Enlightening Geometry

CAUTION: Students must be careful with all lasers. They must not point the laser at anyone's eye.

Engage:
Construct a periscope with a partner that allows you to see around corners. Follow the directions on the task card to construct your periscope. In your journal draw your periscope and record your observations as you construct the periscope.

Explore I:
Students will explore and explain the relationship of the measurement of the angle and the number of images produced in the mirror.

Required Materials
Math/Science notebook
Penny
2 4 x 6-inch mirrors
Masking tape
Paper
Protractor

Procedure I
Work with a partner. Take two mirrors and place them together with the shiny sides facing one another. Tape them along the side to form a hinged door. The mirrors should be able to open freely like a book.
Place a piece of paper on the table and place the hinged mirrors at an angle on top of the paper. Practice moving the mirrors closer together and then spread them farther apart to change the angle.
Place the hinged mirrors at an angle and put the penny between them as close to the mirrors as possible.
Count the number of images you see. Record the angle and the number of images you see in your notebook.
Change the angle of the mirrors and repeat steps 3-4. Repeat this process several times changing the angle each time.
Share your data with another group as designated by your teacher.

Explain I
When you are finished look carefully at your data chart. What do you notice? In your math/science notebook analyze the information you recorded. Did you notice a pattern? What is the relationship of the angle and the number of images you see in the mirrors?

TEACHER NOTES PART I

KJ Matsler © 2011 Ft. Worth Museum of Science and History, Inquiry Institute

Angle	*Images*	*Images + penny*
17	*20*	*21*
20	*18*	*19*
35	*9*	*10*
40	*8*	*9*
60	*5*	*6*
90	*3*	*4*
120	*2*	*3*

Explore II:
Materials
Mirror (approximately 4” by 4” or larger)
Laser
Meter stick
Sticky notes or small pieces of masking tape

Students will work in groups of at least three. Each person will have a job. Group jobs are: A shiner, a marker, a recorder.

Procedure II:
Place the mirror on the floor at a distance between 0.5 and 1.0 m from the wall. This distance will be Dw.
The Shiner will stand the same distance away from the mirror (i.e. if the mirror is 1 meter from the wall, the shiner will be 2 m from the wall). This distance is Ds.
The Shiner will hold the laser at waist height and shine it on the mirror so that the beam of light reflects on the wall.
The Marker will measure the height at which the light hits the wall.
The Recorder will record the measurement (values) on the table and make sure the Shiner holds the laser in the same manner each time
Move everything back by doubling the distance for both Dw and Ds,
Measure the height of the reflected light on the wall.
Repeat two more times

Explain II
When you are finished look carefully at your data chart. What do you notice? In your math/science notebook analyze the information you recorded. Did you notice a pattern?

TEACHER NOTES PART II
Height of laser = 86 cm

Trial	*Distance from mirror to wall*	*Distance from shiner to mirror*	*Calculated*	*Observed*	*Percent Error*

KJ Matsler © 2011 Ft. Worth Museum of Science and History, Inquiry Institute

1	*100 cm*	*100 cm*	*86 cm*	*99 cm*	*12.8%*
2	*200 cm*	*200 cm*	*43 cm*	*49 cm*	*14%*
3	*300 cm*	*300 cm*	*29 cm*	*33 cm*	*15%*
4	*400 cm*	*400 cm*	*21.5 cm*	*25 cm*	*16.3%*

Explore III:
Materials
Mirror (approximately 4" by 4" or larger)
Laser
Meter stick
Sticky notes or small pieces of masking tape

Students will work in groups of at least three. Each person will have a job. Group jobs are: A shiner; a marker, a recorder.

Procedure III:
Place the mirror on the floor at a distance between 0.5 and 1.0 m from the wall. This distance will be Dw.
The Shiner will stand the same distance away from the mirror as the mirror is from the wall (i.e. if the mirror is 1 meter from the wall, the shiner will be 2 m from the wall). This distance, from the Shiner to the mirror, is Ds.
The Shiner will hold the laser at waist height and shine it on the mirror so that the beam of light reflects on the wall. Measure the height of the laser and record in your notebook as Hs.
The Marker will mark the height at which the light hits the wall using a small piece of masking tape or a sticky note. Do not measure this height at this time.
The Recorder will record the measurement (values) on the table and make sure the Shiner holds the laser in the same manner each time
The Shiner will then move back (i.e. away from the wall) doubling the original distance from the mirror. (i.e. if the original Ds was 1 meter, they now move to 2m)
Mark the location of the reflected light on the wall.
Repeat two more times

Explain III
When you are finished look carefully at your data chart. What do you notice? In your notebook analyze the information you recorded. Did you notice a pattern? If so, what?
Use ratios (Ds, Dw, Hs) of to calculate the height of the reflection on the wall (Hw). (Hs/Ds=x/Dw)
Measure the actual height of the light reflecting on the wall. Compare the actual height to your calculated height and determine your percent error.

