AKA SCIENCE

Fun Physics: Forces & Motion
Grades K-3

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Fun Physics: Forces & Motion (Grades K-3)

Welcome to AKA Science!

Physics is the study of matter, motion, and energy. Physics explores forces such as heat, light, sound, pressure, density, gravity, and electricity, and the way that they affect objects. By studying physics, we can understand much of the world around us, from the tiniest atomic particles to the mind-boggling vastness of our galaxy. We observe physics in action every day; when we're riding in a car, watching tv, seeing an airplane in the sky, observing a construction site, or running at the gym. There is so much to discover in the great world of Physics!

Over the next 8 weeks, you will put the properties of physics to the test by launching catapults, mastering coin tricks, and connecting electrical circuits! Power up for fun as you make magic of magnets, build a drag racer, and make a boat paddle itself! Sink a diver in a bottle, send a balloon rocket zooming, and design a marble speed track!

BEFORE YOU START:

- **Please ensure take-home supply advisories are given to your students' caring adults.**
- **NOTHING from the AKA Science kit should go in anyone's mouth, nose, eyes, or ears.** Mystery substances can be harmful, and even familiar substances can be contaminated. **If a student ingests a non-food product, call Poison Control: 1-800-222-1222 or 911.** Make sure you consult with your Site Coordinator about any issues.
- **Reserve about 15-30 minutes prior to class starting to prep materials** (see "Prep Steps" section below. If you don't have access to your classroom in advance, see if your site can provide a cart or tray.
- **Newspaper is helpful for covering desks.** A small bundle is in your kit. If it gets used up, you may want to grab a free newspaper to replenish your supply.
- **Be thoughtful about your strategy for handing out supplies.** To minimize spills and accidents, don't give students more supplies than they need for each step of an activity, and gather back supplies when they're no longer being used.

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- **You don't have to do all the activities.** You may not have time to do every activity in the curriculum and that's okay! It's up to you which activities to shorten, lengthen, or skip if needed.

- **Make time for- and encourage students to use their Lab Notebooks** to plan, record, and reflect on their observations as you go.

- **Utilize the "Suggested Readings" at the beginning of each Pair & Share.** These picture books can be checked out from your local library and have been selected because they align that each class session's theme. These should be read before Pair & Share questions begin.

- **Mistakes are okay!** Assure your students that mistakes are part of science; they are learning opportunities and how discoveries are made. It may take time, but you will learn how to do this, you will get better at this, and you will overcome challenges that arise. <u>You can do hard things!</u>

  If an experiment didn't work, we encourage you to debrief with students and reflect. Here are some example prompts:

  - ✓ *What happened today that made you try hard?*
  - ✓ *What can I learn from this?*
  - ✓ *What other strategies or improvements can I try next time?*
  - ✓ *What do I need to get info about or work on before I try this again? Where could I get advice or help from?*
  - ✓ *How could I safely try this experiment in a different way?*
  - ✓ *What did I do today that I am proud of? What are my goals for the next class?*

HELPFUL "*FUN PHYSICS: FORCES & MOTION* VOCABULARY:

- **<u>Physics</u>:** The study of matter, motion, and energy. Physics explores forces such as heat, light, sound, pressure, density, gravity, and electricity, and the way that they affect objects.
- **<u>Properties</u>:** Characteristics of matter that enable us to differentiate one material from another, including qualities like strength, stretchiness or absorbency.
- **<u>Friction</u>:** The resistance of motion when one object rubs against another.
- **<u>Potential Energy</u>**: A form of energy that has the potential to do work but is not actively doing work or applying any force on any other objects.
- **<u>Kinetic Energy:</u>** The energy an object has because of its motion.
- **<u>Density:</u>** A physical property that measures how closely packed together a substance's particles are.
- **<u>Matter:</u>** Anything that takes up space and can be weighed.
- **<u>Energy:</u>** The force that causes things to move and work. It may exist in potential, kinetic, thermal, electrical, chemical, nuclear, or other various forms.
- **<u>Force:</u>** A push or pull on an object. A force can make an object move, speed up, slow down, stay still, or change shape. Common forces include gravity, friction, tension, electrical force, magnetic force, spring force, and applied force.
- **<u>Gravity:</u>** The force by which a planet or other body draws objects toward its center.
- **<u>Pressure:</u>** The physical force exerted on an object.

Fun Physics: Forces & Motion (Grades K-3)

Class 1: The Build Up

Supplies	#
Balance birds (plastic, with cone-shaped stand)	16
Butcher paper (sheets, white)	1
Markers (various colors, washable)	1
Newspaper (issues)	4
Notebooks	16
Paper (8.5inx11in sheets, white)	16
Pebble weight bags	8
Pennies	48
Tape (rolls, masking)	1
Tape (rolls, painter's)	1
Tape (rolls, Scotch)	4
Trays (Styrofoam) *	8

Worksheets	#
Worksheets: "Dear Parents" AKA Science Take-Home Supplies Advisory (half-sheet)	16
Worksheets: Consent Form for Publicity	16
Worksheets: Magnet Take-Home Permission Slip	16

<u>*Note on Styrofoam trays:</u>
You may have trays of a different material in your kit. Possible trays are Styrofoam, paper, plastic (clear), or aluminum. The experiments work the same no matter which type of tray you receive.

Prep Steps (prior to class) Time: 15-30 Minutes

- **<u>Act. 3 (Optional):</u>** You may want to construct the paper columns as prep if you think students will struggle to make them and/or if you want to save time.
- **<u>General</u>:** Ask your Site Coordinator about the best way to send home the Take-Home Supply Advisory.
- **Note that if your class has a lot of Kindergarteners, activities may take a little longer and you might want to prep additional activities ahead of time based on students' motor skills.**

Activity One – Set the Tone Time: 5 Minutes

Supplies	#	Supplies	#
Butcher paper (sheets)	1	Markers (dark blue, washable)	1
Tape (roll, Scotch)	1		

<u>Goal</u>: To set the tone by establishing class agreements.

<u>Procedure</u>:

1. Gather students in a circle and facilitate an introductory icebreaker (e.g., name + kind of animal they would like to be for a day).
2. Using marker and butcher paper, facilitate a discussion among students to establish a set of class rules that they can all agree on.

<u>Example questions:</u>

- ***We have limited supplies in class. How can we share?***
- ***How do we safely use science supplies?***
- ***What is appropriate/inappropriate behavior in class?***
- ***How do we want to be treated in class?***
- ***How can we be our best selves in class?***
- ***What happens if someone breaks one of our agreements?***
- ***What are the clean-up procedures?***

3. Once rules are established, have students sign their name or something that is unique to them (like a stamp pad and thumb print, or a symbol, etc.) directly onto the paper.

Activity Two – Pair & Share Time: 10 Minutes

Supplies	#	Supplies	#
Pencils	16	Lab notebooks	16

Goal: To engage students' thinking and questioning related to the day's activities.

Suggested Reading: *Balancing Act* by Ellen Stoll Walsh

Procedure:

1. Prepare a quiet space for students to give them a physical area to think. The space can be an area set aside from the activity area, where students sit in a circle to ponder the *Pair & Share* question.

2. Make lab notebooks and pencils available.

3. Ask students a *Pair & Share* question. For example:

   - ***What is science?***
   - ***What do you know about physics?***
   - ***Where have you seen or used physics in your life?***
   - ***What is a force?***

4. Ask students to discuss their ideas with their neighbor before inviting students to share what they came up with. This is a "challenge by choice" opportunity and no one is required to share with the class if they are not comfortable.

Activity Three – Paper Columns Time: 15 Minutes

Supplies	#	Supplies	#
Paper (8.5inx11in sheets, white)	16	Tape (rolls, Scotch)	4
Pebble bag weights	8	Trays (Styrofoam) *	8

***Note on Styrofoam trays:** You may have trays of a different material in your kit. Possible trays are Styrofoam, paper, plastic (clear), or aluminum. The experiments work the same no matter which type of tray you receive.

Goal: To demonstrate how different structures support weight by testing different shapes of paper columns.

