The Science Play Activities were developed in response to a need for activities that could be implemented in situations when typical classroom patterns have been disrupted, such as by extreme events (e.g., earthquake, hurricane, evacuation). In these situations, there is likely to be uncertainty about material resources, time, and consistent attendance by students. Students in such situations will benefit from activities that are designed to bring out positive feelings by seeming very much like play, but that also provide opportunities for learning of limited and accessible ideas to help students recognize their capacity to gain new understanding. These Science Play Activities are also designed to use accessible materials and to generate items that the student can take away to share with friends and family — which is itself motivating and empowering.

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### SUPPLIES FOR CLASS OF 30

<table>
<thead>
<tr>
<th>Item</th>
<th>Total Quantity</th>
<th>Number per Student</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balloons (about 20 cm)</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Tissue Paper</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Straws (flexible end)</td>
<td>450</td>
<td>15</td>
</tr>
<tr>
<td>Paper cups (9 oz)</td>
<td>120</td>
<td>4</td>
</tr>
<tr>
<td>Pencil</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Clear, plastic cups (9 oz)</td>
<td>150</td>
<td>5</td>
</tr>
<tr>
<td>Clear, plastic cups (small, 1.5 oz)</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Small cups, (3 oz)</td>
<td>90</td>
<td>3</td>
</tr>
<tr>
<td>Tape</td>
<td>60 meters</td>
<td>2 meters</td>
</tr>
<tr>
<td>Cotton string</td>
<td>180 meters</td>
<td>6 meters</td>
</tr>
<tr>
<td>4 inch x 6 inch (10cm x 15cm) Index cards</td>
<td>360</td>
<td>12</td>
</tr>
<tr>
<td>Thick rubber bands</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Thin rubber bands</td>
<td>60</td>
<td>2</td>
</tr>
<tr>
<td>Metal spoon or fork</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Clean paper</td>
<td>60</td>
<td>2</td>
</tr>
<tr>
<td>Printed/newspaper</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Small piece of sponge (about 2cm x 3cm)</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Large paper clips</td>
<td>480</td>
<td>16</td>
</tr>
<tr>
<td>Dark marker or crayon</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Scissors (can be shared)</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Coin (penny)</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Sewing pin</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Small/thin straw (about 3 mm diameter)</td>
<td>30</td>
<td>1</td>
</tr>
</tbody>
</table>
**Ringing a Spoon**

<table>
<thead>
<tr>
<th>Potential Conceptual Focus: Waves travel at different speeds through different media.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Activity Brief:</strong> Students listen to the sound made that is hanging from a string. First the sound travels through air, then the sound travels through the string and the student’s finger tips. The sounds heard are very different, despite being made by the same object in the same way.</td>
</tr>
<tr>
<td><strong>Kit Materials:</strong></td>
</tr>
<tr>
<td>• 1 m string</td>
</tr>
<tr>
<td><strong>Materials at Setting:</strong></td>
</tr>
<tr>
<td>• spoon (fork, or other metal object that is flat or made of wire)</td>
</tr>
<tr>
<td>1. Tie a spoon (or other metal object) at the mid-point of the string.</td>
</tr>
<tr>
<td>2. Wrap one end of the string around an index finger. Repeat with the other end of the string on the other index finger.</td>
</tr>
<tr>
<td>3. Lean over so that the object hangs freely, and let it hit a hard object such as the edge of a table. Listen to the sound as it comes through the air to your ear.</td>
</tr>
<tr>
<td>4. Put the tips of the index fingers into your ears. Lean over so the object hangs freely. Tap the object and listen. Compare to the sound through air.</td>
</tr>
<tr>
<td><strong>Energy Connections:</strong> Energy can move through different materials. As it does, some aspects of its properties change. In this case, the energy from tapping the spoon moves through the solids more quickly than through air. This affects the wavelength and the tone that is heard.</td>
</tr>
<tr>
<td><strong>Geoscience Connections:</strong> As energy in the form of seismic waves passes through the crust and in to the mantle and core it encounters different boundaries. The differences in the properties of each layer cause the waves to bend in a predictable direction. These relationships enable geoscientists to determine Earth’s interior structure from the surface.</td>
</tr>
<tr>
<td><strong>STEM Connections:</strong> Scientists can measure the characteristics of waves traveling between two locations and compare them. Because scientists understand precisely how waves are changed by different materials, comparing these measurements allows them to infer the properties of the materials the wave(s) have traveled through.</td>
</tr>
<tr>
<td>Repeat this activity using several items of different sizes and materials. What patterns can you identify in how different objects affect sound?</td>
</tr>
</tbody>
</table>
Ringing a Spoon, continued

Materials

Step 1

Step 2
# Clattering Cup

**Potential Conceptual Focus:** Movement of objects against one another can cause waves that can in some cases be converted into sound.

<table>
<thead>
<tr>
<th>Activity Brief:</th>
<th>Kit Materials:</th>
</tr>
</thead>
</table>
| Students make a device that creates an unexpected sound. This helps them recognize the connection between vibrations and sound. | • 1 m string  
• Small sponge (2 cm x 3 cm — dampened)  
• paper cup  
• Two paper clips |
| 1. Punch a hole in the bottom of a cup with a sharp pencil. Feed string through hole.  
2. Tie a paper clip to each end of the string. Pull the string so the paper clip inside the cup is against the hole.  
3. Hold the cup up so that the paper clip outside the cup hangs down.  
4. Use the damp piece of sponge to pinch the hanging string near the cup. Pull down in a jerking motion. Listen to the sound. | |

**Energy Connections:**

Rubbing the string causes vibrations that travel through the string, making the bottom of the cup vibrate. Those vibrations are then transferred to air, making sound. Sound energy is a vibration that travels as waves through materials. We hear most sounds through the air.

