MODULE m3

Mirrors and Images

INTRODUCTION

Module 3, Mirrors and Images, consists of two activities that facilitate students' discovery of the Law of Reflection and how light reflects off different surfaces.

Activity 6: Mirror, Mirror on the Wall
Activity 7: Mirrors and Multiple Images

Activity 6, Mirror, Mirror on the Wall, will point students to Snell's Law (the angle of incidence equals the angle of reflection) in words that they can understand. Students will study how light reflects off mirrors to produce images. This incorporates math if you have students measure the angles using protractors.

Activity 7, Mirrors and Multiple Images, has students explore the relationship between the angle of a hinged mirror and the number of images produced.

The following interactive web-based tutorials can be used to enhance this module, explain difficult concepts, and enrich the classroom experience: Angles of Reflection, Refraction of Light, and Multiple Images, http://micro.magnet.fsu.edu/optics/tutorials/index.html

ACTIVITY 6

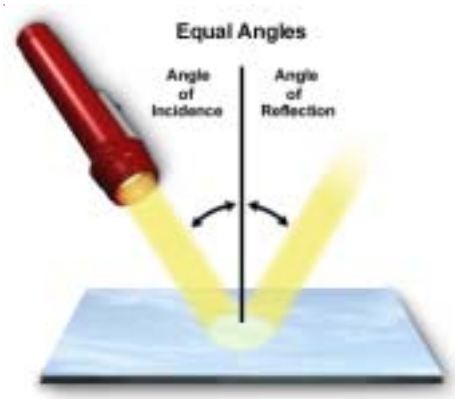
Mirror, Mirror on the Wall: Angles of Reflection

When light strikes a mirror it bounces off. This is called reflection of light. When you look at an object in a mirror, you are seeing the reflection of light from the object. Reflection involves two types of rays: the incoming or incident ray, and the outgoing or reflected ray. The angle between the incident ray and an imaginary perpendicular line drawn to the surface of the mirror is called the angle of incidence. The angle between the reflected ray and the perpendicular is called the angle of reflection. Light is reflected at the same angle that it strikes the mirror. The angle of reflection is always exactly equal to the angle of incidence. This is called the *Law of Reflection*.

In this activity, students will explore the law of reflection by trying to guess where two people must stand so each can see the other's reflection in a mirror.

MATERIALS:

- ☐ Mirror
- ☐ Masking tape
- ☐ Paper
- ☐ Science Notebook



What will the students do?

1. Students mount the mirror flat on a wall with masking tape. The mirror should be at eye level covered with a piece of paper.

2. Tape a 2-3 meter length of masking tape on the floor extending out from and perpendicular to the wall and centered on the mirror.

3. Students will work in pairs using the Student Page as a guide.

4. Students will be challenged to predict where **two people** must stand so each can see the other's reflection in the mirror.

5. Each pair will discuss and agree on the places where they think they must stand.

6. They will draw diagrams in their Science Notebooks to show the places they have selected.

7. Once students have determined where they will stand, they remove the paper from the mirror and test their predictions.

8. Pairs of students will continue doing this until they have found and marked the places where they must stand to see both reflections in the mirror.

Extensions:

Measurement. Show students how to use protractors to measure angles. Then have students design and construct large protractors out of cardboard to measure their angles of incidence and reflection. Draw and record results in student Science Notebooks. Each team of students should be able to explain to another group how they constructed the protractors and how they used the tools to measure the angles.

Reading. Either read aloud or have students read the fairy tale, *Sleeping Beauty*, or the story of *Alice in Wonderland* before they go onto the narrative writing prompt. Discuss ahead of time how mirrors are used in both stories and how the use of mirrors allows characters to see and do things they could not do in a real world.

Writing. Use the following as a narrative writing prompt.

In the fairy tale Sleeping Beauty and in the story of Alice in Wonderland, mirrors are magical.

Use your imagination and think about how mirrors could be used in magical ways.

Now write a short story about your magical mirror.

Writing. Use the following as an expository writing prompt.