Source: Science Sparks: http://bit.ly/3XhqJsl

Background:
Cylinders are an amazing shape. No matter what they're made of, the way they distribute weight makes them very durable—even when they're made of something as flimsy as paper! Many bones in your body have a

cylindrical structure. The rigid outer material of your bones evenly distributes the weight and pressure of your body. This shape helps prevent your bones from breaking from everyday use, without adding too much weight for you to carry around! (http://bit.ly/3JLSDd5, http://bit.ly/3lcuB0A)

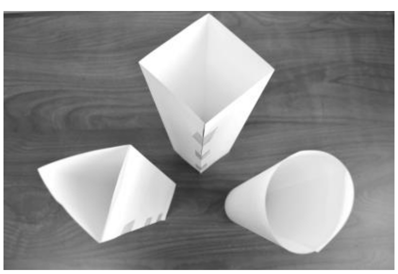
Procedure:

1. Ask students:
   - ***What shapes are the buildings we see around Portland?***
   - ***When buildings are constructed, why are some shapes used more than others?***
   - ***How could we test if certain shapes are better for holding up a structure than others?***

2. Give each student a sheet of 8.5inx11in paper. Make Scotch tape available.
3. Tell students: ***We will be testing how different-shaped structures can hold up weight. We will test 3 basic shapes: square, a triangle, and a circle.***

4. Put students in four groups. Have each student pick one of the shapes (square, triangle, or circle). If there are four students in a group, have the fourth student double up on one of the shapes.
5. Have students create a tube that corresponds to their shape (see photo at left):
   a. **Square:** Fold the paper in half hot dog-style (bring the two long edges together). Unfold the paper, then fold the long edges in so they meet at the center fold. Unfold the paper, then tape the long edges together at a corner to form a square tube. (Use three pieces of tape: one in the middle of the tube and another near each end, *at least an inch from the opening*. Students may need help taping the square tube.)
   b. **Triangle:** Fold the paper in half hot dog-style (bring the two long edges together). Unfold the paper, then fold the long edges in so they meet at the center fold. Unfold the paper, then overlap the two sections with long edges to form a triangular tube. Tape the tube together. (Use three pieces of tape: one in the middle of the tube and another near each end, *at least an inch from the opening*.)
   c. **Circle:** Bring the two long edges of the paper together and roll the paper into a tall tube with a diameter of about 1.5-2 inches. Tape the tube together. (Use three pieces of tape: one in the middle of the tube and another near each end, *at least an inch from the opening*.)

6. Have each student place one open end of their tube on the table. The tubes should stand up next to each other as columns with space in between.



Paper Columns. Triangle, square, and circle tubes made from paper.

Paper Columns. Place the Styrofoam tray on top of a paper column. Attempt to place a pebble bag weight in the center of the tray. If the column can support one bag, it may work best to add a second bag perpendicular to the first one (instead of next to it, as shown).

Discussion Prompts:

- ***What do you think will happen if we place a weight on top of these columns?***
- ***Which column will be the strongest?***

7. Give each group a Styrofoam tray and two pebble bag weights.
8. Have students test the columns one at a time, starting with the square column, then the triangular column, then the circular column.
9. To test each column, have students:
   a. Place the Styrofoam tray on top of the column (centered on top).
   b. Attempt to place a pebble weight bag on the tray (centered on top).
   c. If a column can hold one bag, try adding a second bag perpendicular to the first one (see top photo at left).
   d. If a column can hold two bags, try adding other objects.

Discussion Prompts:

- ***What happened?*** *(The circular column supported both bags of pebbles without collapsing!)*
- ***Which column was the weakest?*** *(Square column)*
- ***Which column was the strongest?*** *(Triangular column)*
- ***Why?*** *(The circular column—called a cylinder—has a shape that distributes weight evenly, so it can hold more weight.)*
- ***What are some things that use the strength of cylinders to support weight?*** *(Pillars, columns, poles, bones, etc.)*

Activity Four – Paper Tower Time: 15 Minutes

Supplies	#	Supplies	#
Newspaper (issues)	4	Tape (rolls, painter's)	1
Tape (rolls, masking)	1	Tape (rolls, Scotch)	4

Goal: To apply knowledge about structure and support to build a newspaper tower.

Source: http://bit.ly/3jyo3sE

Background:

Architects are people who design the structures of buildings. As you just learned, this is a very difficult process—and usually one that can't be figured out through trial and error. Though you built your tower with newspaper, more common building materials include wood, concrete, steel, and glass. Architects use these materials to create giant, beautiful structures like the Eiffel Tower in Paris, the Taj Mahal in India, and the Empire

State Building in New York. All these buildings use certain shapes for structure and appearance. How did you use different shapes to create your tower? (http://bit.ly/3Y9ZeT4)

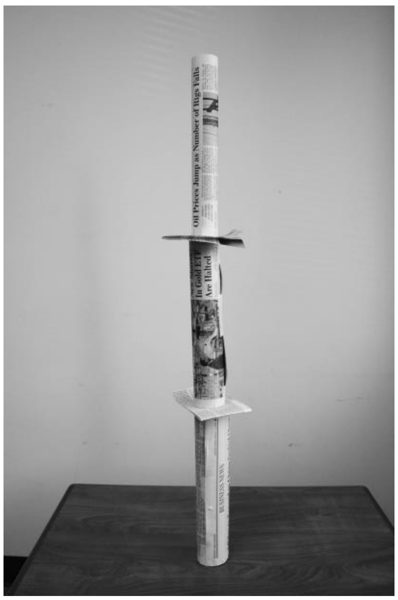
Procedure:

1. Ask students: ***You just learned that the best shape of column to support weight is a circular column, also called a cylinder. How could you use that knowledge to build an even bigger structure?***

2. Keep students in four groups.
3. Give each group one issue of newspaper and a roll of Scotch tape (or pieces of tape, to make sure tape is conserved for future activities). Make painter's tape and masking tape (or pieces of tape) available.
4. Ask students: ***How can you use these materials to build a structure that stands on its own?***

5. Students can select one out of two goals to work on:
   - Build the tallest tower
   - Build the strongest structure (the pebble bag weights can be used to test for the strongest structure).

6. Allow students time to build their structures (see bottom photo at left).
7. Although this activity is intended as a "free build," if students are struggling, you can guide them through the process with these suggestions/questions:
   a. Remember that cylinders are good at supporting weight when they're standing up, but not when they're sideways.
   b. How can you create a base for your tower?
   c. What are you using to stick your tower together?
   d. Would it help to make a repeating pattern?



Paper Tower. Sample tower made from newspaper and masking tape.

Activity Five – Balance Bird Time: 15 Minutes

Supplies	#	Supplies	#
Balance birds (plastic, with cone-shaped stand)	16	Tape (rolls, Scotch)	4
Pennies	48		

Goal: To observe how changing an object's center of gravity affects its balance using a balance bird toy and pennies as weights.

Source: http://bit.ly/3I29cAd

Background:

In this experiment, the main force you were working with (and against) was gravity! When you balanced the bird at the tip of its beak, all the weight of the bird was equally balanced around that point. The tip of the beak is the bird's natural <u>center of gravity</u>—the point where gravity pulls down on all the parts of the bird equally.

When you added a penny to the bird's tail, you added more weight toward the back of the bird. As a result, you shifted the bird's center of gravity backwards. You created a new point—near the bird's belly—at which the weight of the bird was balanced. When you added more pennies to the bird's wingtips (at the front of the bird), you evened out some of the extra weight and brought the bird's center of gravity back near the tip of its beak.

Everything has a center of gravity! On humans, it's usually somewhere near your hips. When scientists try to find the center of gravity in an object, they have to use difficult calculations—but they also use familiar concepts like symmetry. An object is symmetrical if there's a place where you can split it in half and have one half be the mirror image of the other (i.e., the same size and shape, just flipped). Did you notice that your balance bird is symmetrical? Where could you cut it in half so that both halves would be the same size and shape? (http://bit.ly/3JHLD0Q)

<u>Procedure</u>:

1. Have students try to balance on one foot.

   <u>Discussion Prompts:</u>
   - ***What happens when you try to balance?***
   - ***How does your body move?***
   - ***Do you have to make some changes in the way you're standing in order to balance?*** *(Many people hold their arms out to their sides to balance, shifting their bodies and tilting their arms as needed. Rumor has it that you can place a finger on your bellybutton to help keep still!)*
2. Give each student a balance bird toy and the plastic stand that goes with it.
3. <u>Ask students:</u> ***How could you get this bird to balance on its stand?***

4. Allow students to experiment with placing the bird on the stand in different ways to get it to balance (see top photo at left).