**Geoscience Connections:**

Many types of movements can cause vibrations that travel as waves. Earthquakes, for example, are sudden movements that send vibrations traveling out from the site (epicenter) of the earthquake. While those vibrations (called seismic waves) are outside of the frequency range that people can hear, people have built instruments (called seismometers) to detect them. We can also see the effects of large earthquakes on the ocean floor at the surface by the movement of a tsunami.

**STEM Connections:**

The string and cup were used in a particular way to make one type of sound. How can changing the materials (e.g., different type of string, different cup, longer string) change the sound made? The sound was made by rubbing the string with the sponge. What else could be done to the string to make the sound?
Clattering Cup, continued

Materials

Step 1

Step 2

Step 4
### Cup Phone

#### Potential Conceptual Focus:
Vibrations travel through a medium.

#### Activity Brief:
Students each build a device that can be used as a half of a cup phone. Then, working with a partner, they create and test a full cup phone. Additional investigations can be done using three or more of the devices linked together.

1. Punch a hole in the bottom of a paper cup with a sharp pencil. Feed string through hole.
2. Tie a paper clip to each end of the string. Pull the string so the paper clip inside the cup is against the hole. Hold the cup up so that the paper clip outside the cup hangs down.
3. Working with a partner, clip the loose paper clips (the ones hanging outside the cup) of two cups together. Pull the string tight.
4. Have one partner talk into a cup while the other partner holds the other cup up to her/his ear. Listen to the sound of the partner’s voice.

#### Energy Connections:
Energy can be transferred from one place to another in several ways. Mechanical waves (that is, vibrations in matter) can transfer energy through matter. There are some conditions necessary for this to occur in different materials. In the case of the string, it must be pulled tight for the energy to move along the string.

#### Geoscience Connections:
Different Earth materials transfer waves more or less effectively. In fact, some Earth materials can amplify waves that pass through them. Unconsolidated sediments (e.g., loose soil, gravel sand or mixtures) can amplify the effect of seismic waves that pass through them, causing stronger ground movements than in compact rock.

Other materials and/or structures can lead to a decrease (damping) of the earthquake effects.

#### STEM Connections:
What makes the most effective cup phone?
Can three of the end paper clips be connected and have the phone still work?
What are the effects of using different string lengths, different types of string, and different types of cups on the phone?

#### Kit Materials:
- 1 m string
- Paper cup
- Two paper clips
Cup Phone, continued

Materials

Step 1

Step 2

Step 3
### Balancing Card

**Potential Conceptual Focus:** Gravity is a Universal force of attraction.

<table>
<thead>
<tr>
<th>Activity Brief:</th>
<th>Kit Materials:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students fold over a card to make a triangle, which they see cannot be balanced by its point. Adding structures to each side of the triangle allows it to balance.</td>
<td>- Index cards about 10 cm x 15 cm (4” x 6”)</td>
</tr>
<tr>
<td>1. Fold an index card diagonally so that a short edge meets a long edge. This will form an isosceles right triangle with an extra small rectangle.</td>
<td>- Two flexible straws.</td>
</tr>
<tr>
<td>2. Cut off the rectangle so that just a folded right triangle remains.</td>
<td>- Four paper clips</td>
</tr>
<tr>
<td>3. Tape around the edges of the triangle.</td>
<td>- Tape</td>
</tr>
<tr>
<td>4. Try balancing the point of the right angle on your finger.</td>
<td></td>
</tr>
<tr>
<td>5. Put two paper clips on the long edge (hypotenuse) of the triangle — each about 3 cm from the center of that edge.</td>
<td></td>
</tr>
<tr>
<td>6. Push a flexible straw onto each paper clip so they hang down when you try to balance the right angle on your finger. Add a paper clip to the bottom of each flexible straw.</td>
<td></td>
</tr>
<tr>
<td>7. Try again to balance the triangle.</td>
<td></td>
</tr>
</tbody>
</table>

**Energy Connections:**
Gravity is a type of potential energy relating to the position of a body in a gravitational field. It can cause objects to move, depending on their position. If force on two parts of a system are unbalanced, the system may move until the forces are balanced.

**Geoscience Connections:**
Gravity affects all things on Earth, and many things beyond the Earth (e.g., natural and artificial satellites). Gravity always pulls objects toward the center of Earth. Even when forces are balanced (e.g., when a piece of furniture is not moving) gravity is acting on it. Water, sediments, rocks, and even air tend to move from higher positions to lower positions due to gravity until they rest in equilibrium. When humans walk on Earth the ease with which we move is related to the planet’s gravity.

**STEM Connections:**
How might longer flexible straws or more mass affect the balancing card?
Notice that a small movement of your finger can make a large movement in the balancing card. How could this be used as an indicator for vibrations?
Rather than balancing the card on your finger, build a tower for the card to balance on.
Balancing Card, continued

Materials

Step 2

Step 5

Step 6
String Climber

Potential Conceptual Focus: Systems can be arranged in ways that allow forces to combine so that the resulting force is in a different direction than might be expected.

Activity Brief:
Students build a device in which friction and other forces combine so that pulling down causes the device to move up.

1. Fold an index card in half by bringing the two shorter edges together. Make a crease and then unfold the card.
2. Select one of the long edges to be the “top” of the card.
3. Draw a dot on the crease about 3cm from the top edge. Draw a line from the dot to the left corner on the “bottom” of the card.
4. Fold the short edge on the left of the card so that the edge is along the line you just drew, and make a crease.
5. Draw a second line from the dot to the other “bottom” corner of the right side of the card. Fold in the short side on the right so it is along the second line, and make a crease.
6. Unfold the card.
7. Cut a flexible straw in half. Tape half of the straw along each of the creases you made on the left and right sides. Fold the short edges back over so they touch the lines, and tape the corners down against the dot you drew.
8. Push the string through one flexible straw, and then through the other so that the ends come out the “bottom” of the card. Tie a paper clip to each of the ends.
9. Make a hook from a paper clip and have someone hold it. Loop the string over the hook. Holding your hands at about shoulder width, pull back on one side of the string, and then the other.

