LITTLE ENGINEERS

CAN DO!

LESSON PLANS, READINGS & ACTIVITIES

PHYSICAL SCIENCE

PHYSICAL SCIENCE

FREAKY FRICTION

GRADE LEVEL: 2 | TIME REQUIREMENT: 1-2 HOURS

INTRODUCTION

Children learn science more effectively when they work like scientists to collaboratively explain what they experience. By connecting what they are doing today with the work of scientists and engineers in the past, they begin to understand the value of investigations and the power in the investigative process itself.

The following activity asks students to investigate properties of materials and friction. In most states, students in the second grade are expected to be able to explain phenomena regarding friction and the basic properties of materials. In order to prepare students, appropriate scaffolding experiences should be provided in kindergarten and first grade.

OBJECTIVE

Students will first listen to a story about tanks from World War II getting stuck in mud and will then investigate the properties of friction by packing rice and other materials around an object in a bottle. By modifying variables, discussing their observations, and coming to conclusions, they will learn about friction and how to work like a scientist.

STANDARDS

NGSS DCI PS1A
Structure of matter.

NGSS SEP
Planning and carrying out investigations.

NGSS CCC
Cause and Effect.

CCSS RI.2.8
Describe how reasons support specific points the author makes in a text.

CCSS W.2.7
Participate in shared research and writing projects.

CCSS MP.2
Reason abstractly and quantitatively.

PERFORMANCE EXPECTATIONS

NGSS 2-PS1-2
Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

HOW TO USE THIS RESOURCE

After reading the story about a real WWII situation with students and discussing it with them to ensure their understanding, lead them through the following investigation of friction.

Materials (per group or station)

- Plastic bottle (like a used sport drink bottle)
- Chopstick or long pencil
- Uncooked rice, sand, or dirt

Throughout the investigation, have students make predictions before making observations. Have students draw pictures of what they are doing and observing. Have students discuss their ideas and explanations. Record student observations in a place where the whole class can see and discuss them.

Instructions

1. Fill your plastic bottle with uncooked rice, sand, or dirt.
2. Insert a pencil or chopstick into the mouth of the bottle so that it enters the material you filled your bottle with. Lift up on the pencil or chopstick. Observe how the pencil or chopstick just slides out with no resistance.
3. Now tap the bottle against a table or desk so that the material inside settles and becomes more tightly packed.
4. Insert the pencil or chopstick into the bottle of material again, pushing it as far down as you can. Now pull up on it. The material should be so tightly packed against the pencil or chopstick that the friction will prevent it from coming out of the bottle and allow you to lift the bottle using just the pencil or chopstick.
5. Further investigation: Would this work with other substances? What kinds? What about sand? Would it work with tools other than a pencil or chopstick?

To discuss with students

WHAT IS FRICTION?

Friction is a force that exists between two objects rubbing together. Friction slows the movement of each object as they slide against each other. Many times, such as in flight, people try to design things that reduce friction. However, sometimes we want to increase friction and get it to work for us. Without friction, we wouldn't be able to walk or drive in a controlled or safe way. The friction between your shoes and the ground allows you to stay upright. Without that friction, walking, or even standing, would become very difficult. That's why walking on ice is very difficult—there is very little friction.

In the Freaky Friction activity, the pencil or chopstick is able to lift the bottle full of material because of friction. Because the material is tightly packed in the bottle when the pencil or chopstick is inserted, the friction of the grains of material push against the pencil or chopstick and prevent it from sliding out. However, when the material is loose in the bottle, the force of the friction is less than the weight of the material; thus, the pencil or chopstick slides out. Particles of different sizes and shapes will pack differently and create varying amounts of friction.

FURTHER READING

+ *Sheep In a Jeep,* by Nancy E. Shaw

A rhyming picture book in which talking pigs and sheep investigate forces such as friction while trying to travel together in an old Jeep.

READING
FREAKY FRICTION

Have you ever been in a car that got stuck in the mud or that was slipping on the road because of snow or ice? Situations like this happen due to a lack of friction. Friction is the force between two objects rubbing together. How could you make or design a vehicle that would travel better on wet and sticky roads or across slippery surfaces?

