SCOPING THE SCENE (2 Hours)

In this activity, students will explore the relationship between angles of incident and reflected light and use this relationship to design and test their own periscopes in a classroom competition.

Topic: Mirrors and reflection

Real World Science Topics:

- An exploration of how laser beams travel through the air
- An exploration of how light is reflected from a mirror

Objective

Students will gain an understanding of the law of reflection, and they will see how this applies to light and mirrors.

Materials Needed for Demonstration:

two cardboard milk or juice cartons
three mirrors
construction paper
tape
scissors
laser pointer
chalk dust, flour, or talcum powder

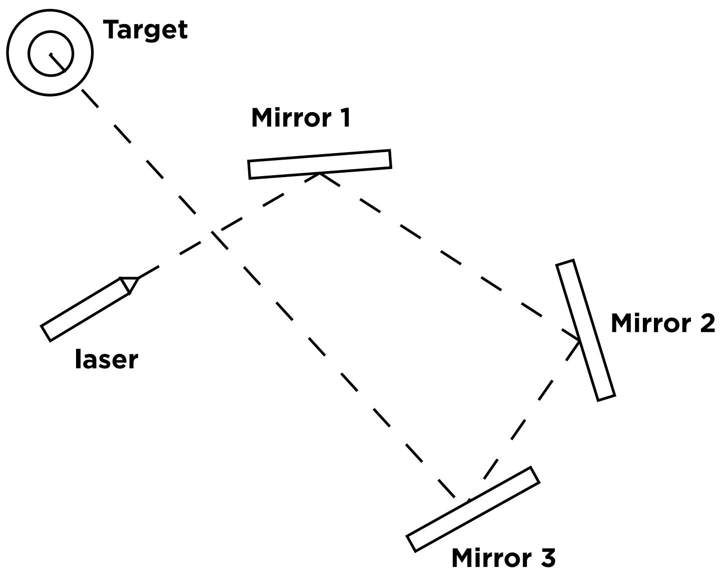
Materials Needed for Each Team of 2-4 Students:

four cardboard milk or juice cartons
four small mirrors
scissors
tape
colored tape
colored pencils
two laser pointers

Teacher Preparation

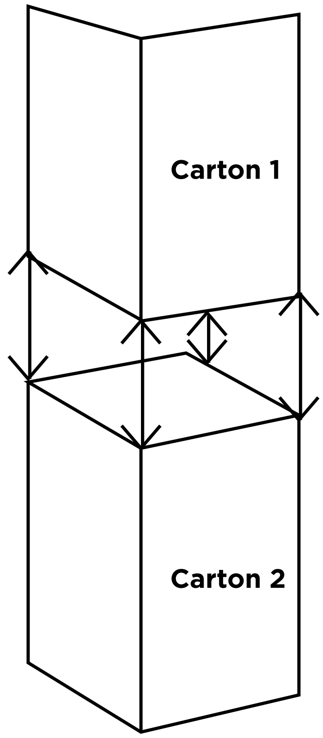
For the demonstration: arrange the three small mirrors in such a way that a laser pointer beam can reflect from one mirror to the next and strike a target on the wall. An example is shown below:

SCOPING THE SCENE



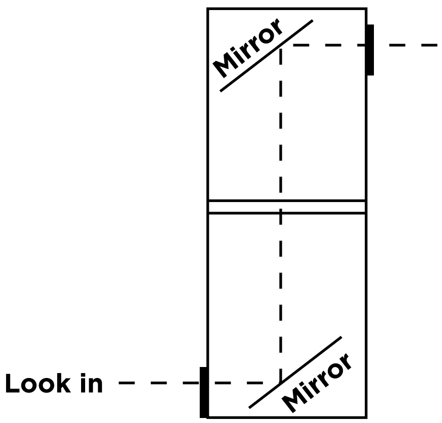
Cut out small, circular bull's-eye targets from colored construction paper. There should be two for each group of two to four students. Tape one of these targets a few inches above the ground and the other about five feet off the ground at various locations throughout the room and ensure that there is at least a few feet of space in front of each of the targets.