Energy Connections:
Movement is the result of forces, which require energy. Forces can combine, affecting the speed and direction of the resulting force and motion of an object.

Geoscience Connections:
Earth materials move in many ways. These movements include the movement of solids (e.g., landslides), liquids (e.g., streams), and gases (e.g., wind). Often these movements are the result of a combination of forces. For example, water flowing in a stream is affected by downward force of gravity, but also the frictional effect of the stream bed and banks that retard the flow of water in contact with them. Earth’s moon is kept in orbit by the combination of the moons inertia (which is in a straight line) and the gravity between the Earth and moon. It is the combination that makes the curved path of the moon’s orbit.
STEM Connections:
Suppose you wanted to use this device to lift an object. Would it be strong enough? How much mass can it lift? How could you re-design it so that it lifts more mass?
### Potential Conceptual Focus:
An object with a static charge will be able to attract other objects, such as those made of paper.

### Activity Brief:
Students make a paper figure that is affected by an object that has a static electric charge. Waving the charged object can make the figure wave back and forth in response — that is, dance.

1. Fold an index card in half by bringing the two long edges together and making a crease. Cut the card in half along this fold. Set one half aside.
2. Fold one of the halves in half again by bringing the long edges together. With this piece of the card folded, cut out the figure of a person — legs, arms raised.
3. Fold a small amount (about 1cm) at the bottom of each leg to make feet.
4. Tape the feet to the half of the card that was set aside in step 1. The figure should stand up.
5. Rub a flexible straw with a piece of paper.
6. Wave the flexible straw just above the standing figure.

### Energy Connections:
Some types of forces can act at a distance. These include forces due to magnetism, gravity, electric, and (as in this case) static electricity.

### Geoscience Connections:
Forces that act at a distance are important in many Earth system processes. Gravity is a Universal force related to the mass of an object. Gravity causes the distant asteroids to collide with the Earth, the moon to stay in orbit, as well as tides, landslides, the flow of rivers, and more.

Particles from the sun can interact with the Earth's magnetic field, ultimately causing the patterns we know as the "northern lights" and "southern lights" in the sky near Earth's poles.

### STEM Connections:
Try charging other objects, such as pencils, pens, a ruler, paper cup, plastic up, and so on. How can you use the “dancing man” to test whether the object has become charged?

#### Kit Materials:
- Index card
- Flexible straw
- Tape
Dancing Man, continued

Materials

Step 1

Step 2

Step 3

Step 4

Step 5

Step 6
Potential Conceptual Focus: Static electricity can exert a force across a distance as a charged attract materials by inducing an opposite charge.

Activity Brief:
Students will make a model tree and use a balloon as a model cloud to learn about how lightning can affect tall objects.

1. Fold over the long edge of the tissue paper to make a crease about 2 cm from the edge and unfold it to lay the tissue paper flat.
2. From the other long edge, make cuts from the edge to the fold. Do not cut all the way to the other edge. Make the cuts about every .5 to .75 cm or so (the exact distance is not critical). This will create a fringe along the tissue paper edge.
3. On the edge that was folded over in the first step, lay the flexible straw on the end of the tissue so it is perpendicular to the length of the tissue (that is, laying the same direction the cuts were made. Position the flexible straw so that the end of the flexible straw is at the crease made in the first step, and the rest of the straw extends in the opposite direction of the fringe.
4. Use a small piece of tape to attach the flexible straw to the tissue. Roll the flexible straw toward the other end of the tissue so that the tissue wraps around the end of the flexible straw, leaving the fringe hanging over the end of the flexible straw.
5. Fluff the fringe by gently pulling the cut pieces down, without pulling them off.
6. Hold the flexible straw so the fringe is on top. Place the bottom of the flexible straw in the hole in the cup so it stands. You have made a model tree.
7. Rub the inflated balloon on a piece of paper, a cloth, or a paper towel. This will charge it with static electricity.
8. Move the balloon above the model tree at a distance of only about 2-3 cm from the tree top.
9. You should be able to see the fringe move. Sometimes (depending on humidity and how well charged the balloon is) you may hear small “snap” sounds as static electricity discharges between the tree and the balloon.

Kit Materials:
- Strip of tissue paper, about 8 cm x 20 cm
- Scissors
- Flexible straw
- Tape
- Paper cup (with hole in the bottom)
- Inflated balloon (Note that a second flexible straw can be used in place of the balloon, although the balloon gives a better impression of a cloud)

Energy Connections:
Some forms of energy can exert forces that act across a distance. These include magnetism, static electricity, gravity, and others.

Geoscience Connections:
Many Earth processes involve forces acting across a distance. In this case, static electric charges can build up in clouds, and on objects attached to the ground. The arrangement of charges creates concentrations of net positive and negative charges in different parts of the cloud. If the opposing charges between the cloud base and the ground become strong enough, they can discharge — which may be visible as lightning.
A Tree in a Storm, continued

STEM Connections:
How could you build a second tree in a way that demonstrates why it is safest to stay away from tall objects during a storm?

How can this example be used to show how a lightning rod works.

Materials

Step 1

Step 2

Step 3

Step 8
### Potential Conceptual Focus:
As light or sound move from one material to another, the direction of its movement changes. This is called refraction. A lens works as a result of the refraction of light by the lens. In this case, water refracts the light, acting as a lens.