In World War II, soldiers often had to travel over bad roads or sometimes even off-road. Some soldiers traveled in vehicles called tanks. Tanks are made to be strong for protection, but they have another special feature too. Instead of wheels like a car, they use tracks like a bulldozer. The tracks provide more area for the tank to push against the ground and spread its weight across more of the ground so that it avoids getting stuck.

The tracks on a tank help it move over beaches and muddy ground. Many times, soldiers in World War II had to land on jungle islands with wet sandy beaches. The tank tracks pushed against the beach sand better than wheels. As a result, though the tanks went slower than they would if they had wheels, their tracks helped the tanks get across the beach sand where a car or truck with wheels would get stuck. The tracks also helped when the soldiers had to move through the jungles. In the jungles, there were no roads, and the ground was covered with plants and sticky mud. Normal tires would get stuck in holes or between logs and sink into deep mud. The tracks helped the tanks roll right over the holes and logs, and they didn't sink into the mud as much.

At other times, soldiers in World War II had to go over mountains. Sometimes in the mountains, ice and snow would cover all the roads. The tank tracks kept the tanks from sliding down the icy roads and crashing. If the ice was very hard and snow was very deep, there would be no way a vehicle with wheels could get through. Using their tracks, the tanks could roll over ice and get through deep snow.

Soldiers pushing Jeep stuck in mud, Italy, November 1943.
(Image: The National WWII Museum, 2002.337.244.)

NAME: **DATE:**

During World War II, soldiers were able to use friction to help them move over slippery and muddy roads and surfaces. Let's investigate how!

Your teacher will give you directions and supplies for your investigation. You will be given material, like sand, dirt, or rice. When these small objects are pushed together, something interesting happens.

2 1/2 ton Army truck stuck in the mud in Italy, November 1943.
(Image: The National WWII Museum, 2002.337.269.)

Sherman tanks on the sandy beach of Kwajalein island, February 1944.
(Image: The National WWII Museum, 2002.075.022.)

Follow the instructions. Be careful with the materials.

Before you make observations, say or write down what you think will happen. Draw pictures of what you see. After the activity, decide if your predictions were correct or incorrect. Discuss with your classmates what is happening, and try to explain it out loud or written down.

PHYSICAL SCIENCE

SECRET SOUNDS

GRADE LEVEL: 1 | TIME REQUIREMENT: 1-2 HOURS

INTRODUCTION

This activity allows students to investigate how sounds and vibrations are related. Students learn about waves as mechanical phenomena throughout elementary school, and they connect patterns of motion to waves. Students can start this development as early as kindergarten and further develop the ideas through the first and second grades.

OBJECTIVE

Students will learn about noisemaking 'crickets' that some soldiers carried to communicate during World War II. Using this as a launch point, they will investigate how sound moves through materials. Thus, they will learn about waves, about conducting their own investigations, and about collaborating to come to a consensus explanation.

STANDARDS

NGSS DCI PS4
Wave Properties.

NGSS SEP
Constructing explanations (for science) and designing solutions (for engineering).

NGSS CCC
Cause and Effect.

CCSS SL.1.1
Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups.

CCSS W.1.7
Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions).

CCSS MP.5
Use appropriate tools strategically.

PERFORMANCE EXPECTATIONS

NGSS 1-PS4-1.
Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.

HOW TO USE THIS RESOURCE

Read the story about a real WWII situation with students and discuss it with them to ensure their understanding, and then lead them through an investigation about sound waves.

Materials (per group or station)

- String, cut to a length of 3 feet
- Large metal utensils (the utensils that carry sound waves must be ONLY metal, for example no plastic or wooden handles.) You can use utensils of other materials for comparison.

Have students make predictions before making observations. Have students draw pictures of what they are doing and observing. Have students discuss their ideas and explanations. Record their observations and conclusions for all the class to see and discuss.

Instructions

1. Cut a piece of string about 3 feet in length.

2. Create a loop in the middle of the string and tighten the loop around one end of a metal spoon or spatula.

3. Wrap both ends of the string around each of your index fingers and hold the string so that the utensil is swinging freely in the air.