   <u>Discussion Prompts:</u>
   - ***What did you notice?*** *(The bird will only balance by the tip of its beak!)*
   - ***Why do you think that is?***

5. <u>Tell students</u>: ***Every object has a point where it will balance—a point where its weight is equally distributed on all sides. That point is called its <u>center of gravity</u> because it's the center where gravity pulls down on all the parts of the object equally! The bird's center of gravity is at the tip of its beak.***

   <u>Discussion Prompt:</u>

Balance Bird. The bird balances on the stand by the tip of its beak.

Balance Bird. Tape a penny flat on the top of the bird's tail. This changes the bird's center of gravity.

Balance Bird. Tape a penny flat on top of each of the bird's wingtips. This restores the bird's original center of gravity.

- ***Do you think the bird will balance on something other than the stand? Maybe on your finger? Try it!***

6. Allow students to experiment with balancing the bird on their fingertip.

   Discussion Prompts:
   - ***Did it work?***
   - ***You may have noticed that the bird can wobble and spin a little. Do you think you could get it to spin in a full circle?***
   - ***How long do you think it will spin?***

7. Have students balance their bird by its beak on the stand, then gently push its tail sideways to get it to spin. Make sure students don't stare at the spinning bird for too long, or they may get dizzy.
8. Ask students: ***What allowed your bird to spin for so long?***

9. Tell students: ***Since the bird is perfectly balanced, the small contact point of its beak has very little friction with the stand. We'll learn more about friction later—for now, just know that friction usually slows down moving objects or makes them stop. In this case, there wasn't much friction to stop your bird from spinning!***

10. Give each student a penny. Make tape available.
11. Ask students:
    - ***How could change your bird's center of gravity?*** *(Add weight to part of the bird.)*
    - ***What do you think will happen if you tape a penny on the bird's tail? Try it!***

12. Have students tape a penny flat onto the top of the bird's tail, then try balancing the bird again on a stand or on their fingertip (see top photo at left).

    Discussion Prompts:
    - ***Does the bird still balance by its beak?*** *(No.)*
    - ***Why not?*** *(By adding more weight to the back end of the bird, you shifted the bird's center of gravity backwards, as well.)*
    - ***Where is the bird's new center of gravity?*** *(Near its belly.)*
    - ***Could you add more weight somewhere else to return the center of gravity to the bird's beak?***
    - ***Where do you think you would you have to add the weight?***

13. Give each student two more pennies.
14. Have students tape one penny flat on top of each of the bird's wingtips (near the tip of the wing). Allow them to balance the bird again (see bottom photo at left).

Discussion Prompt:
- ***Did you restore the center of gravity?*** *(Yes, mostly!)*

15. If time allows, have students experiment with adjusting the pennies to continue changing the center of gravity on their bird.

Activity Six – Daily Debrief Time: 5 Minutes

Supplies	#
Lab Notebooks	16
Pencils	16

Goal: To draw today's activities together through a thoughtful question and give students an opportunity to ask their own questions.

Procedure:
1. Encourage students to reflect on what they learned in today's class and what new questions they might have.
2. Allow students a few seconds to think. Have them discuss their thoughts and questions with a partner, then share with the rest of the class and/or write down in their lab notebook.
3. If needed, feel free to offer prompts like:
   - ***What do you think would happen if we changed one thing about today's activities (for example: materials, speed, temperature, etc.)?***
   - ***If you could investigate (explore) one more thing about today's activities, what would you like to find out?***

4. If time allows, ask the following question:
   - ***If you could build the tallest skyscraper in the world, what would it look like?"***

Cleanup: Make sure students help clean the room before they leave.

Notes about sending supplies home from AKA Science:

- Remember to save all the items in the "SAVE" column of the "WHAT TO SAVE" table (see next page).
- Let students know that they'll get to take home various AKA Science supplies over the course of the term—however, they won't take home *all* of the supplies, and they won't necessarily take supplies home after *every* day of class.
- **Instruct students that they should never put AKA Science supplies in their mouths, eyes, ears, or noses, or use them in a way that could hurt anyone.**

- Please use your judgment about sending supplies home with students. If the "WHAT GOES HOME" section includes a supply item that you don't think your students can handle safely while unsupervised, **don't send it home.**

<u>What to Save</u>:

Materials used	#	SAVE	Materials used	#	SAVE
Balance birds (plastic, with cone-shaped stand)	16	0	Tape (rolls, masking)	1	1
Butcher paper (sheets, white)	1	1	Tape (rolls, painter's)	1	1
Markers (various colors, washable)	1	1	Tape (rolls, Scotch)	4	4
Newspaper (issues)	4	0	Trays (Styrofoam)	8	8
Notebooks	16	16	Worksheets: Consent Form for Publicity	16	Any left
Paper (8.5inx11in sheets, white)	16	0	Worksheets: "Dear Parents" AKA Science Take-Home Supplies Advisory (half-sheet)	16	Any left
Pebble weight bags	8	8	Worksheets: Magnet Take-Home Permission Slip	16	Any left
Pennies	48	48			

<u>What Goes Home</u>: Balance bird with cone-shaped stand.
(Review safety guidelines with students: small items should always be kept away from children ages 3 and younger to avoid the risk of choking)

- <u>REMINDER</u>: Ask your Site Coordinator about the best way to send home the "Dear Parents" Take-Home Supplies Advisory and the Consent Form for Publicity.
- <u>REMINDER</u>: Ask your Site Coordinator if they want to send home the Magnet Take-Home Permission Slips.* *If they don't want to deal with the permission slips, it's no problem—it just means you'll give the magnets to the Site Coordinator at the end of the term instead of having students take them home. When you get to Class 7, feel free to tell students that the magnets must stay at the site.*

Fun Physics: Forces & Motion (Grades K-3)

Class 2: Freaky Forces

Supplies	**#**
Cardboard rectangles (large, 7inx14in)	4
Cups (9oz paper)	16
Eggs (plastic)	16
Foam tubing (grooved track, 6ft pieces)	4
Index cards	16
Marbles (small)	20
Pennies	48
Planter boxes (plastic)	4
Play dough (1.5oz containers)	8
Popsicle sticks (regular size)	16
Tape (rolls, Scotch)	4

Prep (prior to class): Time: 15-30 Minutes

- **Act. 4:** Remove the eight pieces of play dough from their containers. Split each piece of play dough in half to make a total of sixteen pieces. **Save the play dough containers for Class 4.**
- **Act. 5**: Turn each of the four planter boxes upside down. Create four ramps by taping a cardboard rectangle to each upside-down planter box. (Best method: allow the short edge of the rectangle to rest flat on the "ledge" where the upside-down planter box has an indent. Tape the top edge of the rectangle in place—see Act. 5).

Activity One – Pair & Share Time: 10 Minutes

Supplies	**#**	**Supplies**	**#**
Pencils	16	Lab notebooks	16

Goal: To engage students' thinking and questioning related to the day's activities.

Suggested Reading: *Queen of Physics: How Wu Chien Shiung Helped Unlock the Secrets of the Atom* by Teresa Robeson.

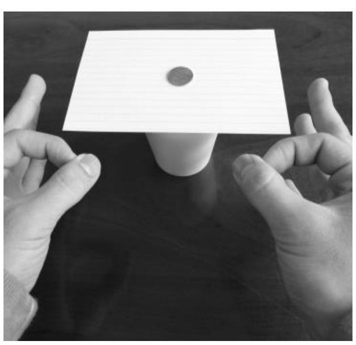
Procedure:

5. Prepare a quiet space for students to give them a physical area to think. The space can be an area set aside from the activity area, where students sit in a circle to ponder the *Pair & Share* question.
6. Make lab notebooks and pencils available.
7. Ask students a *Pair & Share* question. For example:
   - ***What happens when you push something, like a desk or a chair?***
8. Ask students to discuss their ideas with their neighbor before inviting students to share what they came up with. This is a "challenge by choice" opportunity and no one is required to share with the class if they are not comfortable.