### Activity Brief:
Make a simple lens using a drop of water. Explore how changing the size of the drop and/or the distance to the thing being viewed changes what is seen through the lens.

1. Hold the flexible straw so that the flexible end is pointed downward. At the upper (non-flexible) end, bend over about 4 cm of the flexible straw completely, so the flexible straw is creased at the top. Now the flexible straw will act like a dropping pipette (medicine dropper). Put the flexible end into a cup of water, squeeze the folded part, and release. When you lift it out of the cup there will be some water in the end of the straw.
2. Set the cup on its side on top of a page of letters. Put one or two drops of water on the inside of the cup. Look down from above the cup through drop.
3. Carefully lift the cup about 1 cm so it is slightly above the page. What do you notice about how the print looks when seen through the drop?
4. Continue lifting the cup so it is several cm above the page. What happens to the appearance of the print?

### Kit Materials:
- Water
- Flexible straw
- Clear plastic cup

### Materials at Setting:
- Page of printed letters that can be gotten wet (e.g., newspaper, magazine)

### Energy Connections:
As light energy moves through a substance (medium) it tends to move in a straight line. When it changes from one substance to another — or if the attributes of the substance (e.g., its density changes) — the path of the energy will change direction. This is called refraction. Both light and sound can be refracted.

### Geoscience Connections:
The refraction of light is responsible for rainbows. Different colors (wavelengths) of white light are refracted by raindrops in slightly different directions, so the colors appear to be coming from different places.

Sound and other mechanical waves can also be refracted, causing them to bend or change direction. This is what happens when seismic waves travel through the ground — they change direction as they pass through different materials in Earth’s interior.

### STEM Connections:
What happens as the lens (water drop) is made bigger or smaller? Is the lens better or not as good at changing the image?

Try making a hand-held water lens by bending a paper clip into a loop, and then placing a drop in the loop. How big can the loop be? How small? Does a bigger or smaller loop work better?
Water Lens, continued

Materials

Step 1

Step 2

Step 3
**Potential Conceptual Focus:** As light or sound move from one material to another, the direction of its movement changes. This is called refraction. A lens works as a result of the refraction of light by the lens. A convex lens will make an object near it look larger. However, when the object is farther away, the lens may make it look smaller and backwards.

**Activity Brief:**
Students see that the image of a fish drawing seen through water appears to move in the opposite direction that the drawing itself is moved.

1. Put water in the clear plastic cup so that it is almost full but can be moved without spilling and set it on a table. The water should be less than 1 cm from the top of the cup.
2. With the index card placed in the tall (portrait) position, draw two simple fish with tails, both facing to the right. Draw one of them about 3 cm from the bottom edge, and the other about 10 cm from the bottom edge.
3. Hold the card upright so it is about 10-15 cm behind the cup. Move the card back and forth slowly behind the cup. How do the fish appear to move?
4. Bring the card closer to the cup so it is about 2-3 cm behind it. Now move it back and forth. How do the fish appear to move now?
5. Pick up the cup and look through it across the room. Notice how the apparent position of the objects in the room changes. Move the cup back and forth. Notice which way the items in the room seem to move.

**Kit Materials:**
- Clear plastic cup of water
- Index card

**Materials at Setting:**
- Dark marker, crayon, pencil or pen for drawing.

**Energy Connections:**
As light and sound are refracted, how we perceive them can depend on the position of the source, the refracting material, and the detector (our eyes or ears, or an instrument).

**Geoscience Connections:**
The construction of various instruments, such as those used in astronomy, take into account the type of detectable wave, the effects of refraction, and the relative positions of the source, refracting material, and detector. This is very important, for example, in the development of telescopes.

**STEM Connections:**
Collect several clear containers of different sizes and shapes. Fill them with water and look through them. How can you describe what you see in a way that relates it to the shape of the container?
Swimming Fish, continued

Materials

Step 3
Smooth or Sudden Slip

**Potential Conceptual Focus:** Friction is a force that opposes motion. Inertia is an object’s resistance to a change in motion. Depending on their relative strength, friction and inertia will cause some objects to start to move smoothly or suddenly when a force is applied to it.

**Activity Brief:** (Note that because the rubber band could break, it is good to have safety goggles on when doing this activity)

Students see that under different conditions an object will start moving more or less easily.

1. Open the book (or the bottom book if a stack is being used) to about the middle. Lay the string in the crease at the book binding and close the book.
2. Tie the ends of the string together behind the spine of the book.
3. Slip a paper clip on the string at about the center of the spine. Slip a rubber band onto that paper clip. Put a second paper clip on the rubber band on the far end of the rubber band.
4. Lay the book flat on its side, and slowly pull on the second paper clip. Notice what happens to the rubber band as you pull on the paper clip. (It stretches.)
5. Put the thin rubber bands around the book so they are all around the cover — from the spine to the opening (they will be parallel to the direction of movement when the book is pulled). Pull on the string again. Notice how the rubber bands on the book change how it moves. Remove the rubber bands from the book.
6. Place two flexible straws under the book so they are about where the rubber bands were on the underside of the book. Pull on the string again. Notice how the movement is different.
7. Students may notice that when they first pull the book, the rubber band stretches for awhile before the book moves. Then when it does move the rubber band contracts. That is, the book stays still and then suddenly slips forward when the force pulling on it is great enough.

**Kit Materials:**
- String (about 2.5 x the height of the book used)
- Paper clips (2)
- Thick rubber band (1)
- Thin rubber bands (2)
- Flexible straws (2)

**Materials at Setting:**
- Large book (4+ cm thick) or a stack of smaller books

**Energy Connections:**
It takes energy to change how something is moving — starting to move, slowing down, speeding up, stopping, or turning. In most settings, friction resists motion, which means that more energy has to be applied in order to change something’s motion.