We know that light reflects off a mirror like a ball bounces off a surface. Think about how a basketball bounces off the backboard of a basketball goal.

Make up a game in which you use flashlights to reflect light off of a mirror onto a goal or target.

Now describe in writing how the game should be played. Include diagrams to help explain the game.

HISTORICAL VIGNETTE: EUCLID

Euclid and His Students

The ancient Greek scientist and mathematician Euclid was one of the first to explain how light reflects off a mirror. He lived 2300 years ago in Alexandria, Egypt. Euclid was very interested in learning about how light works, but he is most famous for his work in geometry.

Euclid started a school in Alexandria and worked hard to help his students learn. The young King of Egypt was one of his students. One day, the King asked Euclid if there was an easier way for him to learn geometry than by studying. Euclid answered, "There is no royal road to geometry" and sent the young King off to study.

There is another story about Euclid in which a student wanted to know what he was going to get for learning geometry. Euclid was concerned that this student felt that he needed to receive something for learning. So Euclid called his assistant and told him to give the student just a penny, since "he must make gain out of what he learns."

Research. Euclid was not the only scientist that contributed to our understanding of light and reflections. In the 1100s the Arab scientist Alhazen studied the reflection of light and came up with the law that describes exactly what happens to a ray of light when it strikes a surface and then bounces off of it. Using a variety of print and electronic media, students can research and write about the discoveries of Euclid and Alhazen.

ARTIST VIGNETTE: LEONARDO DA VINCI

This vignette is designed to be read aloud to the class. It can be used to introduce an activity on mirror writing or as a jumping off point for further research on Leonardo da Vinci. Although da Vinci was a prolific artist, inventor, architect, and engineer, little is known about Leonardo the person. This fact alone may pique students' curiosity and encourage them to further research.

Leonardo da Vinci was a great artist and scientist that lived from 1452 to 1519, during a time called the Renaissance. He was one of the greatest painters of the Renaissance. The Last Supper and the Mona Lisa are two of his best known paintings.

Leonardo was also a great engineer and inventor. He designed buildings, bridges, canals, forts and war machines. He was fascinated by birds and flying and drew designs of fantastic flying machines. Leonardo kept huge notebooks of his designs and ideas.

In his notebooks, Leonardo wrote using mirror writing, writing backwards from right to left, instead of from left to right. In order to read his writing, you can place a mirror beside the writing and read the reversed image in the mirror. No one knows why Leonardo wrote this way. Some people believe he was trying to keep people from stealing his ideas. Others point out that he was left handed which made it easier for him to write from right to left.

To this day, people enjoy looking through the fantastic notebooks of Leonardo da Vinci. You can find many books in libraries with pictures of his notebooks and paintings. There are also many Internet sites with more information about Leonardo, his art, his inventions and his mirror writing.

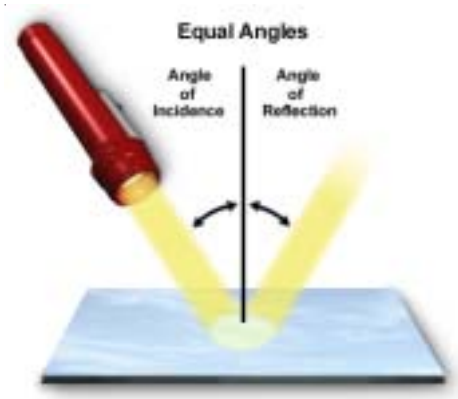
Activity. After reading aloud the vignette, challenge students to write their names backwards. Have students use mirrors to check to see if they correctly reversed the letters. Students can also use the mirrors as they are writing and write messages to their parents or friends. After looking at reproductions of da Vinci's notebook pages, challenge students to draw designs of fantastic flying machines or space ships. Have them label their designs using mirror writing.

ACTIVITY 6

Mirror, Mirror on the Wall: Angles of Reflection

Have you ever wondered why you can see your face in a mirror? Mirrors are very smooth and shiny. Light bounces, or reflects, off of the smooth and shiny surface of mirrors. When you see your face in a mirror you are seeing light from your face reflecting off the mirror.

