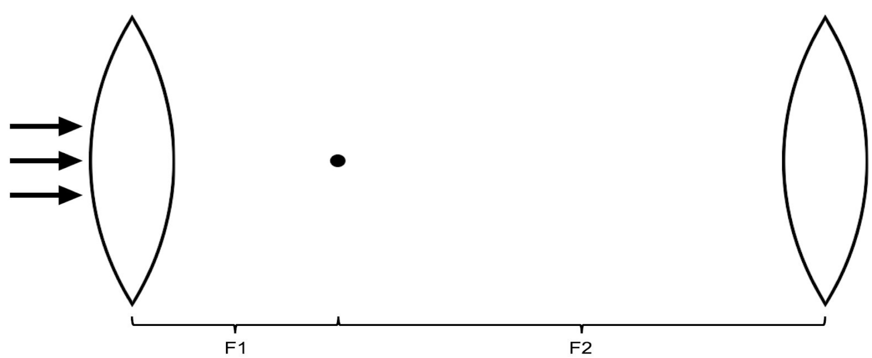
Aim
Construct a microscope using two convex lenses of different focal lengths.

Materials:		
Lens #1 and 2	PVC Microscope Tube	Printed Graph Paper with Binder Clip

Light moves the same way in both directions: it will take the same path between two points no matter which one is the start. This is call **reciprocity**. Using this principle and what you learned from Activity 2, draw and label the diagram below to predict what happens when light rays are emitted from a focal point and then pass through a lens. ***Hint: Look at your diagrams rom Activity 2 and think about how they would look if the light was going "backwards"!***



What do you think will happen when we send parallel light through two lenses? Draw and label your predictions. F1 and F2 are the focal lengths of each lens. ***Hint: Look at the diagram you drew above.***



You noticed in the last activity that one lens can be used to magnify an object (like a magnifying glass!). This is known as a simple microscope. A **compound microscope** uses

Lenses can magnify objects because they spread rays coming from a small area. Look at the

picture you drew above. Are the light rays farther apart or closer together after passing through the lenses?

Method:
Lay your microscope tube flat on the table and open it up.
Use the binder clip as a stand for the graph paper, so that it stands up. Position the vertical paper so that it touches the edge of the microscope tube on the tabletop at 0 cm (marked on the ruler inside your microscope). This is your *sample*.
Position Lens #1 in the hole in the middle of the microscope tube so that the raised white edge of the lens holder is closer to your eye. The arrows drawn on the lens should point in the same direction as the arrows drawn in the tube. All the arrows should point away from your eye, towards the sample.
Position Lens #2 between Lens #1 and the sample (make sure the arrows are all pointing the same way!). Look through lens #1. What do you see? Is the image in focus? Is it magnified?

Image in Focus	**Image out of Focus**
	

Look through the microscope and have a partner move Lens #2 to different positions between Lens #1 and the sample while you observe what happens to the image. Try to find the position of Lens #2 so that the squares on the graph paper appear the largest **without being blurry**.
When you have the best image, write down the position of each lens using the ruler in the microscope. The black lines on the lens holders mark the position of the lens. Write down your results:

Lens #1 Position (cm)	**Lens #2 Position (cm)**

Measure the separation between the two lenses at this position.
Distance between lenses = ____________ cm

How does the separation between the two lenses compare to the focal lengths you found in Activity 2?

Conclusion
The separation between the two lenses is _________________________________ the focal lengths of both lenses.

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Activity 4

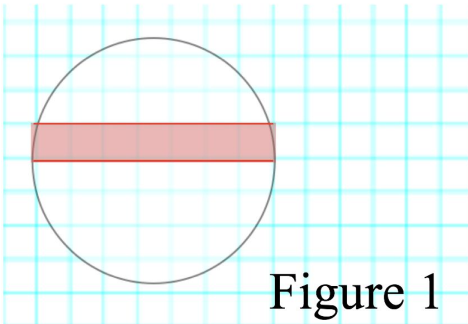
Calculating the magnification for the microscope

Aim:
To calculate the magnification of the microscope.

Background Info:
Magnification is the ability to enlarge the appearance of something that we cannot see with our eyes alone. It is one of the most important features of a microscope, and it's the reason why we know what very small things like bacteria, pollen and dust mites look like. Dutch eyeglasses maker Zacharias Jansen is believed to have created the first compound (two or more lenses) microscope in 1595. It wasn't a good microscope—with a maximum magnification of 9x, it was comparable to most magnifying glasses at the time. Today's compound microscopes have maximum magnifications of at least 1,000x. How does your microscope compare? **In this activity, you will determine the magnification of your microscope using an image of a known size.**

Materials:		
Microscope	Calculator (optional)	Graph paper (from Activity 3)

Method:
Congratulate yourself. You just made a microscope! We're going to use your microscope just the way it is, so don't add or change the position of the lenses for now.

Look at the circle printed on your graph paper (see below). The circle represents the circumference of your lens. Count the number of grid squares you see across the diameter of the grid paper (the squares in the pink region in Figure 1) and write it in the box below.	
 Figure 1	Number of squares on paper = ______________

Put the grid paper back at the end of your microscope and look at it again through the microscope with the lenses in the best positions you just determined. Count the number of grid squares you can see across the field of view while looking the microscope in the same way you did above. How many grid squares do you see through the microscope?
Number of squares through microscope = ______________

The magnification of the microscope is the **number of squares you counted on the graph paper** divided by the **number of grid squares you saw using the microscope**. Calculate the magnification of your microscope and write it below.
Magnification = ______________x

Questions:
What was the magnification of your microscope? How did it compare to Jansen's microscope (9x)? What about a standard compound microscope (1,000x)?
What kind of objects do you think you'd be able to see with your microscope?
How does the magnification you found relate to the focal lengths of the lenses you measured in Activity 2?
How would you increase the magnification of your microscope?

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Activity 5 (Bonus)

Changing the microscope configuration

Aim:
Observe how changing the lenses can improve the microscope's magnification.

Materials:		
Microscope	Calculator (optional)	Graph paper (from Activity 3)

Method:	
Open the microscope and remove Lens 1, leaving Lens 2 where it is. Insert Lens 3 into the hole farthest from the sample. Write down the positions of each lens below:	
Lens 3 position __________ cm	Lens 2 position __________ cm

Determine the new magnification of the microscope by counting the squares visible across the field of view (as you did in Activity 4). Write down the number below, and the number you counted on the paper in Activity 4.	
Squares on graph paper: ___________	Squares through microscope: ___________
Write down the magnification of this microscope setup below. Remember, the magnification is the number of squares on the paper divided by the number you see through the microscope.	
Magnification: ___________ x	