4. Swing the utensil so that it knocks against the edge of a desk or table. Ask "What do you hear?"

5. Next, lift the ends of the string to your ears as though you're going to plug your ears. You don't need to shove the string inside your ears, just hold them against your ears.

6. Now, lean forward and swing the utensil against the desk or table again. What did you hear this time? You should have heard something more like a church bell or a gong vibrating through the string by your ear.

For extra experimentation, you could also try this investigation with wood or plastic utensils to see if the same thing happens or if students hear something different.

To discuss with students

HOW DO SOUNDS TRAVEL?

What materials carried the sound well? What materials didn't? Sound travels in waves as the particles in air or water or metal vibrate. Things made of wood or rubber or other soft substances tend to absorb the vibrations and not pass them along. Stiff materials like metal pass the vibrations along well.

ADDITIONAL RESOURCES

To accompany this lesson, try this book:

+ *What Makes Different Sounds? I Wonder Why,* by Lawrence Lowery

You can get a replica cricket from the National WWII Museum store here: store.nationalww2museum.org/replica-wwii-clicker-d-day-cricket/

READING

SECRET SOUNDS

In the middle of the night, 13,000 young men were on board hundreds of planes over France, a country in Europe. It was June 6, 1944, and these men, who were part of the huge effort to free France from enemy Nazi forces, were about to jump out of the planes using parachutes to land on the ground in the dark.

After they landed, the men had to find each other. Because it was in the middle of the night, the men had all landed in different places in the fields and forests of France, and it was hard to meet up. They couldn't use flashlights or call out to each other because enemy soldiers might hear them. Radios back then were big and heavy and not everyone had one. So how could the men find each other safely and quietly?

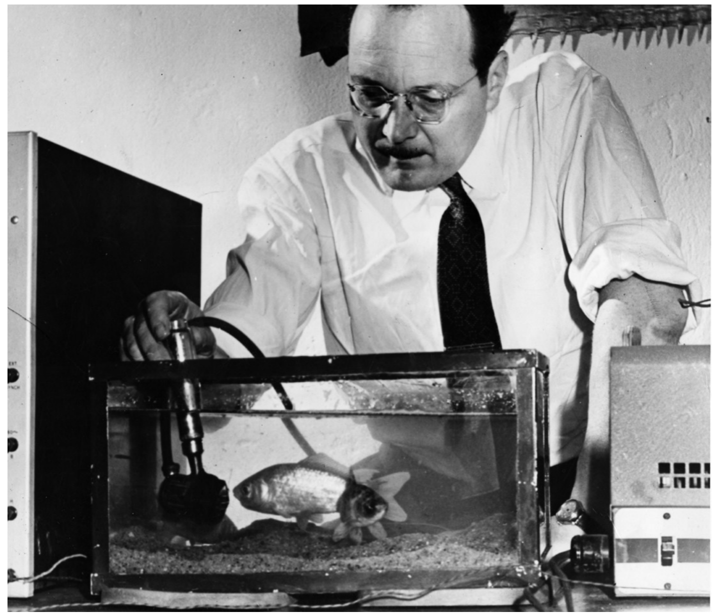
Some of the men who jumped from the planes were supplied with a small piece of metal called a cricket. When the men pressed down on the cricket, it made a clicking sound. Just as real crickets can use sound to find each other in the dark of night, the soldiers used their crickets and followed the sounds of each other's clicks to signal and to find each other in the darkness.

Parachuting soldiers drop from the air into Holland, September 1944.
(Image: The National WWII Museum, 2004.311.089.)

NAME: **DATE:**

We just learned about how soldiers during World War II used secret sounds to find each other in enemy territory by using a metal tool called a "cricket." So why does a piece of metal rubbing on another piece of metal make a sound? What carried that sound across the fields and forests in France? How can the type of material used affect the sound and how far it will carry? Let's investigate to find out.

A military band entertains fellow troops on an Air Base in Texas, 1944. *(Image: The National WWII Museum, 2009.353.003.)*



A scientist demonstrates apparatus to record the underwater sounds of fish, New York, NY, June 1945. *(Image: The National WWII Museum, 2012.019.607.)*

Your teacher will give you information about how sound is made, and how sound travels. You will investigate these ideas using different materials and methods of making and receiving sound waves.