Light bounces off mirrors very much like a bouncing ball. You can throw a ball straight down, and it will bounce straight back at you. Or you can bounce a ball at an angle and it will bounce off the floor at the same angle away from you. Light reflects the same way off a mirror. Light reflects from a mirror at the same angle as it arrives.



MATERIALS:

- ☐ Mirror
- ☐ Masking tape
- ☐ Paper
- ☐ Science Notebook

1. Work with a partner to do this activity. Find a place where there is a wall with plenty of space around it. Attach the mirror flat on a wall with masking tape. The mirror should be at eye level. Cover the mirror with a piece of paper.

2. Now both you and your partner try to predict where you both need to stand to see each other's reflection on the mirror. When you both agree on the places, mark them on the floor with pieces of masking tape. Draw a diagram in your Science Notebook.

3. Now remove the paper from the mirror. Stand at your chosen places. Can you see each other in the mirror? Write several sentences in your Science Notebook about what you discovered.

4. If you cannot see each other, try different places until you can. Mark the places that work with the pieces of masking tape.

5. Now place long pieces of masking tape on the floor from the center of your place markers from step 2 to the wall straight under the center of the mirror.

6. Look at the angles made by the taped lines on the floor and the wall. Measure the angles with a protractor. Draw a diagram in your Science Notebook that shows the angles.

7. In your Science Notebook, write a description of what you did in this activity.

8. Compare your results with other students in your class and write down any questions that you still have about mirrors and reflections in mirrors.

9. With your partner, design a *different* way to show this same idea to a parent or friend. Record this in your Science Notebook.

ACTIVITY 7

Mirrors and Multiple Images

What is it that lets us see objects? If an object does not emit its own light, then it must reflect light in order to be seen. The walls in the room do not emit their own light; they simply reflect light from overhead lights or from window light. Polished metal surfaces reflect light quite similar to the silvering on the back of a mirror.

The reflection of light involves two rays, the incoming or incident ray and the outgoing or reflected ray. The law of reflection requires that two rays are at identical angles but on opposite sides of the normal which is an imaginary line at right angles to the mirror located at the point where two rays meet. Reflected light follows the relationship known as Snell's Law, which states that the angle of incidence equals the angle of reflection, as you and your students discovered in Activity 6.

Reflection of light from a smooth mirror-like surface, such as water, results in a clear image and is called specular. When the surface of a lake or pond is wind-blown, the incident rays strike the surface of the water at many different angles. As a result, the reflected rays produce an unclear image. The reflection of light from such a surface is called diffuse reflection.

Activity. To illustrate this concept, have students, take a piece of aluminum foil that is smooth and observe the clarity of the image. Then they roll the aluminum foil into a tight ball, open it back up, and observe the image. Have students record their observations in their Science Notebooks.

Brainstorming activity. Before beginning this activity, place students in small groups and have them list uses of mirrors, types of mirrors, or places they have seen mirrors. This is a good warm-up activity to encourage students to clarify what they learned in Activity 6 and to further extend their thinking about mirrors. You may want to have students create a K-W-L chart (See Activity 2).

Materials:

- ☐ 2 mirrors
- ☐ Masking tape
- ☐ Paper
- ☐ Protractor
- ☐ Science Notebook
- ☐ Tape measure

Before you begin this activity, have your students "hinge" two mirrors using masking tape on the back or clear tape on the front.

What will the students do?

This activity builds on Activity 6: Mirror, Mirror on the Wall: Angles of Reflection.

1. Students will observe the relationship between the angles of two hinged mirrors and the number of images produced. On a piece of paper or cardboard, have students mark angles of 180 degrees, 90 degrees, 60 degrees, 45 degrees, 36 degrees, 30 degrees and 20 degrees.
2. Students will open the hinged mirrors to each of the above angles and place an object (for example, a paper clip or a coin) between the two mirrors. Students will then count and record the number of images they see at each of the seven angles.

What is happening?