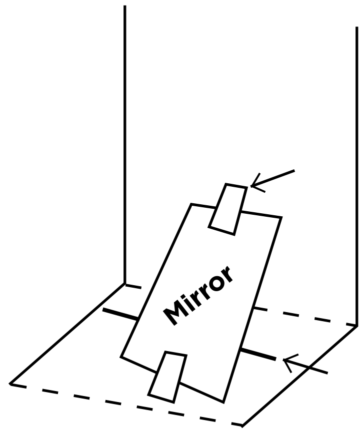
Build the periscope to pass around to students while they are building their own. First obtain two milk (or juice) cartons and open up one end of each carton. Tape the open ends together, as shown:



STEPS FOR *SCOPING THE SCENE*

Then cut two small holes, one in the front of the bottom box and the other in the back of the top box. (These will be the holes that you look through). To insert the mirrors into the periscope, cut a thin slit (a little larger than the width of the mirrors) into the bottom and top of the periscope. Insert the mirrors and angle them so that you can look into the bottom and see through the top. (It may take some time to find the appropriate angle for the mirrors.) Once the mirrors are oriented appropriately, tape the mirrors in place as shown:





Standards Met

National Science Standards Addressed

Content Standard A: Science as Inquiry

- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Develop descriptions, explanations, predictions, and models using evidence.
- Identify a simple problem and propose a solution.

Content Standard B: Physical Science

- Light interacts with matter by transmission (including refraction), absorption, or scattering (including reflection). To see an object, light from that object—emitted by or scattered from it—must enter the eye.

National Math Standards Addressed

Data Analysis and Probability: collect data using observations, surveys, and experiments

National Technology Standards Addressed

Apply existing knowledge to generate new ideas, products, or processes.

Contribute to project teams to produce original works or solve problems.

Sources:

National Science Teachers Association

http://books.nap.edu/html/nses/overview.html#content

National Council of Teachers of Mathematics

http://standards.nctm.org/document/appendix/meas.htm

National Educational Technology Standards

http://cnets.iste.org/currstands/cstands-netss.html

STEPS FOR *SCOPING THE SCENE*

1. **Warm-up Activity:** Ask students where they may have seen their reflection before. Some examples include: mirrors, glass windows or doors, metallic surfaces, a pool or lake, and so on. Pass the small mirrors around the room. Turn off the lights in the classroom and ask students if they can see their reflection in the dark. Turn the lights back on. Ask students what is necessary to see their reflection. (They should answer: light.) Tell students to hold the mirror to the side and look into it. Ask if they can see their reflection if they look into a mirror from the side. Help students see that the position of something in front of a mirror is related to the reflection of the object in the mirror.

2. Distribute the *Scoping the Scene* handout to students. Show students the three-mirror setup and have them sketch the setup. Ask students what they think will happen when you point a laser at the first mirror. Where will the laser beam go? Have students draw the path that the light will follow when it strikes the mirrors. Turn the lights out in the room and turn the laser pointer on. Have students examine the path of the laser beam. (If the room is dusty, this path will be illuminated. If the room is not dusty, you may want to clap chalk dust or flour over the beam so that it is illuminated. See the Teacher Background section for more details about this.) Ask students if they correctly predicted the path of the beam. You may change the angle of one or two mirrors to show students how the path of the laser changes. Explain that a laser beam is a beam of single-colored light that does not spread out much as it travels (as opposed to a flashlight beam, which spreads a lot). (See the Teacher Background section for more information on lasers.) Tell students that they are going to investigate how laser light reflects from a mirror.

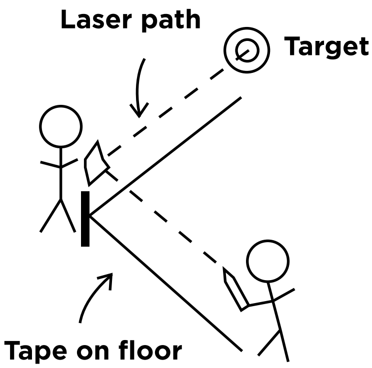
3. Have students answer question 2 on the Student Handout with a colored pencil. When considering the direction of the reflected light, have students think about how other objects reflect off of surfaces. If the dotted line represented a soccer ball and the thin rectangle represented a wall, which way would the soccer ball bounce off of the wall?

4. Have each team of two to four students move in front of a particular bull's-eye target (one that is a few inches off the ground) around the room and distribute the activity materials. Tell students that each group is going to be given a laser pointer, and explain that laser pointers can be very dangerous if they are not handled correctly. Tell students that they should never look directly into a laser pointer or shine it into another student's eyes. Have one student in each group sit a few feet in front of the target, facing the target. Have another student in each group hold a mirror and sit between the the first person and target, just off to the side of the target. Tell students that the person directly in front of the target is going to try to aim the laser pointer at the mirror, and the person holding the mirror will adjust the angle of the mirror so that the laser strikes the target.