Follow the instructions. Be careful with the materials. Before you make observations, say or write down what you think will happen. Draw pictures of what you see. After the activity, decide if your predictions were correct or incorrect. Discuss with your classmates what is happening and try to explain it out loud or written down.

PHYSICAL SCIENCE

SOLAR OVENS

GRADE LEVEL: K | TIME REQUIREMENT: 1-2 HOURS

INTRODUCTION

Students in the earliest grades develop understanding about the concept of energy. A great introductory example is heat energy, or warmth. It is natural for students to connect heat energy to the sun. In this activity, students connect sunlight to electromagnetic energy and build a device to store and use solar energy.

OBJECTIVE

In this activity students will learn about waves that travel in a different way—light waves and other electromagnetic waves. They will read about the invention of RADAR that uses waves kind of like radios. Observations during the development of RADAR led to the invention of the microwave oven. Using a different form of waves to heat food, the students will build a solar oven. This exercise, an engineering design project, will show students how engineers work to improve things by tinkering and modifying their designs.

STANDARDS

NGSS DCI PS3.D
Energy in chemical processes and everyday life.

NGSS SEP
Analyzing and interpreting data.

NGSS CCC
Cause and effect.

CCSS K.MD.A.2
Directly comparing two objects with a measurable attribute in common to see which object has "more of"/"less of" the attribute, and then describing the difference.

CCSS W.K.7
Participating in shared research and writing projects.

PERFORMANCE EXPECTATIONS

NGSS K-PS3-1
Making observations to determine the effect of sunlight on Earth's surface.

HOW TO USE THIS RESOURCE

Read the story about a real WWII situation with students and discuss it with them to ensure their understanding, and then lead them through an investigation about electromagnetic waves.

Materials (per group or station)

- Pizza box (clean unused)
- Pencils
- Ruler
- Utility knife (for adult to use
- Scissors
- Aluminum foil
- Glue
- Plastic wrap
- Tape
- A sheet of black paper
- Wooden dowels
- S'mores supplies (graham crackers, chocolate, marshmallows) or some

Instructions

1. On the top of the pizza box lid, draw a square that is about one inch inward from each edge. You could modify these instructions and use shoeboxes or other boxes as well.

2. Cut along each side of the square you just drew except for the side that runs along the hinge of the box. Cut all the way through the cardboard on those three sides of the square. Then fold the flap back slightly along the attached side.

3. Line the inside of the cardboard flap with aluminum foil. Fold the edges of the foil over the flap to help hold the foil in place and glue the foil onto the flap. Keep the foil as smooth as possible. Ask the students, What do you think is the purpose of this foil?

4. Cover the opening made by the flap (in the lid) with a layer of plastic wrap. Using shipping tape or black electrical tape, attach the plastic wrap to the edges of the opening. Make sure there are no holes in the plastic wrap and that all of its edges are completely attached to the lid. Ask the students, Why do you think it's important to make sure the plastic wrap completely seals the opening of the lid?

5. Line the inside of the box with aluminum foil also so that when the box is shut the entire interior is coated with foil. It is easiest to do this by covering the bottom of the box with foil and then covering the inside part of the lid (going around the plastic-covered opening) with foil as well. Secure the foil in place with glue. Ask the students, Why do you think we coated the inside of the box with foil like this?

6. Glue or tape a sheet of black paper to the bottom of the box, centering it there. This will act as your solar oven's heat sink. Ask the students, How do you think something like this pizza box could help heat or cook your food?

7. Lastly, use a wooden skewer or pencil (and some tape) to hold the lid of the solar oven upright, at about a 90-degree angle from the rest of the box.

8. If you want to use the solar oven to heat or cook something, a S'more is the easiest and fastest item to use. To make a S'more, break a graham cracker in half and place a marshmallow and small piece of chocolate between the cracker halves. The chocolate will melt long before the marshmallow so it may be best to save the chocolate until after the marshmallow has melted.