Activity Two – Coin Tricks Time: 15 Minutes

Supplies	**#**	**Supplies**	**#**
Cups (9oz paper)	16	Pennies	48
Index cards	16		

Goal: To demonstrate that an object at rest stays at rest until a force acts on it, using pennies and stacks of pennies.



Coin Tricks. Place one hand at each bottom corner of the index card and flick the card straight forward. The penny should fall into the cup.

Source: http://bit.ly/3wYqhVx

Background:

Newton's First Law (INERTIA) says that an object at rest wants to stay at rest. As a result, when you flicked the index card sideways off the cup—or flicked it sideways from in between some pennies—the pennies didn't move sideways. Why? The pennies wanted to stay still because they were already still. The only force that acted on the pennies was gravity, which pulled them downward.

The pennies on your elbow were a little trickier. They were at rest, then you took them out of rest by moving your elbow out from under them. However, it took gravity a little time and effort to pull them out of rest and downward. If you swung your hand fast enough, you could rely on their inertia (wanting to stay still) to catch them before gravity had a chance to pull them all the way down to the ground!

How do you overcome inertia and move an object from rest? You apply a force, of course! The one you used to move the index card and the bottom penny in the stack is called the "APPLIED FORCE" because you (a person!) applied it. (http://bit.ly/3jv8XUZ)

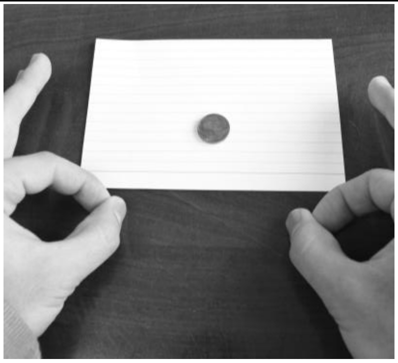
Procedure:

1. Give each student a 9oz paper cup, three pennies, and an index card.
2. Have students place the index card over the mouth of the cup and place one penny in the middle of the index card.
3. Ask students: ***What do you think will happen to the penny if we flick the index card off the top of the cup? Let's find out!***

4. Have students flick the index card away from themselves and off the top of the cup. Use two hands (one positioned at each corner on one of the long sides of the index card) then flick with both pointer fingers straight ahead. The motion of index card should be parallel to the table (see photo at left).
5. Allow students to practice flicking the card until they see a reliable result.

Discussion Prompts:

- ***Where does the penny go?*** *(It falls down into the cup.)*
- ***Is that what you predicted?***
- ***Why did this happen?*** *(According to Newton's First Law of Motion, an object at rest tends to stay at rest until a force acts on it. This is called INERTIA. When we say "at rest," we mean the object is still—not that it's sleeping! The penny stays still when the index card moves sideways because it started still and wants to stay still.)*
- ***If the penny wants to stay still, why does it fall into the cup?*** *(Once the card is gone, the penny has no surface to rest on, and gravity pulls it down. Gravity is the force that pulls all objects toward the earth. It's the reason you walk on the ground instead of floating through space!)*


Coin Tricks. Place an index card on a stack of 2 pennies, then place a penny on the index card directly above the stack of pennies. Flick the index card forward as before.


Coin Tricks. Place penny on elbow and quickly swing your hand down.

6. <u>Have students</u>:
    a. Set the cup aside and place one penny on the table (ideally near the edge of the table).
    b. Place the index card over the penny so that one of the long edges of the index card hangs very slightly off the edge of the table.
    c. Stack the other two pennies directly above the penny that's under the index card.

7. <u>Ask students:</u> ***We know that a penny at rest will want to stay at rest. So, what do you think will happen if you flick the index card out from between these resting pennies? Try and see!***

8. As with the cup, have students line up one hand at each corner of the index card, then flick the card out from between the pennies (see top photo on next page).
9. Allow students to repeat until they see a reliable result.

<u>Discussion Prompt:</u>
- ***What happens?*** *(The index card flies out and the pennies fall into a stack.)*

10. Have students work together to try using different numbers of pennies above and below the card to see which combinations are successful.
11. <u>Ask students:</u> ***Now you know that a penny at rest wants to stay at rest. But, do you think you can react faster than the pull of gravity?***

12. Have students lift one arm up and back so their elbow is pointing straight forward (like a waiter carrying a tray but extended back so the whole forearm is parallel to the ground—see bottom photo at left).
13. Have students balance a penny on top of their elbow and cup their palm.
14. <u>Ask students:</u> ***If you swing your hand down quickly, do you think you can catch the penny?***

<u>TIPS</u>:
- **You may need to demonstrate the motion for students.**
- **It helps to do this activity in an open area** (or have students take turns) so that flying pennies don't hit anyone.

15. Allow students to experiment with a quick motion, swinging their hand forward and down to grab the penny. This may take a few tries. ***Speed is key!*** It may help to avoid looking and just go by feel.
16. Once students have mastered one penny, have them add another penny on top of the first and try again. Students can work up to a stack of three pennies.

<u>Discussion Prompts:</u>

- ***Is it easier to catch one penny, two pennies or three pennies?*** *(Surprisingly, it should only be a little harder to catch three pennies than it is to catch one.)*
- ***What allowed you to catch the pennies in midair?*** (*Newton's First Law of Motion – INERTIA! The pennies are at rest until your elbow moves out from under them. At that point, gravity pulls them out of rest, and they fall straight down. If your arm is moving fast enough, your fingers end up directly below the pennies and you can catch them before they hit the ground!)*

Activity Three – Newton's Cradle   Time: 10 Minutes

Supplies	#
Foam tubing (grooved track, 6ft pieces)	4
Marbles (small)	20

Goal: To demonstrate that every action causes an equal and opposite reaction by knocking marbles into each other on a foam track.

Source: *The Science of Forces* by Steve Parker

Background:
Newton's Third Law of Motion says: "For every action there is an equal and opposite reaction"—but what does that mean, exactly? You just demonstrated what it means! When your action was pulling one marble back and letting it go, the reaction was one marble shooting out the other side. When your action involved two marbles, so did the reaction! Each of your actions had an equal & opposite reaction.
This activity is such a good demonstration of Newton's Third Law that there's a standard version of it called "Newton's Cradle." The more common version features a row of metal balls that hang from thin wires. You can see one at OMSI or a science store! (*The Science of Forces*, Steve Parker)


Newton's Cradle. Have one student hold the foam track to form a loop.

Procedure:
1. Ask students: ***What happens when you jump up or push something or roll? Is there an equal reaction? How can we test that?***

2. Put students in four groups.
3. Give each group a piece of foam track and three marbles.
4. Have one student make the foam track into a loop by crossing one end over the other with the groove on the inside. Hold the loop so the ends are crossed at the top, and the smooth part of the loop is resting on the table (see top photo at left).
5. Have another student put three marbles in the groove at the bottom of the loop.

Newton's Cradle. While one student holds the center marble still, have another student push marbles up one side of the track, then release them so they hit the center marble.

6. Have another student press one finger down on the center marble to hold it still.
7. Ask students: ***If we hold the center marble in place, what do you think will happen if we push one of the other marbles up the track then let it roll back down? Let's try it!***

8. Have the fourth student push one of the marbles almost midway up the side of the track, then release. Make sure the other student is still holding the center marble in place with their finger (see bottom photo at left).

   Discussion Prompts:
   - ***What happened?*** *(The center marble remained still, but the third marble rolled up the other side of the track!)*

9. Ask students: ***Can you control how far the third marble goes if you change the release point of the first marble? Try it!***

10. Have students switch roles (one person holding the track loop, one person holding the center marble, one person pushing and releasing the first marble, one person observing) and repeat the experiment. Students should vary the release point of the first marble and see a corresponding change in the third marble (e.g., the higher the release point on the first marble, the higher the third travels).
11. Ask students:
    - ***What do you think will happen if we add one marble to each side (to make a row of five marbles)?***
    - ***Will we see the same effect?***

12. Give each group two more marbles. Have students place one new marble on each side of the original three marbles.
13. Ask students: ***If we push one marble up on one side and let it go, how many marbles do you think will shoot out from the other side? Try it!***

14. You may want to have students switch roles again and try the experiment. With one person still holding the central marble still, have another push one of the farthest marbles up the ramp then release it.