**Geoscience Connections:**
The sudden sticking and slipping motion observed is similar to what happens when one tectonic plate moves against another, or as a segment of the crust moves along a fault. There is a force applied by moving plate, but friction can keep the plate from moving. If the force to move exceeds the resistance, the plate will slip. This slipping is what we experience as an earthquake. Processes that change the amount of friction at a plate boundary (such as the injection of water along faults) can increase the chance of an earthquake. Landslides operate in a similar manner. Slopes tend to fail more often after heavy rainfall due to the lubricating affect of water along fractures in slope materials. Landslides continue to move downslope until their momentum is exceeded by frictional forces acting along their base.
STEM Connections:
Try different materials under the book, such as paper, plastic, or even sand paper. Which are good at keeping the book from moving? Which are good at letting the book slide easily? Describe the results in terms of friction.
Potential Conceptual Focus: Spinning objects have properties that tend to keep them spinning in a certain plane. For example, a toy top that starts to spin so its axis is up and down (perpendicular to the floor or table it is spinning on) will tend to stay upright as long as it keeps spinning. This is due to a principle known as the "conservation of angular momentum".

Activity Brief:
Students see that a top made of index cards and a penny will tend to stay upright as long as it is spinning fast.

1. Place a clear plastic cup upside-down on an index card. Trace around the mouth of the cup with a pencil. Cut out the circle. Repeat this for another card.
2. Fold one circle half with the lines inside. Unfold the circle, and fold it in half the other way so that the lines cross at the center. Repeat the folding with the other circle.
3. Re-fold one circle in half. Make a small cut at the center, a little less than a cm long (it will be twice this long when the circle is opened flat). Repeat this with the other circle.
4. Put the two circles together so that the lines are facing each other and so that the cut slits align with each other. Use two pieces of tape on opposite sides of the circle to hold the circles together.
5. Slip a penny into the slit at the center of the cards. (Note that a piece of tape can be used to hold the penny in place, but this may slow the spin on that side.)
6. Draw patterns on the cards and see what they look like when they are spun. For example, draw a yellow line along one of the creases so it goes through the center of the circle. Next, draw a red line crossing the yellow line at the center. Draw another yellow line, then another red, and so on, making sure that all the lines cross at the center. When this pattern spins, what will you see?

Kit Materials:
- Clear plastic cup (as a circle template)
- Index cards (2)

Materials at Setting:
- Coin such as a penny (1)

Energy Connections:
A spinning object tends to stay spinning. Friction slows the spin, and any imbalance will also decrease the likelihood that it will keep spinning.

Geoscience Connections:
Many objects in space — such as planets, moons, and galaxies — have a spinning motion, called rotation. They tend to continue rotating with very little change over time. Still, they do change. The length of Earth’s day is a result of the speed of its rotation. The length of a day on Earth has increased by three hours over the past six hundred million years. Over geologic time Earth’s rotation has also wobbles due to long term variations in the tilt of its axis.

STEM Connections:
Many machines use parts that spin at high speed. This top was constructed to maintain the balance of the parts during motion. What happens if a spinning object is off balance? How can you use this top to show what happens to the way an imbalanced object spins?
Coin Tops, continued

Materials

Step 1

Step 3

Step 5

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Potential Conceptual Focus: All objects have inertia — which is the tendency to resist changes in motion. This inertia is present when an object is still (inertia tends to keep it still), or is in straight-line motion (inertia tends to make it continue in a straight line). Inertia also causes a spinning object to continue spinning. However, a change in the spin of an object — such as going from clockwise to counter-clockwise motion — requires the input of energy.

Activity Brief:

In this activity a large “button” is created from the index card. The button spins when its “drive” string unwinds due to being pulled. Like a top, the button spinner tends to go on spinning. In this case, the button winds its drive string back up the other way, due to the button’s inertia. Putting energy into the system (by pulling the string) causes the spin to change directions and the system to continue moving.

1. Place a clear plastic cup upside-down on an index card. Trace around the mouth of the cup with a pencil. Cut out the circle. Repeat this for another card.
2. One side of the card has lines. Fold one circle in half with the lines inside. Unfold the circle, and fold it in half the other way so that the lines cross at the center.
3. Tape the two circles together.
4. Use a sharpened pencil to carefully punch a hole big enough for the string to pass through on one of the fold creases of the first circle you cut out. The hole should be about .5cm from the center. Repeat this, punching a second hole on the other side of the center point along the same crease, again about .5 cm from the center point.
5. Put one paper clip on the circle, centered along the crease where you punched the holes. One of the holes should end up just inside the loop of the paper clip. Repeat this for the other side of the crease. Use two piece of tape — one on each side — to tape the paper clip in position on the card. This is your very large “button”.
6. Hold the button so one side is facing you. Push the string through one hole from front to back (you may need to make the hole a little bit larger to do this). Then push that same end of the string through from the back to the front. The string should also end up going through the loop of the paper clip. (This is important as it keeps the paper clips from coming off as the button spins.) Tie the ends, making a loop.
7. Put the loop of string over a finger on each side of the button. Have someone wind up your button by turning it in one direction for 15 to 20 turns.
8. Use your fingers to pull the loop of string tight, but after pulling, release the string so there is slack. The button will spin as the string unwinds, but will keep spinning and wind up the string the other direction. Let the button wind up the string, then pull the string tight again. Briefly, again releasing it after the spin begins so it will wind itself back up again.

Kit Materials:
- Index cards (2)
- Clear plastic cup (as a circle template)
- Sharpened pencil (to poke a hole)
- String (about 70 cm)
- Tape
- Paper clips (2)
### Energy Connections:
The “button” spinner system seems to move continuously, but this is actually a good example of a system that requires an input of energy to continue the motion. Because the motion changes direction with each pull of the string, inertia is not enough to keep the system moving. The force exerted by pulling the string (i.e. which in turn requires energy) is needed or the system will stop working.