9. Place the prepared S'more or item you wish to warm or try to cook on a small square of aluminum foil that is slightly larger than the S'more—this will serve as its tray—and place it in your solar oven on top of the black sheet of paper.

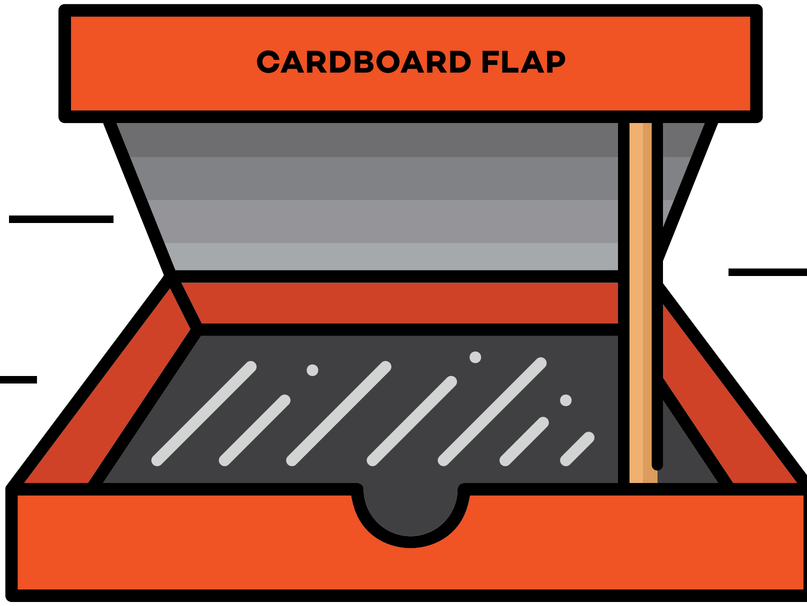
10. Place the solar oven outside where it will get full, direct sunlight for at least 30 minutes, and keep it turned so that the flap faces the sun. How long it needs will depend a lot on the outside temperature and how sunny it is. You could put them outside in the morning and then come back later in the day. When the marshmallow is soft, your S'more should be ready to eat and enjoy! Ask the students, How long does it take to cook the S'more in your solar oven?

ADDITIONAL RESOURCES

To accompany this lesson, try this book:

+ *Let's Ride a Wave!: Diving into the Science of Light and Sound Waves with Physics,* by Chriss Ferrie

SOLAR OVEN

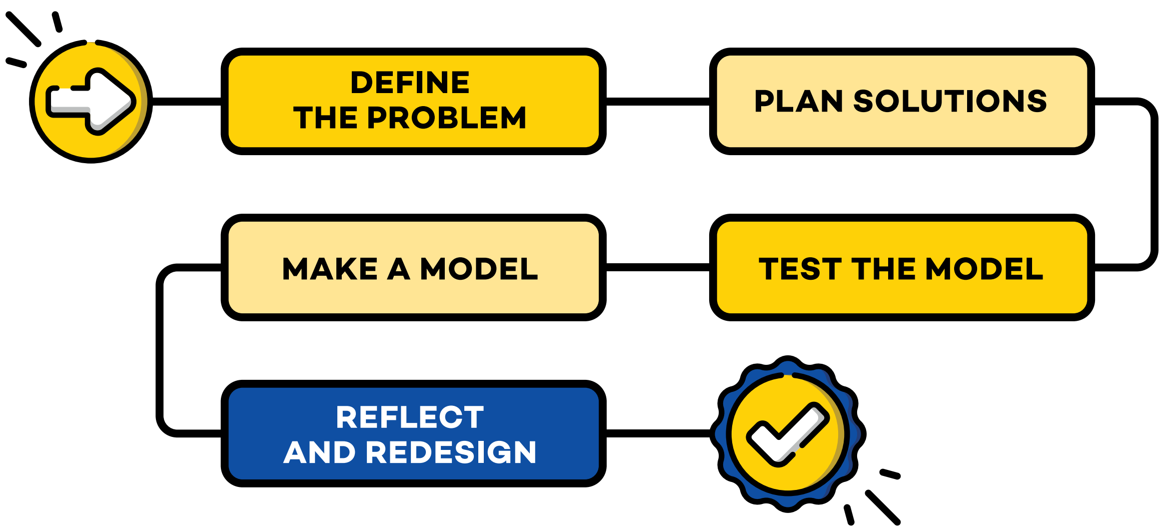

CARDBOARD FLAP
ALUMINUM FOIL
(lines the bottom of the flap)
STICK
(to keep the box open)
PIZZA BOX
BLACK PAPER
(lines the bottom of the box)
CLEAR PLASTIC WRAP
(covers the hole)