    Discussion Prompt:
    - ***How many marbles shot out of the other side?*** *(Only one!)*

15. Ask students: ***What do you think will happen if we send two marbles down to hit the center marble?***
16. You may want to have students switch roles and repeat the experiment, this time pushing two marbles up one side of the track and releasing them.

    Discussion Prompt:

- ***What happens?*** *(Two marbles shoot up the other side!)*

17. Allow students to continue experimenting if they wish.
18. OPTIONAL: You can add two marbles from another group for a total of seven marbles on one track as a demonstration. Holding the central marble still, if you release three marbles from one side, three marbles will shoot out the other side.

Activity Four – Roly Poly Time: 15 Minutes

Supplies	#	Supplies	#
Eggs (plastic)	16	Popsicle sticks (regular size)	16
Pennies	16	Tape (rolls, Scotch)	4
Play dough (1.5oz containers)	8		

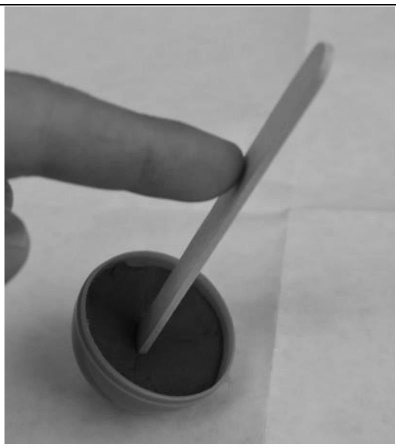
Goal: To explore how a high vs. low center of gravity affects balance by making a plastic egg toy filled with play dough that pops back up when you knock it over.

Source: Hands on Science Outreach

Background:
Have you ever ridden in a very small boat, like a canoe or a kayak? Or have you ever seen people ride in one? People have to sit down in the boat so that the total weight of the people plus the boat is as low as possible. If people stand up in the boat, it shifts the weight higher (like in this activity when you'll tape a penny to the top of the popsicle stick on your roly poly). That causes the center of gravity to be higher up, which makes it more likely for the boat—with the people in it—to tip over! (http://bit.ly/3RE9JeS)
In this activity, you'll construct a roly poly. You'll notice that when your roly poly toy has a low center of gravity, it refuses to stay tipped over! Whenever an object has a low center of gravity, it tends to be very stable. However, when you add weight at the top of the toy, you shift the toy's center of gravity higher, and you could tip the toy over.

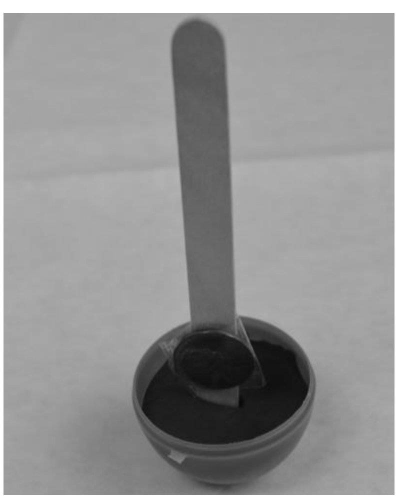
Procedure:
1. Ask students: ***Sometimes in carnival games, the goal is to knock something over, but there's a catch—the object you have to knock over has all of its weight concentrated at the bottom, which makes it more stable than it looks. Can you make a toy that wobbles back and forth, but doesn't fall over? Let's try!***

2. Give each student half a container of play dough (from prep), a plastic egg, and a popsicle stick.



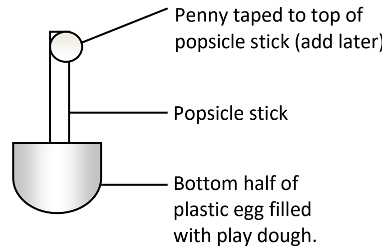
Roly Poly. Gently push the top of the popsicle stick sideways. The toy will return to its upright position.

Roly Poly. Tape a penny near the top of the popsicle stick. The toy will fall over when pushed.



Roly Poly. Move the penny lower on the stick to correct the balance.

3. Have students pull the top and bottom half of their egg apart to break the plastic thread that connects them. Set the top half aside for the next activity (only the bottom half is needed for this activity).
4. <u>Have students</u>:
    a. Roll the play dough into a ball.
    b. Put the ball of play dough inside the egg half. Press the play dough down and smooth it out so that it's evenly distributed inside the egg half.
    c. Put one end of the popsicle stick in the center of the play dough. Push the popsicle stick all the way into the dough so the stick stands straight up.



5. <u>Ask students:</u> ***What would happen if you tried to push this toy over? Try it!***

6. Have students push the top of the popsicle stick sideways (see top photo at left).

    <u>Discussion Prompts:</u>
    - ***What happened?*** *(The toy returned to its original position.)*
    - ***Why?*** *(You learned in the last class that the point at which an object's weight is equally distributed is its <u>center of gravity</u>. The toy swings back and forth without falling over because most of the weight is at the bottom. Its center of gravity is very low, which makes it stable and hard to knock over.)*

7. <u>Ask students</u>: ***What would happen if you added weight to the top of the popsicle stick?***

8. Give each student a penny. Make tape available.
9. Have students use tape to attach the penny near the top of the popsicle stick. Put the toy back in its upright position.
10. <u>Ask students:</u> ***What would happen if you tried to push the toy over now? Try it!***

11. Have students push the top of the popsicle stick sideways (see middle photo).

    <u>Discussion Prompts:</u>
    - ***What happened?*** *(The toy fell over.)*
    - ***Why?*** *(It became "top-heavy." It has a high center of gravity without anything to support its balance.)*

12. <u>Ask students:</u> ***Where could you place the penny that would keep the center of gravity the same as before?*** *(Low on the popsicle stick)*.

13. Have students remove the penny and tape it as low as possible on the popsicle stick (close to where the stick meets the dough—see bottom photo at left).
14. Have students push the top of the popsicle stick sideways again.

Discussion Prompts:
- ***What happened?*** *(The toy stayed upright. It only tilted slightly more than it did without the penny.)*
- ***Why?*** *(By adding weight near the bottom, you didn't change the toy's center of gravity much—definitely not as much as when you put the penny at the top!)*

15. Ask students: ***Do you think your body has a high or low center of gravity? Let's find out!***

16. Have students line up at a wall with their heels against the wall.
17. Have students keep their heels pressed against the wall and carefully lean forward as far as they can without falling.
18. Have students keep their roly poly toy and the top half of their egg for the next activity.

Discussion Prompts:
- ***Is it hard to keep your balance?***
- ***How does your center of gravity compare to the toy's?*** *(Your center of gravity is higher than the toy's, so you can't tip over as far without falling.)*

Activity Five – Egg Roll — Time: 10 Minutes

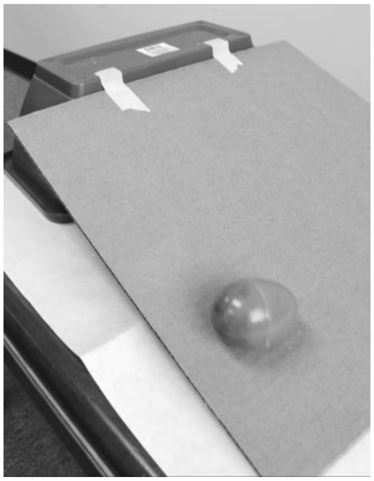
Supplies	#	Supplies	#
Eggs (plastic)	16	Play dough (1.5oz containers)	8
Cardboard rectangles (large, 7inx14in)	4	Planter boxes (plastic)	4

Goal: To apply an understanding of weight distribution to a rolling object using play dough and plastic eggs.

Source: Tyler Oshiro, AKA Science

Background:

When you made the roly poly toy, you learned that placing all the weight at the bottom gave it a low center of gravity and made it stable. However, in this activity, you discovered that having all the weight on one side of the egg made the egg unable to roll. By shifting the play dough around inside the egg, you were able to change the egg's center of gravity—just like when you changed the center of gravity of your Balance Bird! Through your


Egg Roll. Test each egg by trying to roll it down the ramp.


Egg Roll. Press the dough into the bottom of the egg. Close the egg.