### Geoscience Connections:
Inertia causes objects to maintain their state of motion. Therefore, any observed change in motion of an object in space can be used as evidence for a force acting on the object. For example, if a comet’s path changes from straight line motion to a curve, there must be a body in space, such as a planet or star, that is exerting a force (usually due to gravity) on the comet.

### STEM Connections:
The button spinner is designed so that the sides of the button are balanced around the center. What would happen if the button was not balanced?
(Note — it is important to consider safety. The spinner will move very fast. A paper clip added to the spinner, for example, should be taped down so it does not fly off (which would be another result of inertia).)
Button Spinner, continued

Materials

Step 1

Step 3

Step 6

Step 5

Step 7
### Potential Conceptual Focus:
The path of light changes direction (refracts) when it moves from one material to another. This change in direction can be pronounced enough that the light actually reflects back into the object. This causes many interesting effects in nature and can be used in technologies.

### Activity Brief:
Students observe how a cup of water changes the appearance of a straight object (a straw) when it is viewed in different positions. They see that water changes how things appear, even to the point of making the objects disappear.

1. Fill a clear plastic cup with water to about .5 cm from the top.
2. Set a flexible straw just beside the bottom of the cup.
3. Look toward the straw from the top of the cup through the water. You cannot see the flexible straw!
4. Place another flexible straw in the cup, so it is touching the bottom and leaning back against the brim of the cup on the other side. Line up the flexible straw so you are looking down it from top to bottom. Stay here and observe what the inside of the cup looks like. You can see the reflection of the flexible straw, though it looks quite bent and split.
5. Look at the flexible straws from the side of the cup. You can see them both, but the cup of water changes how they look.
6. Remove both flexible straws and set them aside.
7. On a small piece of paper (smaller than the bottom of the cup) draw a simple picture.
8. Place the cup of water on the small piece of paper.
9. Center an index card on top of the cup
10. Ask someone to look at the picture through the side of the cup and guess what it is. They will not be able to see it!

### Kit Materials:
- Clear plastic cup
- Small piece of paper
- Index card
- Straws (2)
- Small piece of paper

### Energy Connections:
The path of energy (moving as a wave) can be changed as it passes from one substance to another. These changes have been studied, and people are now able to design materials that have predictable effects on light.

### Geoscience Connections:
Light is refracted by water, changing the way objects in what look as they are viewed from the air. We can observe this effect from the general magnification of objects in water. When we look across the boundary of an object in two different media the distortion we observe is related to the relative changes in the speed of light traveling through the different media.

### STEM Connections:
Light can be refracted by a substance enough that it bounces back into the container rather than going out. This happens when light strikes a medium at a very high angle. This is called “internal reflection”, and is the principle behind fiber optics, such as those used in telecommunications and other technologies.
Bending a Straight Flexible Straw, continued

Materials

Step 2

Step 4

Step 5

Step 7

Step 9
Potential Conceptual Focus: As matter interacts, forces are exerted. A basic law of motion states that “for every action there is an equal and opposite reaction”. The “equal” part refers to magnitude, and the “opposite” part refers to direction. This is known as the “3rd Law of Motion”.

Activity Brief:
Students build a device that spins due to air being pushed out one direction, causing the arm of the spinner to move in the opposite direction.
Be sure to use a clean piece of paper with your name on it as a place to set your spinner on as you work on it, to keep the end you blow through clean and sanitary.
1. Cut the flexible portion off of a large flexible straw and set it aside.
2. Fold the remaining part of the flexible straw in half and crease it. At the crease snip off the corners, being careful to leave a small part of the straw between where you are cutting (so the straw stays together, but has a hole in each side).
3. Unfold the straw. There should now be a hole through the center of the straw.
4. Hold the straw so you can see through the hole. The holes go through the “front” and the “back” of the straw. Squeeze the end of the straw so the front and back are flattened together. Tape the end of the straw so it is flat and closed. Repeat this at the other end of the straw.
5. Hold the straw so you can see through the hole. Snip off the right corner of the top of the straw. Snip off the left corner of the bottom end. These two snips will be on opposite sides of the straw.
6. Pinch the end of the thin straw. Snip at an angle and make a diagonal cut to take off about 1 cm of the straw. The cut end will now be pointed.
7. Put the pointed end thin straw through the hole in the larger straw (what started as the flexible straw).
8. Hold your finger at the pointed end of the thin straw. Blow gently through the thin straw (not too hard — you’ll get a headache).

Kit Materials:
• Flexible straw
• Thin straw
• Tape
• Paper to use as a clean surface

Energy Connections:
Forces can exert energy on objects. In this case, the moving air gets pushed to the side as it goes through the end of the larger straw. As the air gets pushed in one direction, the air pushes the straw in the other direction.

Geoscience Connections:
The 3rd law of motion (action-reaction forces) is applied in many places as material from the Earth and living things interact. It is the basis for many kinds of locomotion including propulsion.
For example, as birds fly their wings push the air down and back, which pushes them up and forward, walking and running (feet push back on the ground, which pushes the animal forward), and swimming (fish push water back with their fins, and the water pushes them forward).
STEM Connections:
The 3rd law of motion is applied in many machines — and very visibly in rockets. The rocket housing pushes the engine exhaust back, and the exhaust pushes the rocket forward. The gases from the rocket have to be accelerated to great speeds to make up for their relatively low mass compared to the rocket — and there are a lot of gas molecules being released.
Potential Conceptual Focus: The 3rd law of motion — that every action will have an equal and opposite reaction (i.e. equal in magnitude and opposite in direction) is fundamental to many technologies, and especially rockets. However, there is more to a rocket than getting it moving — they have to fly straight and dependably.