To discuss with students

HOW DO ENGINEERS IMPROVE THEIR SOLUTIONS?

Engineers are always trying to improve their solutions to problems. They make something, test it, change it, and then they test it again. There are many variables that you can try to tweak to improve your oven design. What would make your oven heat food faster? What if we change the angle of the reflecting top? What if we insulate it with other material? What if we change its shape or size?

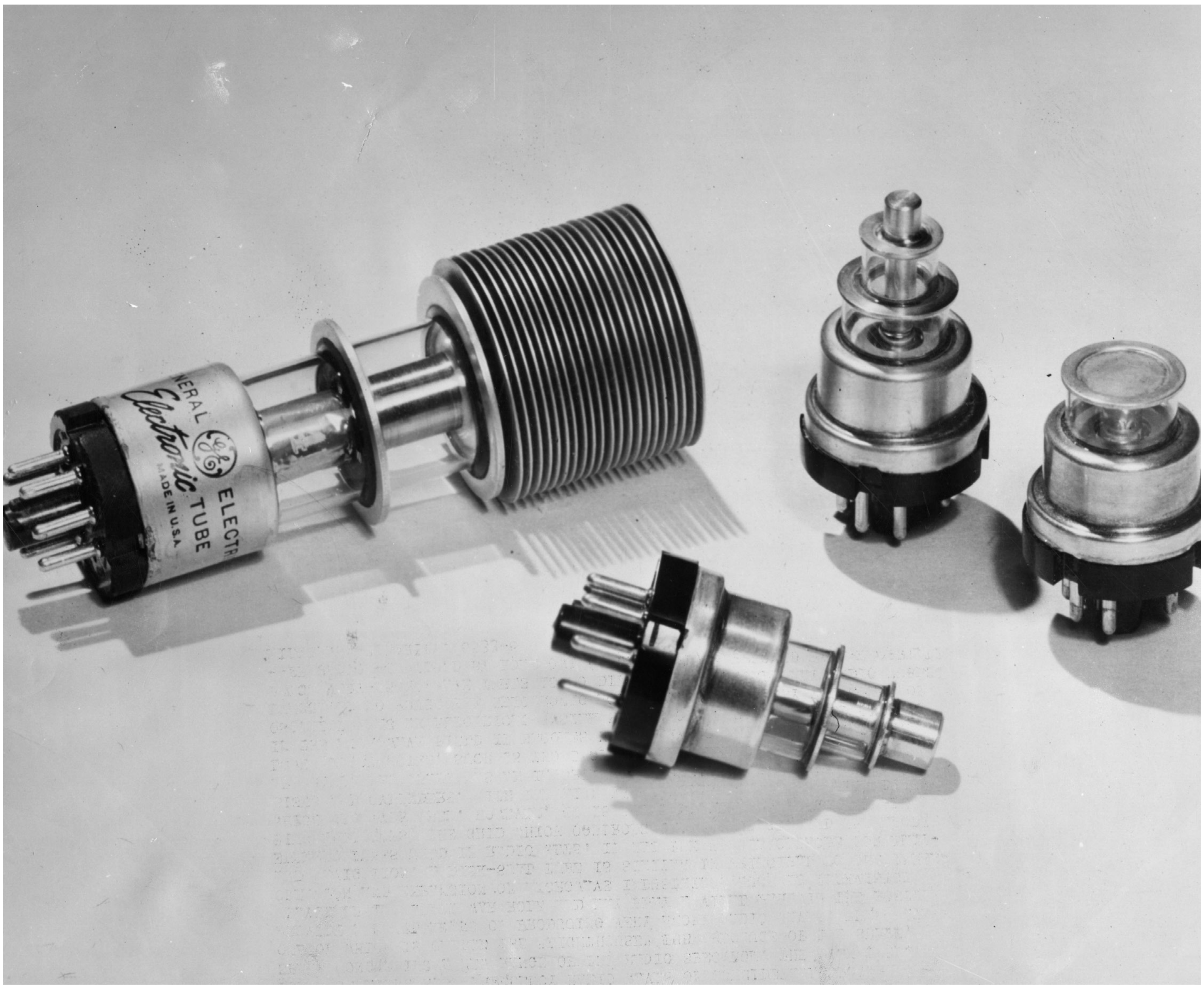
ENGINEERING DESIGN PROCESS



READING
SOLAR OVENS

During World War II, the first microwave was invented, but it was not made to cook food. At that time, scientists were working on an invention that would give off electromagnetic waves, like the sun and stars. The purpose of this invention was to figure out how to find objects, like ships or planes, that were far away or were moving in the dark of the night. While one of the scientists was working on the invention, he had a bar of peanut butter in his pocket. Because chocolate was rationed during World War II, getting chocolate bars was difficult to do. He noticed that the peanut butter bar started to melt when he was working on the invention. He realized that this invention could be used to heat food. After World War II, the invention was sold as the first microwave ovens. Much bigger than microwaves today, the first microwaves sold in stores was over six feet tall!

There are lots of different kinds of electromagnetic waves, and microwaves are just one kind. All waves have one thing in common: they carry energy from one place to another.



Electrical tubes designed to generate microwaves, high energy electromagnetic waves. June 1945.
(Image: The National WWII Museum, 2012.019.602.)

NAME: **DATE:**

Light is the most common form of electromagnetic wave. We can see light everyday shining from the sun. What ways do we use light? Solar energy (light from the sun) is a renewable energy resource. Using solar energy helps us protect and save resources and prevent pollution. Saving energy was important during World War II. One of the ways kids helped out with the war effort was to take part in energy-saving activities. Let's investigate and see what we can do with solar energy.