Egg Roll. Press the dough into the top of the egg. Close the egg.

engineering, you learned how to redistribute the weight of the play dough so that your egg could roll smoothly.

Did you know you can use your new knowledge of weight distribution to test if an egg inside its shell is raw or hard-boiled? In a raw egg, the egg yolk and egg white can slosh around, which causes the egg's center of gravity to move around. If you spin a raw egg on a counter, the uneven weight distribution will cause it to wobble, just like your unevenly-weighted egg! In a hard-boiled egg, the egg yolk and white are solid, and their weight is distributed evenly. A hard-boiled egg will spin evenly, just like you made your egg roll evenly! (http://bit.ly/3jEHIar)

<u>Procedure</u>:

1. Make sure students have their roly poly toy plus the top half of a plastic egg.
2. Put students in four groups. Give each group a cardboard rectangle taped to a planter box to use as a ramp (from prep—see top photo at left).
3. <u>Ask students:</u> ***In the last activity, the weight of the play dough in the bottom half of your egg made the egg act strangely. What do you think will happen if we put the top half of the egg back on and roll the egg with the play dough inside? Will the egg roll normally?***

4. <u>Have students</u>:
    a. Remove the popsicle stick (with the penny still attached) from the bottom half of the egg. Set the popsicle stick aside.
    b. Press the play dough firmly into the bottom half of the egg, pushing it against the bottom and walls so it sticks inside the egg half (see middle photo at left).
    c. Put the top half of the egg on the bottom half and snap them together.
5. In each group, have students take turns rolling their egg down the ramp. Have them watch to see whether all the eggs in the group behave similarly.

    <u>Discussion Prompts:</u>
    - ***What happens?*** *(The egg doesn't really roll—it just slides down the ramp.)*
    - ***Why?*** *(Most of the weight is in the bottom of the egg, so gravity causes the bottom of the egg to always point downwards.)*

6. <u>Ask students:</u> ***What will happen if we shift the weight to the top of the egg?***

7. Have students open their egg and move the play dough to the top half of the egg. Make sure they press the play dough so it sticks inside the top half of the egg (see bottom photo at left).
8. Have students take turns rolling the eggs down the ramp.

    <u>Discussion Prompts:</u>


Egg Roll. Example of an engineered egg that can roll down a ramp. The weight of the play dough is evenly distributed inside the egg.

- ***What happens?*** *(The egg slides again, but this time the top half of the egg points down.)*
- ***How could we arrange the play dough so the egg can actually roll?***

9. Allow students to engineer their own solutions, reminding them not to put all the weight of the play dough in one place. Students may try placing equal amounts of dough in the top and bottom of the egg, or pressing the play dough into a thin layer all around the inside of the egg (see top photo at left).
10. Have students test their engineered eggs to see if they roll. Allow them to modify their play dough placement as needed.

Activity Six – Daily Debrief Time: 5 Minutes

Supplies	#
Lab Notebooks	16
Pencils	16

Goal: To draw today's activities together through a thoughtful question and give students an opportunity to ask their own questions.

Procedure:
1. Encourage students to reflect on what they learned in today's class and what new questions they might have.
2. Allow students a few seconds to think. Have them discuss their thoughts and questions with a partner, then share with the rest of the class and/or write down in their lab notebook.
3. If needed, feel free to offer prompts like:
   - ***What do you think would happen if we changed one thing about today's activities (for example: materials, speed, temperature, etc.)?***
   - ***If you could investigate (explore) one more thing about today's activities, what would you like to find out?***

4. If time allows, ask the following question:
   - ***Why do you think eggs are egg-shaped, rather than balls or cylinders?*** *(Eggs have a slightly pointed end so that they roll in circles rather than in a straight line. This keeps them from accidentally rolling out of a nest or off a cliff!)*

Clean up: Make sure students help clean the room before they leave.

What to save:

Materials used	#	SAVE	Materials used	#	SAVE
Cardboard rectangles (large, 7inx14in)	4	4	Planter boxes (plastic)	4	4
Cups (10oz paper)	16	16	Play dough	8	0
Eggs (plastic)	16	0	Play dough **containers***	8	8
Foam tubing (grooved track, 6ft pieces)	4	4	Popsicle sticks (regular size)	16	0
Index cards	16	0	Scissors (site provides)	1	1
Marbles (small)	20	20	Tape (rolls, Scotch)	4	4
Pennies	48	0			

WHAT GOES HOME: Egg, play dough, popsicle stick, index card & 3 pennies per student.

(Review safety guidelines with students: small items—including play dough—should always be kept away from children ages 3 and younger to avoid the risk of choking)

*__SAVE THE EMPTY PLAY DOUGH CONTAINERS FOR CLASS 4.__
If possible, you may want to keep the ramps intact for the next class.

Fun Physics: Forces & Motion (Grades K-3)

Class 3: On a Roll

Supplies	#
Binder clips (large)	16
Cardboard rectangles (large, 7inx14in)	4
Pencils	16
Pennies	16
Planter boxes (plastic)	4
Popsicle sticks (jumbo)	17
Scissors (site provides)	1
Stir sticks (half pieces)	32
Straw pieces (2in, "for axles")*	32
Straws (clear, full size)	1
Straws (jumbo, bubble tea)	1
String (1.5ft pieces)	16
Tape (rolls, masking)	1
Tape (rolls, painter's)	1
Wheels (large, wooden)	4
Wheels (small, wooden)	64

Prep (prior to class) — Time: 15-30 Minutes

- **<u>Act. 2 (OPTIONAL):</u>** Tape a penny to one end of each of the sixteen 1.5ft pieces of string. Tie or tape a large binder clip to the other end of each piece of string.
- **<u>Act. 4</u>:** Cut sixteen 2in straw pieces "for axles" in half. You'll end up with thirty-two 1in pieces.
- **<u>Act. 5</u>:** Assemble the Monster Truck (Act. 5, Steps 1-8).

***Your kit contains sixteen extra 2in straw pieces "for axles."** Please bring the extras to class as back-up.

Activity One – Pair & Share — Time: 10 Minutes

Supplies	#	Supplies	#
Pencils	16	Lab notebooks	16

<u>Goal</u>: To engage students' thinking and questioning related to the day's activities.

<u>Suggested Reading</u>: *The Boy Who Harnessed the Wind: Picture Book Edition* by William Kamkwamba

<u>Procedure</u>:

9. Prepare a quiet space for students to give them a physical area to think. The space can be an area set aside from the activity area, where students sit in a circle to ponder the *Pair & Share* question.

10. Make lab notebooks and pencils available.

11. <u>Ask students a *Pair & Share* question. For example:</u>
    - ***What are some things that have wheels?"*** *(Bicycles, skateboards, scooters, roller blades, cars, carts, wagons.)*

12. Ask students to discuss their ideas with their neighbor before inviting students to share what they came up with. This is a "challenge by choice" opportunity and no one is required to share with the class if they are not comfortable.

Activity Two – Pendulum Drop — Time: 15 Minutes

Supplies	#	Supplies	#
Binder Clips (large)	16	String (1.5ft pieces)	16
Pencils	16	Tape (rolls, masking)	1
Pennies	16	Tape (rolls, painter's)	1

Fun Physics: Forces & Motion (Grades K-3)

Class 3: On a Roll

Goal: To observe that the shorter a pendulum is, the faster it swings, using a penny attached to string as a pendulum.

Source: https://bit.ly/3DPPqFt

Background:

The device you created is a penny pendulum. A pendulum is a weight that swings from a pivot or fixed point—in this case, your finger. Playground swings are an example of a pendulum. Usually, as a pendulum swings back and forth over time, it gets slower, and the height of its swing gets lower due to friction.

In our activity, when you let go of the penny, gravity started to pull the binder clip down, which made the penny pendulum shorter and shorter as the penny got closer to your finger. As the penny pendulum got shorter, it swung faster and faster. In the blink of an eye, the force of acceleration got so great that the penny pendulum started swinging high enough to wrap all the way around your finger.