5. Have teams think about question 2 on the Student Handout. They should discuss how they think the mirror should be angled. When the team agrees that they have angled the mirror properly, pass a laser pointer to the student in front of the target and have them point it at the mirror. If the laser does not strike the target, tell the person with the mirror to adjust the angle. The person holding the laser should keep the laser in a fixed position.

Again, remind students that they should never look directly at the laser or shine it in another student's eyes. This can seriously damage their vision.

6. When the laser pointer strikes the target, have the other team members lay tape on the floor representing the path of the laser. They should also lay tape down that represents the angle of the mirror, as shown below. (Note: students are shown standing in this diagram, though they should be seated when conducting the experiment.)



7. Have students attempt to strike the target (and lay tape representing the path) three more times so that each person on the team holds the mirror once. The person holding the mirror should sit in a different position each time. Then have students examine the tape on the floor. Tell them that each time light strikes the mirror, it strikes the mirror at an angle. Also, when light bounces away, or *reflects,* from the mirror, it reflects off the mirror at an angle. Have students identify these angles on the floor. Ask students if they see a relationship between the angle at which the light strikes the mirror and the angle at which it reflects. Have students complete questions 3 and 4 on the Student Handout. Then have students return to question 2. Have them draw in a new sketch of the reflected light using a different colored pencil. Ask students if these new sketches are different from the first sketches. If so, ask them to explain why.

8. Now show students the milk carton periscope. Tell them that a periscope is a device that uses mirrors to direct incoming light to a different location. Point to the different parts of the periscope and explain how light enters through one side, reflects off of the first mirror, travels through the periscope, reflects off the second mirror, and then exits through the other side. People can use periscopes to see over a wall or around a corner. Periscopes are also used in submarines to see outside the submarine or to see above the surface of the water. Tell students that each team is going to assemble two periscopes.

9. Distribute materials to students. Have students read the instructions on their Student Handouts to assemble the periscopes.

10. Tell students that they will now compete with their teammates in a "periscope laser shootout." Have teams position themselves in front of a particular target in the room (the targets that are approximately five feet above the ground). Explain the rules of the shootout: Two students from each team will stand a few feet from the target and hold the periscopes so that they can see the target through the viewing window. Then the students should look around the periscopes at the target on the wall. The other two students on the team will count to three and then shine the laser pointers into the periscope viewing window. Students should then adjust the position of the periscope or the angle of the laser pointer so that the laser strikes the

target. The first team to strike the target gets "one point." The first team to get ten points wins.

11. **Wrap-up Activity:** Have students think about how light reflects through the periscopes. Have them draw a picture of how light reflects through the periscope on the Student Handout. Tell students to identify all of the angles that the light makes with the mirrors in their drawing. Do they see a relationship between the angle at which light strikes the mirror and the angle at which it reflects? Explain to students that these angles are equal, and this is called the law of reflection. Tell students that all light strikes and reflects off mirrors like the laser beams in this activity. When we see the image of an object in the mirror, light must have traveled from that object, reflected off the mirror, and landed in our eyes. Tell students to think about the incoming light and the reflected light the next time they look in the mirror.

Scoping the Scene Extension Activity

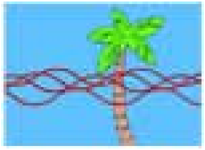
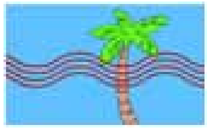
Have students design more complex mirror setups. For example, two or three students could hold mirrors and attempt to strike a target. Students could also link multiple periscopes together, or they could attempt to direct the laser emerging from one periscope into the opening of another periscope as they try to strike targets.

SCOPING THE SCENE
BACKGROUND INFORMATION

What is a laser?

A laser is a coherent, monochromatic, collimated beam of light. Laser light is said to be coherent because all of the light waves in a laser beam are in phase—that is, the crests and troughs of all the waves are perfectly aligned. (In non-laser light, such as the light from a flashlight, the individual light waves are not necessarily in phase.)