Activity Brief:
Students are shown a basic pattern for a rocket, which they can then alter to try to improve on the design. The idea of what is meant by an “improved” can be a point of discussion (i.e. “improved” could mean a rocket that is more accurate, flies farther, uses less material, or something else).

Be sure to use a clean piece of paper with your name on it as a place to set your straw as you work, to keep the end you blow through clean and sanitary.

1. Place an index card on a clean, flat surface so a long edge is closest to you.
2. Place a flexible straw on the card so that the flexible end hangs off of the card.
3. Roll the card around the straw, trying to keep it tight, but with a little space between the straw and the card. When you’ve finished rolling it, hold the card and check to be sure that the straw slides in and out easily. Leave the straw in the rolled card.
4. Wrap a piece of tape or two around the end of the card farthest from the flexible part. Be sure that the tape does not touch the straw. Pinch the end of the tape to close the end.
5. Define a “launch range” where no one will be standing. The rocket may go off course, so the launch range must be both wide and long.
6. With no one standing in the launch range, blow one hard, quick breath through the straw. The rocket should fly away. Be sure to only set the straw on your clean piece of paper.
7. Consider the flight of the rocket. What would you like to improve about it?

Kit Materials:
- Flexible straw
- Index card
- Tape
- Paper to use as a clean surface

Energy Connections:
Rockets and other machines that move need a source of energy. Usually the energy source is some sort of chemical. Chemicals such as rocket fuel contain what is referred to as “chemical energy”. This is a type of potential energy, which in the right circumstances can be released to make things move (movement is called “kinetic energy”).

Geoscience Connections:
All materials that people use to make machines come from the Earth — either as substances that are mined, or as substances that come from living things. The fuel that a rocket uses comes from processed chemicals whose primary ingredients come from the Earth.

STEM Connections:
The design of rockets has changed over the decades of space flight. Many techniques have been used to improve the stability, efficiency, and dependability of rockets. Try using different materials and different materials to build other rockets. Decide what you are trying to achieve first, then design with that goal in mind.
Rocket Away, continued

Materials

Step 3

Step 4
Potential Conceptual Focus: Air surrounds the Earth. We cannot see air, but we can see its effects on objects.

Activity Brief:
Students make a device that spins as it falls through the air. The spinning is the result of the device coming in contact with air as it falls. Because of the design of the device, the forces exerted by the air are not balanced, which causes the device to spin.

1. Fold an index card in fourths, make creases and then unfold the card.
2. With a short edge closest to you, cut along the longer crease (along the center of the long axis). Stop cutting before you get to the other crease — leaving about 1 – 2 cm distance between the end of the cut and the other crease. This will be the top of the device.
3. Cut in from the edge along the shorter crease, making a cut of about 3cm. Repeat on the other side of the crease.
4. With the bottom edge (now the only edge without a cut) closest to you, fold in the left side of the bottom to about where you made the cut, and the left side to about where you made the cut — the bottom will now be folded about in thirds.
5. Put a paper clip on the bottom section to keep it from unfolding, and to add some mass.
6. Hold the device upright. The top has two flaps. Fold one flap toward you, and the other flap away from you.
7. Lift the device as high as you can and drop it. It will spin as it falls.

Kit Materials:
- Index card
- Paper clip

Energy Connections:
The spinning of the device shows that air and other forms of matter interact. Just as the air made the device spin, it can also turn the blades of a wind turbine. Rather than the blades moving through the air the way the device does, a wind turbine depends on moving air (wind) to move the blades of the stationary turbine.

Geoscience Connections:
All objects (matter) are affected by matter that they come into contact with. Even though we cannot see air, we can observe its effects on things. For example, when steam or smoke leaves a chimney it typically moves and spreads out depending on how the surrounding air is moving. Similarly we can see the effects of the wind as it blows clouds across the sky, creates waves in the ocean, or blows sand grains on beaches.

STEM Connections:
Designing objects that turn in air efficiently is important as people consider the use of wind power. Try making another device using different materials, and/or a slightly altered design. What if lighter paper is used? What if the flaps are smaller, or larger? What if there is more weight added?
Twist and Turn, continued

Materials

Step 2

Step 3

Step 4

Step 5
Potential Conceptual Focus: Since air is invisible, it cannot be seen. However, its effects on objects can be observed. These effects can include exerting a force on objects.

Activity Brief:
Students build a device that lets them see the effects of wind on an object. The device is a version of an “anemometer”. Anemometers are used to measure wind speed, such as at airports.

1. Cut a 1-2 cm slit in each of four small cups from the brim toward the bottom. 
2. Pinch the end of a straw and put about 2 cm of the straw through the slit so it is perpendicular to the slit. Tape this end of the straw against the inner wall of the cup. 
3. Pinch the other end of the straw and put about 2 cm of it through the slit in a second cup. Do this so that the opening of the cups is facing in opposite directions. Tape this end of the straw to the side of the cup. 
4. Repeat the process for steps 2 and 3 with two more cups and another straw. Be sure that the two straws with their cups look the same — both straws should have cups that face opposite directions on the two ends of the straw. 
5. Hold the straws so they cross at their center points. Tape them so they stay in this position. 
6. Cut off the flexible end of the third straw and set it aside. Fold the remaining straight part of this straw in have to find the center. 
7. Lay the straw across the cup so that the center point is about in the middle of the cup. Bend the sides of the straw down so they are against the sides of the cup. Tape them in place. 
8. Use the pin to make a hole at the center of the straw. Remove the pin, and use a sharp pencil to make the hole in the straw a bit larger. 
9. Pick up the assembly with the four cups and two crossed straws. The cups should hang downward. Push the pin through the two straws where they cross. Set this on the third straw so that the pin goes through the hole that was made. 
10. Blow into the open side of one of the small cups. The crossed straws should rotate freely. 
11. Take this device outside when there is a breeze and see what the breeze does to it.