Did you know that Galileo was the first scientist to study the properties of pendulums? According to his student Viviani, Galileo first noticed a swinging chandelier hanging from the ceiling, which led him to define the swinging pendulum. A common type of pendulum is a metronome, which keeps track of the speed of music. (https://bit.ly/3I7xB7F, https://bit.ly/3I7PKIM)

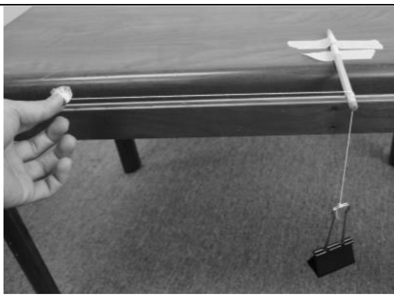
Procedure:

1. Ask students: ***Have you heard of a pendulum before? How does it work?*** *(It's just a weight swinging back and forth!)* ***Let's make one!***

2. Give each student a penny and a piece of string. Make masking tape and painter's tape available (both types will work).
3. Have students tape the penny to one end of the string.
4. Have students stand up and hold the free end of the string about a foot in front of them, so that the end with the penny hangs straight down.
5. Have students pull their penny to one side (keeping the string taut), then release it. Watch the penny swing back and forth.
6. Ask students:
   - ***What do you think will happen to the penny's swinging if we change the length of the string?***
   - ***Will it swing faster or slower?***

7. Have students pull their penny to one side, then release it. While the penny is swinging, have them pinch a part of the string lower than where their other hand holds the end of the string. Then, have them pinch closer and closer to the penny to observe how the speed of the penny changes.

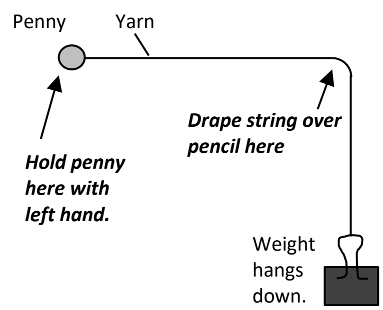
Pendulum Drop. Finished product.



Pendulum Drop. Hold the penny in your left hand. Drape the string over the pencil (which is taped to the table). Release the penny and watch it wrap around the pencil!

8. <u>Ask students:</u> ***Does a shorter string make the penny swing faster or slower?*** *(Shorter string = faster swing!)* ***Let's see how we can use that knowledge to create a tricky contraption!***

9. Give each student a large binder clip and a pencil. Make tape available.
10. <u>Have students</u>:
    a. Tie or tape the binder clip to the end of the string opposite the penny (see left).
    b. Tape the pencil to a table so the eraser end sticks out 3 inches from the edge.
    c. Stand up and hold the penny in their left hand. While holding the penny, drape the middle of the string over the pencil. The string should hang over the pencil and the binder clip should hang straight down below the pencil (see diagram at right).



11. <u>Ask students</u>***: What do you think will happen if you let go of the penny?*** *(The weight of the binder clip is heavier than the penny. It seems like gravity would pull the binder clip down—along with the penny, since they're connected by the string—and both would hit the ground.)*

12. Have students let go of the penny (see photo at left).

    <u>Discussion Prompt:</u>
    - ***What happened?*** *(Instead of falling, the penny on the string wrapped itself around the pencil, causing the binder clip to hang suspended in midair!)*

13. Allow students to explore changing the placement of their pencil along the length of the string.
14. Students can also try using their finger in place of the pencil. To do this: Have students hold the penny in their left hand. While holding the penny, put their right index finger under the string about halfway toward the binder clip. The string should hang over their finger and the binder clip should hang straight down below their finger. They will release the penny from their left hand as before, and the penny should wrap around their right index finger.

Activity Three – The Wheels on the Bus Go Time: 10 Minutes

Supplies	#	Supplies	#
Wheels (small, wooden)	64	Straw pieces (2in, "for axles")	16
Scissors (site provides)	1	Tape (rolls, masking)	1
Stir sticks (half pieces)	32	Tape (rolls, painter's)	1

Goal: To create an axle using a stir stick and wooden wheels.

Source: Hands on Science Outreach

Background:

Trying to roll two wheels together is difficult when they're not connected! To make two wheels move at the same speed in the same direction, you join them together with an axle. Axles connect two wheels together and can stabilize both of them.

There are two types of axles: "fixed axle" and "fixed wheel." In a fixed axle type, the axle stays still, and the wheels can turn freely around it. This is like the first part of the experiment, when you held the ends of the stir stick (the axle) and each wheel was able to turn. These types of axles can be found in smaller vehicles like skateboards! Each wheel on a skateboard turns on its own.

The other kind of axle is a "fixed wheel" axle. In a fixed wheel type, the wheels are attached to the axle and can't move on their own, so the entire axle has to turn inside of a space called a bearing. This is like the second part of the experiment, when the wheels were stuck to the stir stick (the axle) and you had to hold the clear piece of straw (the bearing) so the entire axle could turn inside it. These types of axles can be found in larger vehicles like cars. The wheels don't turn on their own—the axle turns, and the wheels attached to the axle turn with it.

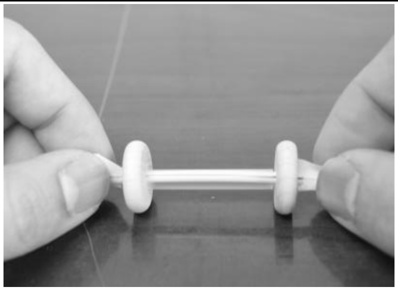
Procedure:

1. Ask students: ***Think about the wheels on a car or bus.***
   - ***Are they connected or do they spin by themselves?*** *(They're usually connected.)*
   - ***Why do you think they're connected?***

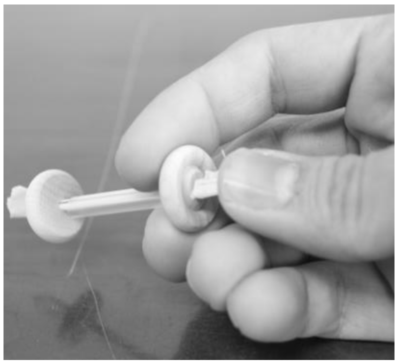
2. Give each student a small wooden wheel.
3. Ask students: ***What happens if you roll a wheel across the table (or floor) by itself?***

4. Have students try rolling one of their wheels by giving it a gentle push.

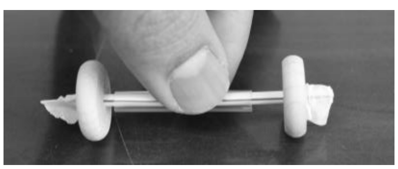
   Discussion Prompts:
   - ***Did it roll smoothly?***
   - ***How long did it stay standing?*** *(Probably not very long.)*



Wheels on the Bus Go. Hold the two ends of the stir stick to roll the wheels together.



Wheels on the Bus Go. Push the wheels so they stick on the masking tape ends of the stir sticks.



Wheels on the Bus Go. Hold the wheels by the clear straw piece to roll the wheels in sync.

5. Give each student another wooden wheel.
6. Ask students:
   - ***How could you get these two wheels to work together?***
   - ***Can you make them go the same direction and speed if you roll them across the table (or floor)? Try it!***

7. Allow students to experiment with rolling the wheels side by side in the same direction, by giving each of them a gentle push at the same time.

   Discussion Prompts:
   - ***How well did the wheels stay in sync?*** *(Probably not very well.)*
   - ***Do you think we could make the wheels work together better if we connect them? Let's try!***

8. Give each student two 1in straw pieces (cut as prep) and two half-pieces of stir stick. Make scissors, masking tape, and painter's tape available (both types of tape work).
9. Have students:
   a. Insert one half-piece of stir stick into a 1in straw piece.
   b. Add a wheel to each end of the stir stick.
   c. Place a small piece of masking tape on each end of the stir stick to keep the wheels from falling off. Try to avoid getting tape on the wheels so they can still turn freely.
10. Ask students: ***What do you think will happen when you roll these wheels? Try it!***

11. Have students hold the ends of the stir stick and try rolling the wheels forward (see top photo at left).
12. Ask students: ***The stir stick that connects the wheels is called an axle! An axle is a pole that goes through the center of one or more wheels.***
    - ***What does the axle do?*** *(It stabilizes the wheels and helps them move together.)*
    - ***If we stick the wheels to the stir stick, will they still roll? Let's find out!***

13. Have students push the wheels outward along the stir stick so the masking tape forces them to stick in place (see middle photo at left). The wheels should not turn freely on the stir stick for this step.
14. Ask students:
    - ***How can you make the wheels move forward by holding the ends of the stir stick?***
    - ***What happens if you hold the middle of the clear straw and try rolling the wheels forward?***

15. Give students time to test these two different methods of rolling the wheels (see bottom photo at left).

16. Ask students: ***What's the difference between holding the stir stick directly and holding the clear piece of straw around it?*** *(When you hold the stir stick directly, you have to roll it between your fingers to make the wheels go forward since the wheels can't turn by themselves. When you hold the clear piece of straw, you can just push the straw forward—the stir stick can turn in the space inside the clear straw, and the wheels move along with it.)*

17. Give each student two more wheels.
18. Have students use the other half-piece of stir stick and the other 1in straw piece to create another set of wheels on an axle.