Example:

ordinary (non-laser) light:  *laser light:* 

Laser light is *monochromatic* because it consists of only a single wavelength (color) of light. (Non-laser light typically contains waves with a variety of wavelengths.) Laser light is said to be *collimated* because it does not spread out as it travels away from its source. Instead, all the light waves in the laser beam travel along parallel paths, so the laser beam is the same width at its source as it is many meters away. (Compare this to a non-collimated flashlight beam, which becomes much wider as you move away from the bulb.)

Why can you see the path of a laser when the lights are turned out?

In a perfect vacuum, the path of a laser beam would be completely invisible. We can see a laser only when it reflects off an object, and the light travels to our eyes. (You could also see a laser if it were shined directly into your eyes, but this is very dangerous and can cause vision damage.) In a vacuum, there are no objects to reflect the light, so the laser is invisible. In most classrooms (and other rooms), however, there is a certain amount of dust suspended in the air. As the laser passes through the air, some of the light reflects off the tiny dust particles in the air. The reflected light travels to our eyes, allowing us to see the laser's path. Darkening the room makes the small amount of reflected light more noticeable. The laser beam's path can be made even more visible by increasing the amount of dust in the air.

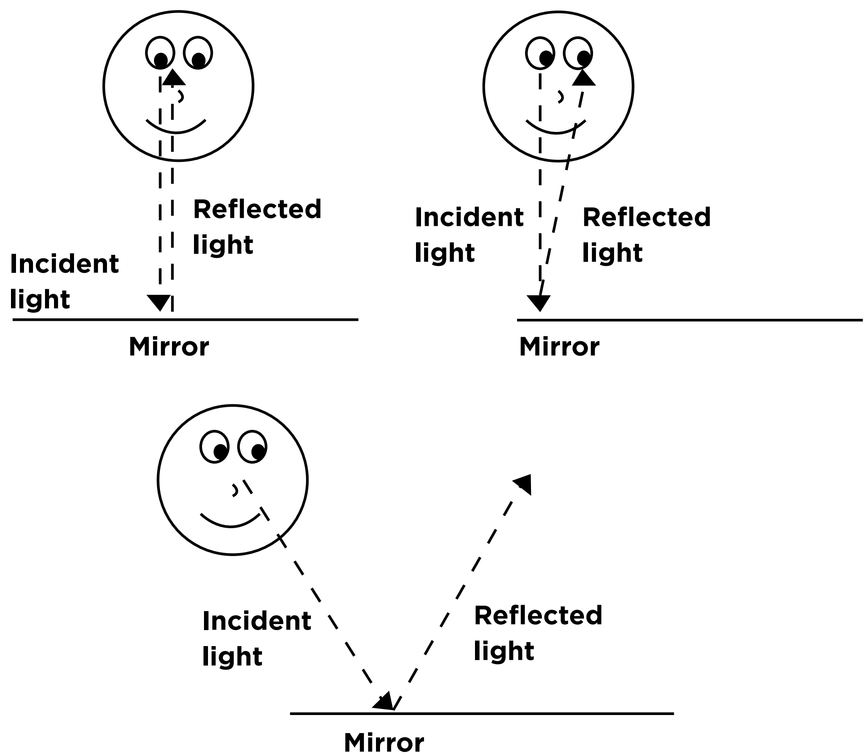
What is the law of reflection?

The law of reflection describes the behavior of a light wave when it reflects (bounces off) a surface. According to the law of reflection, the angle of incidence is equal to the angle of reflection. The *angle of incidence* is the angle between the incoming light ray and a line drawn perpendicular to the surface. The *angle of reflection* is the angle between the reflected light ray and the line perpendicular to the surface.

SCOPING THE SCENE
BACKGROUND INFORMATION

Why is it that when you look into a mirror from a certain angle you cannot see your own reflection?

According to the law of reflection, the angle of incidence is equal to the angle of reflection. You can see your own reflection in a mirror only when the light rays that reflect off the mirror travel into your eyes. If the angle of incidence is too large, the reflected rays (which travel in straight lines once they reflect off the mirror) never reach your eyes, because they are reflected at too large an angle. (See images below.)



How are periscopes used?