When you put an object between the 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 number of images that you see in the mirrors depends on the angle that the mirrors form. As you make the angle between the mirrors smaller, the light bounces back and forth more times and you see more images.

Extensions:

Activity. A spoon is a good example of both a concave mirror and a convex mirror. Have students look at one side of the spoon. Have them write down in their Science Notebook what they see. (For example, they might say that the reflection upside down or right side up or that it is smaller or larger than their face?)

Turn the spoon around and make the same observations. The side of the spoon that caves in is called a **concave mirror**, and the side that curves outward is called a **convex mirror**.

Writing. Have students create a science fiction story that addresses the following:

- science facts about mirrors, reflection, or lenses
- strange or unusual happenings
- human nature

For example, an alien lands on Earth and sees its reflection for the first time when it lands near a clear pool of water. Or, a young person finds a "magic mirror" that shows what it was like at different eras in history. The variations are endless!

Reading. Suggest the following books for students to read.

- *The Face in the Mirror* (ISBN 0688153941) by Stephanie Tolan. This book for young adults blends Shakespeare, a ghost story, and life in the theater. About a 15-year-old boy who is sent to live with his father who works in the theater.
- *The Secret of Mirror Bay* (ISBN 0448095491) by Carolyn Keene. A Nancy Drew mystery where Nancy and her friends investigate reports of a mystery woman gliding over the water at Mirror Bay.

Poetry. Copy the poem *I Am Your Mirror Image*, from *A Pizza the Size of the Sun* by Jack Prelutsky (ISBN 0-590-14963-6). The entire poem is written so it can be read when held up to a mirror. Have students use their mirrors to read the poem to one another.

HISTORICAL VIGNETTE: CAROLINE HERSCHEL

Caroline Herschel was born in 1750 to a working class family in Germany. When she was ten she became sick with Typhus and, from that time on, she thought her only option would be to become a servant. Typhus stunted Herschel's growth, and she never grew past four feet three inches. Her father was sure she would never marry because he considered her to be so ugly. Herschel's family was sure she would not amount to anything other than being a maid, and so she became one.

After a few years of being a maid, Herschel went to live with her brother, William. He felt sorry for her and needed a housekeeper. William was a musician but had developed a deep love of astronomy. William had the desire to see deep into space and the only way he could do this was by constructing powerful telescopes. After receiving a pension from King George III, William quit music to devote all of his time to making and selling telescopes. In time Herschel began to help him in his business. She spent long hours grinding and polishing the mirrors they used to collect light from distant objects. At the age of 32, she became an apprentice to her brother. As Herschel gained confidence, she became more and more of a help to her brother. Frequently when he would leave on business, Herschel would take over in his place. Visitors began to recognize her authority, and King George III gave her an annual pension of fifty pounds. This was the first time that a woman was recognized for a scientific position.

While Herschel lived and worked with her brother, she discovered eight comets, which was a great accomplishment in the late 1700's. Herschel received the Gold Medal of Science for her

life's work from the King of Prussia and became an honorary member of the Royal Astronomical Society and the Royal Irish Academy.

Writing. Have students imagine a letter that Caroline Herschel would have written to her brother after she took over his work. What kinds of things would Caroline write about? Would she discuss household matters? Would she want to share her latest news about looking for comets? As an extension to this have students imagine that Caroline and William had e-mail and could communicate regularly. How would their correspondence be different?

ARTIST VIGNETTE: LEONARDO DA VINCI

Leonardo da Vinci (1452-1519), known as a genius of the Renaissance, was an artist, inventor, engineer, theatre designer, and architect. He is well known for his many notebooks and sketchbooks that continue to be used for study today. Leonardo's notebooks are significant because he did not only record his observations of natural phenomena, he attempted to figure out how things work. To explain his work, Leonardo wrote long descriptions that included diagrams of his scientific and mechanical projects.