Energy Connections:
Air is heated as it contacts warm surfaces on the ground. These surfaces are heated by solar energy that strikes them. Most of this energy travels in wave lengths that are very small, and do not affect the air directly — it must be absorbed by an object and re-emitted as heat (infra-red radiation). 

Geoscience Connections:
Wind occurs as air moves from areas of high pressure to areas of low pressure. These differences in air pressure are caused by differences in the heating of air in different places.
Moving with the wind, continued

STEM Connections:
This device is much like an anemometer used to measure wind speed at airports. How can you use this device in a way that would allow you to compare wind speeds at different times?
**Potential Conceptual Focus:** Matter can exert a force on other matter. The fact that air exerts a force on an object demonstrates that it is a form of matter, despite being invisible.

**Activity Brief:**
Students build a device — a "pinwheel" — and they see that it spins in the wind. This spinning is due to the force that the air exerts on it.

1. Fold over one corner of the index card so that the short edge meets the long edge. This will make a doubled-over triangle with an extra rectangle. Cut off the rectangle so you have just the doubled triangle. Open the triangle to make a square.
2. Fold opposite corners of the square together and make a diagonal crease across the square. Open the square. Fold the other opposite corners together. There will be two creases running between corners, and crossing in the center of the square.
3. Make a cut along each crease from the corner toward the center. Leave about 1 cm of the crease uncut. This will make a shape that has four triangles attached to each other at the center.
4. Use the pin to punch a hole on the right side of each of the triangles. The hole should be about 2 cm from the corner, and about centered between the two edges.
5. Push the pin through the center of the square. Fold each corner with a hole in it down and slip the hole over the pin. Do this one at a time, moving in order around the four holes. Keeping the holes on the pin, pinch the folds in each triangle to make a crease.
6. Push the pin through the side of the soft eraser of the pencil. Push it far enough in to stay securely, but do not let it stick out through the other side.

**Energy Connections:**
Different materials interact with radiant energy, such as energy from the sun, in different ways. Materials can reflect, absorb, or scatter the radiant energy. The more radiant energy the material absorbs, the warmer it tends to become. Temperature differences caused in this way generate wind.

**Geoscience Connections:**
Incoming solar radiation ("insolation") strikes surfaces, which may reflect, absorb, or scatter it. The amount of solar radiation that is reflected by a surface is referred to as the "albedo" of that surface. Differences in albedo lead to differences in temperature. Differences in temperature heat the air by different amounts. These differences in heating of the air are ultimately the source of wind.

**STEM Connections:**
The design here is one way to make a pinwheel. Like all devices, changes in the materials, dimensions, and other properties of the design affect how it operates.

Try building another pinwheel out of writing paper instead of a card. How does this affect how it moves? What would happen if you made the pinwheel larger?

**Kit Materials:**
- Index card (10.2 cm x 15.2 cm)
- Straight pin
- Pencil with soft eraser
Potential Conceptual Focus: Air is matter, which means it takes up space. This is easy to forget when we say that a cup is “empty”, although it is actually full of air. Like all matter, air can exert a force, and have forces exerted on it. Whether or not forces are balanced determines whether or not those objects move.

Activity Brief:
Students do an activity that demonstrates that air takes up space as they see a piece of tissue paper an overturned cup stay dry when the cup is placed in water.

1. Set the large cup and the small cup beside each other. Fill the large plastic cup with enough water that the level is just over the top of the smaller cup, but not much more than that.
2. Turn the small cup upside-down. Push it into the water, keeping the opening horizontal. Stop lowering the cup before the water overflows. Notice that the cup is being pushed upward.
3. Remove the small cup and dry it with the paper towel.
4. Crumple a piece of tissue paper into the bottom of the small cup. If necessary, use tape to hold it in place in the bottom of the small cup.
5. Turn the small cup upside-down. Push it into the water, keeping the opening horizontal. Stop lowering the cup before the water overflows.
6. Observe the tissue paper through the cups. Notice whether or not it is wet.
7. Lift the small cup out of the water — keep it upside-down. Dry it with the paper towel, especially around the edge.
8. Turn over the small cup. Remove the tissue and observe it.
9. Place a small floating object — such as a small piece of wood, or a piece of tape, in the center of the surface of the water in the large cup.
10. Turn the small cup upside-down over the object. Push it down into the water. What happens to the object as the small cup is pushed down into the water.

Energy Connections:
Water exerts a force on the air trapped in the small cup, pushing it upward. The air also exerts a force on the water. Because these forces balance, the water cannot enter the cup. This keeps the tissue paper from coming into contact with the water. When forces are not balanced, matter moves in the direction of the weaker force.

Both air and water can exert forces, which allows them to be used to produce energy that people use, such as by turning turbines.

Kit Materials:
- Small transparent cup (1–1.5 oz.)
- Large transparent cup (9 oz.)
- Tissue paper
- Tape
- Paper towel
Empty and Full Cup, continued

Geoscience Connections:
Like all matter, air takes up space and can exert force on other matter. In this activity, the air exerts force on the water, keeping it out of the cup. Forces exerted by air and by water are part of many Earth processes. For example, most waves in water are the result of air moving across the water’s surface, exerting a force (including friction) on the water.

The force that water exerts on other matter is called a “buoyant force”. Water exerts a buoyant force on solid objects, as well as on gases. It is this force that causes materials such as wood to float.

STEM Connections:
The air in the submerged cup can be released by turning the cup over underneath water.
Suppose you had a small cup under water that was inverted, but filled with water. How could you fill it with air without bringing it out of the water?