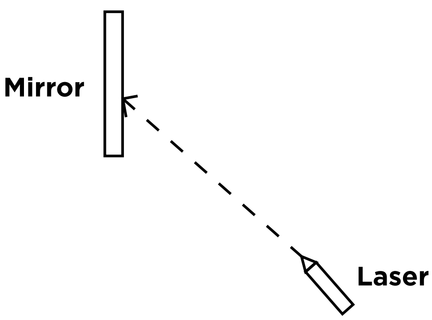
A periscope is a device that uses mirrors to direct incoming light to a different location. Most periscopes use two mirrors to take light coming in at one location and reflect it to the side or downward. Periscopes are most commonly used to allow a person to see around a corner or over a wall without exposing his or her body. They are common in submarines and other enclosed vehicles, where they allow the occupants of the vehicle to see outside the vehicle.

Key Vocabulary
laser: a coherent, monochromatic, collimated beam of light rays
mirror: a flat, typically shiny surface that reflects light rays
reflection: the process in which a wave strikes a surface and then bounces off it; the image produced by a flat mirror
periscope: a device that uses mirrors to direct incoming light to a different location

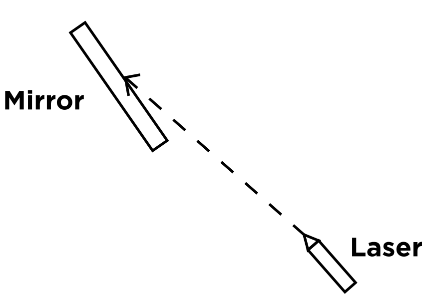
STUDENT HANDOUT FOR *SCOPING THE SCENE*

1. Sketch the mirror setup that your teacher has shown you. Draw the path of a laser beam that strikes one of the mirrors.

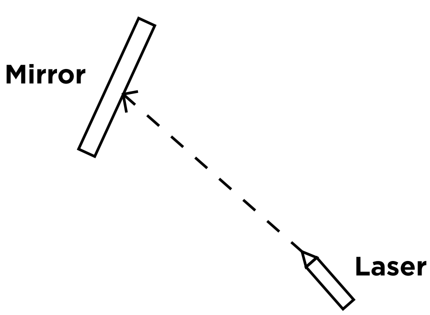
2. Complete the path of the laser beam reflecting on each mirror below:



Mirror angle 1:



Mirror angle 2:



Mirror angle 3:

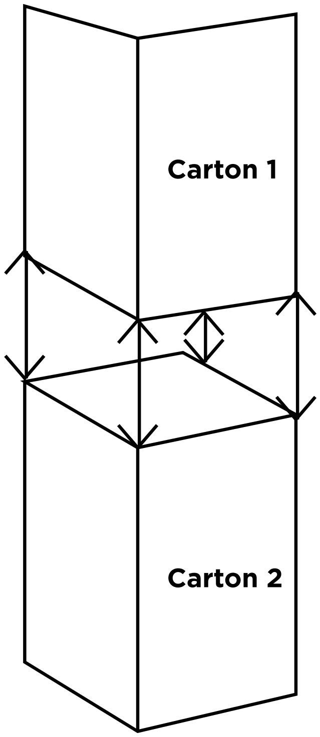
3. What happens when the laser shines on the mirror?

4. Do you see a relationship between the angle at which the light hits the mirror and the angle at which it reflects away? What relationship did you see?

Creating a periscope:

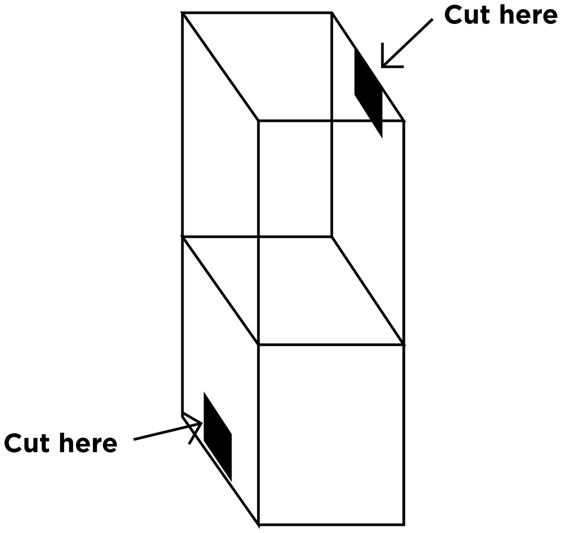
1. Open up the bottom end of each milk (or juice) carton.