Does your percent error remain constant every time you move back? If not, why do you think it changes? Why are possible types of experimental error?

TEACHER NOTES PART III
Height of laser = 86 cm

Trial	*Distance from mirror to wall*	*Distance from shiner to mirror*	*Observed Ht. on wall*
1	*20 cm*	*0.5 m*	
2	*40 cm*	*1.0 m*	
3	*80 cm*	*2.0 m*	
4	*160 cm*	*4.0 m*	

Elaborate:
In your notebook answer the following questions using the information from your investigation.

1. Describe the dependent and independent variables for each investigation.
2. What is a reasonable domain and range for a model?
3. Create a scatter plot of your data. Does there appear to be a relationship between the distance and the height?
4. What parent function has the same appearance as the data you plotted?
5. Using the parent function you selected, develop a model for the relationship between the distance from the wall and the height on the wall. Graph your model on the same graph as your original plot of the data to determine its reasonableness.
6. Use your model to calculate how high up the wall the reflected light would hit if a mirror were placed 2 meters from the wall? 3 meters from the wall?
7. Based on your graphs, predict (extrapolate) where the light would reflect on the wall if you were standing 7 meters away from the mirror.
8. How could you use this technique to measure the height of any object such as the top of a flagpole, the height of a ceiling, or the crossbar of the goal on the football field? Explain why this works.

Evaluation Task/Challenge:
Students will use what they have learned about the reflected light from a mirror to hit a target with reflected light from a mirror.

Materials:
Large whiteboards or large sheets of paper and markers
6-8 mirrors per group of students
binder clips, clay, or wood blocks (used to support mirrors)
protractors
lasers

Procedure
Have each group of students set up mirrors on the whiteboard in a pattern so that the light reflects off one mirror to another and so on until the laser light hits a

KJ Matsler © 2011 Ft. Worth Museum of Science and History, Inquiry Institute

target. The group with the most mirrors in the least amount of time wins. NOTE: the laser path will be less visible as it travels a greater distance. Therefore in order to get multiple mirrors students need a small area (i.e. the whiteboard) to work within.
Once students have their “mirror maze”, have them draw a line indicating the path of the laser beam as it travels from mirror to mirror.
Be prepared to explain to the class why your “mirror maze” worked and what you had to do to be successful.
Have students draw the incident and reflect ray for the mirrors in the maze and then measure them with the protractor.

Construct a Periscope

Trim around the two short tunnel patterns and roll each one into a tube about the size of a toilet paper tube. Secure the edges with tape.

Trim around the long tube pattern and roll into a tube the size of a paper towel roll. Secure the edges with tape.

Place the tubes in the labeled areas of the mats.

Place an object in front of one of the short tunnel tubes just off the mat.

Take turns looking through short tube on the opposite side of the mat. Can you see the object?

Discuss why or why not you can see the object with your partner.

KJ Matsler © 2011 Ft. Worth Museum of Science and History, Inquiry Institute

Place a mirror in each marked area. Adjust the mirrors until you are able to see the object through the tube.

In your journal, draw your periscope system and record the placement of your mirrors. Record all the mirror positions that you tried and what the results of each trial was. Record what you noticed about the placement of mirrors that allowed you to see the object.

Explain why the placement of the mirrors allows you to see the object.

Teacher Notes: Mirrors and Images

What is it that lets us see objects? Some objects, such as the sun, give off their own their own light. Most objects, however, do not. These objects must reflect light in order to be seen. For instance, the walls in the room do not emit light; they simply reflect light from overhead lights or from sunlight that enters the room through a window. Smooth, polished surfaces, like mirrors, are very good at reflecting light.

When you place an object between two hinged mirrors, light from the object bounces back and forth between the mirrors before it reaches your eyes. An image is formed each time the light bounces off a mirror. The angle between the two hinged mirrors has a special relationship with the number of images you see. The relationship students will discover is: as the measurement of the angle decreases the number of images produced increases.

This activity can be used in conjunction with the study of types of angles in geometry. Students should be able to identify the angles created by the mirrors as obtuse, right, or acute. It will also provide opportunities for students to measure and estimate angle degrees.

KJ Matsler © 2011 Ft. Worth Museum of Science and History, Inquiry Institute

Hit the Wall

Distance between mirror and wall	Height of reflected light from floor

KJ Matsler © 2011 Ft. Worth Museum of Science and History, Inquiry Institute