During World War II, scientists were experimenting with microwaves to detect ships and planes in the dark. However, they found that their invention had a completely different use—to cook food. Your teacher will give you the tools you need to investigate the methods for collecting solar energy to cook or heat food.

Follow the instructions. Be careful with the materials. Before you make observations, say or write down what you think will happen. Draw pictures of what you see. After the activity, decide if your predictions were correct or incorrect. Discuss with your classmates what is happening and try to explain it out loud or written down.

PHYSICAL SCIENCE

BUBBLE VIEWER

GRADE LEVEL: 1 | TIME REQUIREMENT: 1-2 HOURS

INTRODUCTION

Students investigate electromagnetic waves in the form of light throughout elementary school. One of the first things students should investigate is how light interacts with different materials. Is light absorbed, reflected or refracted? In this lesson, students will first examine light as it passes through bubbles, and then they will use the light's refraction in order to estimate the thickness of the bubbles.

OBJECTIVE

Students will read about the research conducted by a scientist during World War II and then will conduct an investigation similar to hers. Students will thus learn about electromagnetic waves (light, in this case) and how the waves interact with matter. At the same time, they will work through investigations and observations like scientists.

STANDARDS

NGSS DCI PS4B
Electromagnetic radiation.

NGSS SEP
Constructing explanations (for science) and designing solutions (for engineering).

NGSS CCC
Cause and effect.

CCSS MP.4
Modeling with mathematics.

PERFORMANCE EXPECTATIONS

NGSS 1-PS4-3
Planning and conducting an investigation to determine the effect of placing objects made with different materials in the path of a beam of light.

HOW TO USE THIS RESOURCE

Read the story about a real World War II situation with students. After discussing the story with them to ensure their understanding, lead them through an investigation about electromagnetic waves and how light bends and refracts as it passes through substances.