2. Tape the two cartons together, as shown below:

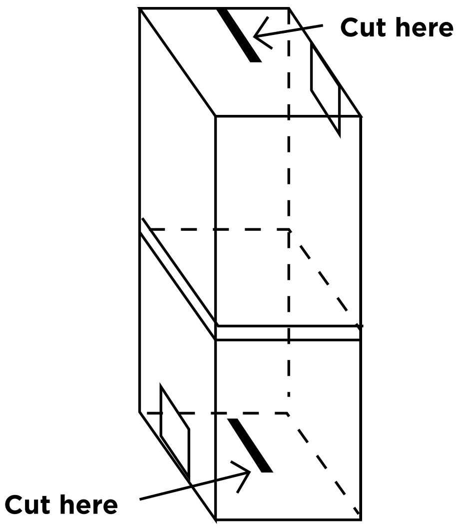


STUDENT HANDOUT FOR *SCOPING THE SCENE*

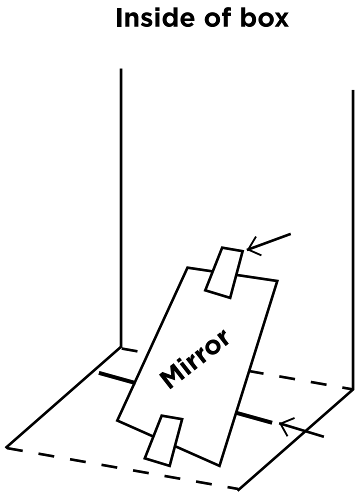
3. Cut two small holes in the front of the bottom box and the back of the top box using scissors. (These will be the holes that you look through).



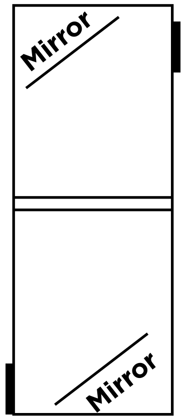
4. To insert the mirrors into the periscope, cut a thin slit (a little larger than the width of the mirrors) into the bottom and top of the periscope. (Ask your teacher for help if you are unsure how to do this.)



5. Insert the mirrors and angle them so that you can look into the bottom and see through the top. Then tape the mirrors in place:



If you could look through the side of the periscope, it would look like this:



STUDENT HANDOUT FOR *SCOPING THE SCENE*

6. On the periscope above, draw in the path of light as it travels through the periscope and reflects off the mirrors.

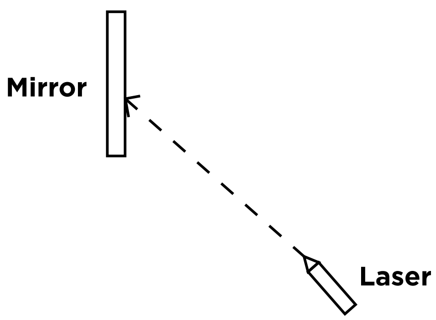
7. How could you use your periscope in your daily life?

8. At some grocery stores there is a curved mirror hanging in the corner above the aisles. Why do you think this is there?

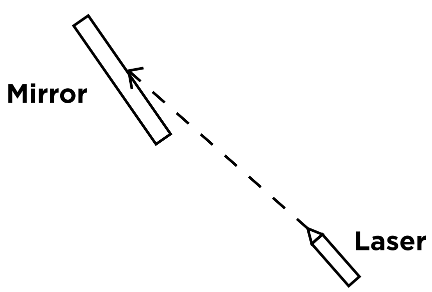
TEACHER HANDOUT FOR *SCOPING THE SCENE*

1. Sketch the mirror setup that your teacher has shown you. Draw the path of a laser beam that strikes one of the mirrors.

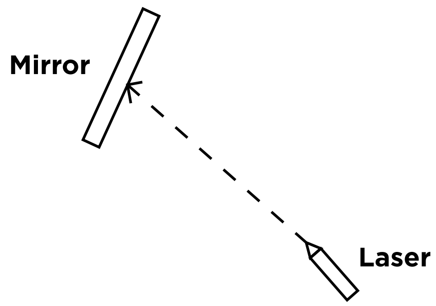
2. Complete the path of the laser beam reflecting on each mirror below:



Mirror angle 1:



Mirror angle 2:



Mirror angle 3:

TEACHER HANDOUT FOR *SCOPING THE SCENE*

3. What happens when the laser shines on the mirror?

[It reflects off in another direction.]