Leonardo da Vinci wrote in Italian using a special kind of shorthand that he invented himself. People have long been puzzled by his use of "mirror writing" in his notebooks. His notes started at the right side of the page and moved to the left. Only when he was writing something intended for other people to read did he write left to right. Contemporaries of Leonardo recorded that they saw him write and paint left-handed. He also made sketches showing his own left hand at work. Being a lefty was highly unusual in Leonardo's time. Because people were superstitious, children who naturally started using their left hands to write and draw were forced to use their right hands. No one knows the true reason Leonardo used mirror writing, though several possibilities have been suggested:

- He was trying to make it harder for people to read his notes and steal his ideas.
- He was hiding his scientific ideas from the powerful Roman Catholic Church, whose teachings sometimes disagreed with what Leonardo observed.
- Writing left handed from left to right was messy because the ink just put down would smear as his hand moved across it. Leonardo chose to write in reverse because it prevented smudging.

Mirror Writing Activity

Materials: paper, pencils, pens, markers and mirrors.

Procedure: Distribute paper and pencils and encourage students to try writing their signatures in cursive from right to left. If students have difficulty forming these letters in reverse, have them try the following: Hold a pencil in each hand. Write backwards with the usual writing hand while writing forwards with the opposite hand.

Have students write backward with pens and markers to make comparisons. Is one kind of writing tool easier to use this way than another? Distribute mirrors and show students how to position them to one side of there backwards writing to read it normally. A mirror also lets them check to see if they actually reversed all letters. Have students try writing reverse messages to a partner who can then decipher them with a mirror.

Follow-up discussion. Ask students if the type of writing implement made a difference in the ease of mirror writing. You may also see if anyone was left handed in the class and whether it was easier or harder for them to do the mirror writing. Have students hypothesize why they think that Leonardo used this technique in his notebooks.

Activity 7

Mirrors and Multiple Images

What is it that lets us see objects? If an object does not put out its own light, then it must reflect light in order to be seen. The walls in the room do not put out their own light; they simply reflect light from overhead lights or from window light. Polished metal surfaces reflect light like the silvering on the back of a mirror.

When you put an object between two hinged mirrors, light from the object bounces back and forth between the mirrors before it reaches your eves. An image is formed each time the light bounces off a mirror.

In this activity you are going to be investigating how the angle between two hinged mirrors determines the number of images you see.

Materials:

- ❑ Mirrors
- ❑ Masking tape
- ❑ Paper
- ❑ Protractor
- ❑ Pencil or some other object such as a coin or paper clip
- ❑ Science Notebook

1. Work with a partner. Take two mirrors; place them together with the shiny sides facing one another. Tape them along one side to form a hinged door. The mirrors should be able to open freely like a book.

2. Take a piece of paper or cardboard. Using a protractor, measure and mark angles (by drawing a line) of 180 degrees, 90 degrees, 60 degrees, 45 degrees, 36 degrees, 30 degrees and 20 degrees.

3. Place the hinged mirrors at each of these angles and put an object (it could be a coin, a pencil, an eraser, or some other item you may have at your desk) between them as close to the mirrors as possible.

4. Count the number of images you see and record your observations in the chart below.

Angle between mirrors	Number of images	Observations

Answer the following questions in your Science Notebook:

1. What happened to the number of images you saw as you changed the angle from 60 to 45 degrees between the mirrors?
2. What happened to the number of images you saw as you changed the angle from 30 degrees to 60 degrees?
3. What can you say about the angle of the mirrors and the images that are produced?
4. Compare your chart with the charts of other groups. How were they alike? How were they different?
5. If you were to do this experiment again, would you change anything? What did you discover from doing this activity?

Student SELF-CHECK

Module 3: Mirrors and Images

Now that you have completed Module 3, follow the directions below as a self-check to see if you need more practice.

1. When light strikes a shiny surface such as mirror, what happens to the light?

2. What instrument would you use to measure angles?

3. Light hitting a mirror behaves like a ball hitting a wall. Explain what this means.

4. If you had two hinged mirrors with a paper clip in front of them, would you see more paper clips with 45 degrees between the two mirrors or would you see more paper clips with 20 degrees between the mirrors?

5. Name 3 uses of mirrors.