Materials (per group or station)

- Flashlight
- Clear plastic lid, like from a Pringles or yogurt container
- Clear packing tape
- Cup
- Dish soap mixed with water in 1:1 ratio
- Straw

Instructions

1. Tape the clear plastic lid to the top of your flashlight. Make sure the rim of the lid is facing out.

2. In a cup, mix together dish soap and water. Use a ratio of 1:1.

3. Turn on the flashlight and dim the lights in the room. The bubble viewer works best in darkness.

4. Carefully pour a teaspoon or so of your dish soap/water mixture onto the plastic lid "platform."

5. Dip one end of your straw into the soap mixture and blow gently into the other end to blow a bubble on top of your flashlight. Carefully remove the straw so that the bubble remains intact on top of the lid. Ask the students, Can you determine how thick our bubble is based on the colors we see in it? Can you tell when it's about to pop?

To discuss with students

WHAT CAN WE PREDICT FROM BUBBLE COLORS?

Can you see the colors on the surface of the bubble? Do the colors change as the bubble gets bigger? Can you tell how thick our bubble is based on the colors we see in it? Can you tell when it's about to pop? Why do we see colors when the flashlight is white light?

ADDITIONAL RESOURCES

To accompany this lesson, try this book:

+ *Let's Ride a Wave!: Diving into the Science of Light and Sound Waves with Physics* by Chriss Ferrie

READING

BUBBLE VIEWER

Do you think you could measure the thickness of a bubble? Katharine Burr Blodgett, a scientist during World War II, figured out how to do it, and she didn't use a ruler.

Dr. Blodgett was working as a physicist for the General Electric company. Her job was to make the lenses on cameras clearer. She did this by coating the glass lenses so that they would be less reflective. Some of Dr. Blodgett's inventions were used in World War II for periscopes in order for submarines to be able to see underwater. Her inventions were also used in the lenses of cameras in airplanes.

While she was investigating the coatings on lenses, Dr. Blodgett noticed something interesting. When light passed through glass, some of the light bent or curved. When light bends, it splits into colors, much like a rainbow. The amount that light is bent determines the colors we see. Blodgett realized that because of this she could tell the thickness of the liquid coating on the glass to a millionth of an inch just by looking at the color. Not only was her invention simple and cheap, it was also very accurate.

The "invisible glass" she invented had very little reflection and is still used today on computer screens, car windshields, eyeglasses, and other things.

Air crewman, in leather flight suit and hat, carrying an airplane camera.
(Image: The National WWII Museum, 2009.278.510.)

NAME: **DATE:**

Dr. Katharine Blodgett's experiments with trying to create glass lenses that were clearer led her to a discovery on light refraction—the bending of light. She learned how to measure how much liquid was on glass by the colors created from light when it hit the glass surface. Do you think you can estimate how thick a liquid is by using colors that you see? Can you find out how thick a bubble is using the same method as Dr. Blodgett?

Your teacher will give you the materials you need to investigate the thickness of bubbles based on the color of light that passes through them.

Follow the instructions. Be careful with the materials. Before you make observations, say or write down what you think will happen. Draw pictures of what you see. After the activity, decide if your predictions were correct or incorrect. Discuss with your classmates what is happening and try to explain it out loud or written down.

Use the line of numbered colors below as your bubble thickness color gauge. Matching the colors in your bubbles to the colors and numbers on this gauge will help you determine how thick your bubble is (and when it's about to pop). The colors of your bubbles may not totally match those on the color gauge because the exact color of your bubble will depend on the angle of the light, the type of soap you use, and other factors.

This gauge shown on the right uses nanometers as the unit of measure. A nanometer is 1 millionth of a millimeter. Think about the hair on your head. One hair is 75,000 nanometers thick. A human red blood cell is between 6,000 and 8,000 nanometers. Katharine Burr Blodgett's gauge wasn't good enough to measure objects that thin, but it was the best and least expensive method of the time. Before her discovery, people could only measure up to 1000th of an inch. Blodgett came up with a method that was a thousand times better and didn't require any fancy equipment. The color gauge goes from thin to thick and cycles through the rainbow spectrum. When the bubble gets dark around the edges, that means it's about to pop.

US airmen hold an aircraft camera used to take surveillance photos.
(Image: The National WWII Museum, 2009.278.329.)