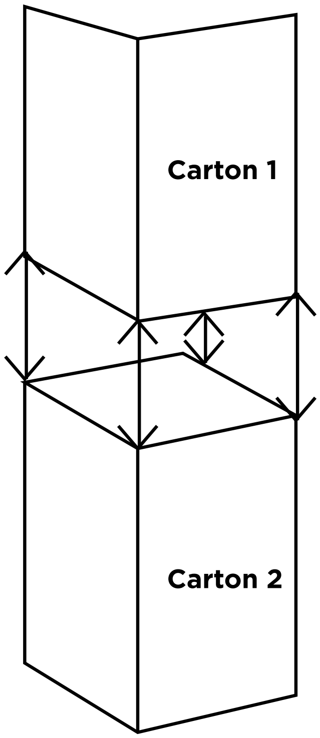
4. Do you see a relationship between the angle at which the light hits the mirror and the angle at which it reflects away? What relationship did you see?

[Yes, these angles are the same.]

Creating a periscope:

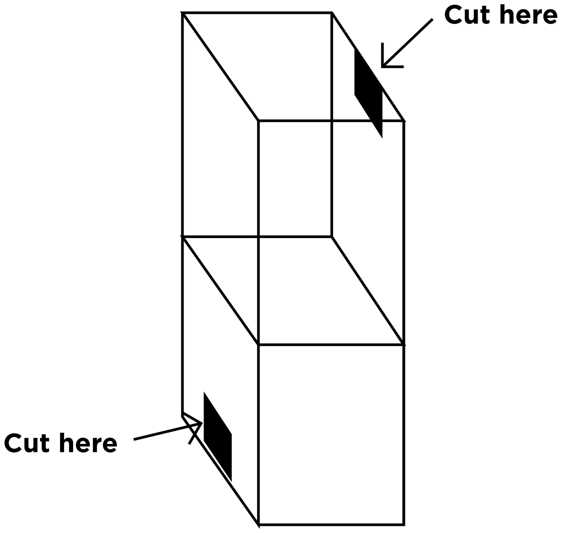
1. Open up the bottom end of each milk (or juice) carton.

2. Tape the two cartons together, as shown below:

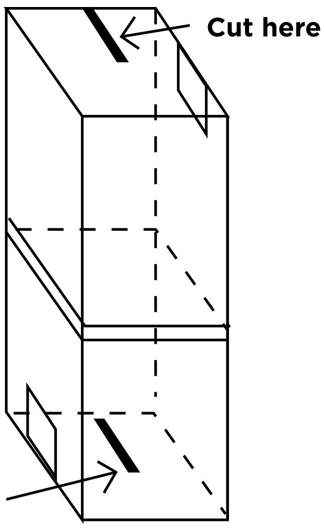


TEACHER HANDOUT FOR *SCOPING THE SCENE*

3. Cut two small holes in the front of the bottom box and the back of the top box using scissors. (These will be the holes that you look through).

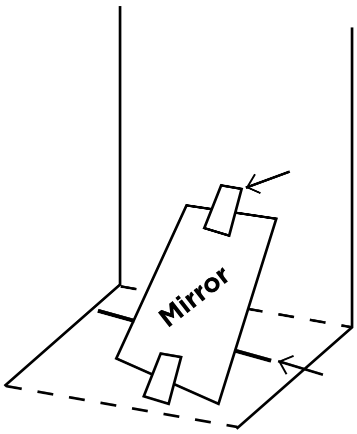


4. To insert the mirrors into the periscope, cut a thin slit (a little larger than the width of the mirrors) into the bottom and top of the periscope. (Ask your teacher for help if you are unsure how to do this.)

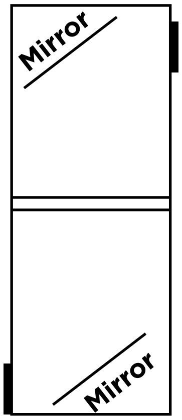


5. Insert the mirrors and angle them so that you can look into the bottom and see through the top. Then tape the mirrors in place:

Inside of box



If you could look through the side of the periscope, it would look like this:



TEACHER HANDOUT FOR *SCOPING THE SCENE*

6. On the periscope above, draw in the path of light as it travels through the periscope and reflects off the mirrors.

7. How could you use your periscope in your daily life?

[I could use it to see over walls or spy on my brother.]

8. At some grocery stores there is a curved mirror hanging in the corner above the aisles. Why do you think this is there?

[So you can see a person coming from around the corner.]