Activity Four – Finger Skateboard Time: 15 Minutes

Supplies	#	Supplies	#
Cardboard rectangles (large, 7inx14in)	4	Straw pieces (2in, "for axles")*	16
Planter boxes (plastic)	4	Tape (rolls, masking)	1
Popsicle sticks (jumbo)	16	Tape (rolls, painter's)	1
Scissors (site provides)	16	Wheels (small, wooden)*	64
Stir sticks (half pieces)*	32		

***Each student should have already created 2 axles with wheels in the previous activity.**

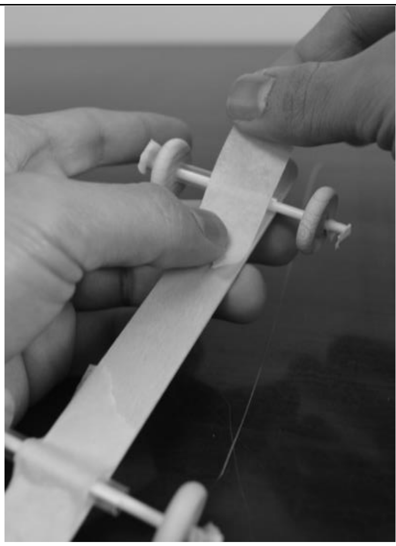
Goal: To observe how wheels and axles work by building a mini skateboard with a jumbo popsicle stick as the base.

Source: bit.ly/3HFgAQF

Background:
In the previous activity, you learned that axles are useful for keeping wheels stable and helping them move in sync with each other. On the finger skateboard you build, the stir sticks inside the straw pieces serve as axles to help the wheels move together in a stable way.
Almost anything you can think of with wheels has one or more axles—from wagons, to strollers, to roller skates, to cars! Although axles are definitely useful for helping multiple wheels move together, sometimes an axle is also needed when there's only one wheel to stabilize. For example, hamster wheels, Ferris Wheels, and windmills all have an axle in the center that they turn around. Even rolling pins and pinwheels turn on an axle! (https://bit.ly/40BXkw0)

Procedure:
1. Ask students: ***We've learned about axles and wheels. How can we use them to create a vehicle? Let's find out!***

2. Have students retrieve their axles with wheels from the previous activity. (Each axle is a half-piece of stir stick inside a clear 1in straw


Finger Skateboard. Tape the 1in straw pieces onto the jumbo popsicle stick to create a basic vehicle with axles and wheels.


Finger Skateboard. Use a finger to push the skateboard on the table.

piece with a wheel on each end. Each student should have two axles.)

3. Give each student a jumbo popsicle stick and a pencil. Make masking tape and painter's tape available (both types will work).
4. Have students write their name on their popsicle stick.
5. Have students tape their axles to the jumbo popsicle stick. Tape each clear straw piece perpendicular to the popsicle stick, close to one end of the stick (see top photo at left).
6. Flip the popsicle stick over so the axles are underneath the stick. Use a finger to push the skateboard along the table (see bottom photo at left).

Discussion Prompts:

- ***What did you build?*** *(A skateboard!)*
- ***How do the stir sticks help the wheels?*** *(The stir sticks serve as axles to help the wheels move together in a stable way.)*
- ***How would your skateboard work on a ramp? Let's find out!***

7. Put students in four groups.
8. Have students retrieve their ramps from the previous activity.
9. Allow students time to run their skateboard down the ramp.

Discussion Prompt:

- ***Did the skateboard go as quickly and as far as you predicted?***
- ***Can you think of a way to improve this design?***
- ***What would you change?***

Activity Five – Monster Truck Time: 5 Minutes

Supplies	#	Supplies	#
Cardboard rectangles (large, 7inx14in)	4	Straws (clear, full size)	1
Finger skateboards (from previous activity)	16	Straws (jumbo, bubble tea)	1
Popsicle Sticks (jumbo)	1	Tape (rolls, masking)	1
Planter boxes (plastic)	4	Tape (rolls, painter's)	1
Scissors (site provides)	1	Wheels (large, wooden)	4

Goal: To demonstrate that larger wheels enable a vehicle to travel farther by comparing the finger skateboard to a skateboard with larger wheels.

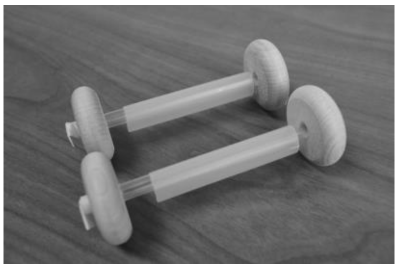
Source: bit.ly/3HFgAQF

Background:

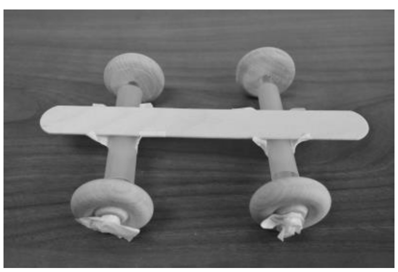
The main difference between the Monster Truck and the regular finger skateboards was the size of the wheels. As you noticed, larger wheels allowed the monster truck to travel farther with the same amount of energy (starting at the same place on the ramp) as a regular finger skateboard. The larger the wheel, the better it converts energy into distance!

Have you ever seen an old bicycle with a giant front wheel and a tiny back wheel? Those types of bicycles were called "penny farthings" or "high wheelers"—and that design was the first type of vehicle to be called a "bicycle." Although high wheelers had some advantages (such as rolling smoothly over bumpy cobblestone streets), they could be dangerous because it was easy for a rider be thrown forward over the handlebars if they hit a rock or had to brake suddenly. The style of bicycle that replaced the high wheeler was called a "safety bicycle"—and that updated design is similar to what we use today!) (http://bit.ly/3jlBpmm)

Procedure:
Steps 1-8 are suggested as prep for the Class Leader to construct the Monster Truck:


Monster Truck. Finished axles with large wooden wheels, jumbo straw pieces, and regular straw halves.

1. What you need: four large wooden wheels, a jumbo popsicle stick, a pair of scissors, one regular straw, one jumbo straw, and masking tape.
2. Cut the regular straw in half. Cut two 2in pieces from the jumbo straw.
3. Insert one of the regular straw halves into one 2in piece of jumbo straw.
4. Add a large wheel to both ends of the regular straw.
5. Place a small piece of masking tape on each end of the regular straw to keep the wheels from falling off.
6. Push the wheels outward along the regular straw so the masking tape forces them to stick in place.
7. Repeat steps 3-6 to build a second axle with wheels.
8. Tape the axles to the jumbo popsicle stick. Tape each jumbo straw piece perpendicular to the popsicle stick, close to one end of the stick (just like assembling the finger skateboard).


Monster Truck. Finished Product.

Discussion Prompts:

- ***How could you improve the design of your finger skateboard?*** *(Build a sturdier model, use glue instead of tape, make everything bigger.)*
- ***How is the Monster Truck different from a regular finger skateboard?*** *(It has bigger straws as axles and bigger wheels).*
- ***How do you think having bigger wheels will affect how fast and far it rolls off the ramp compared to a regular finger skateboard?***

9. Line up the four ramps about a foot apart (if space allows).
10. Have three students each hold their vehicle at the top of one of the ramps. (The other students should line up behind them or stand somewhere to observe.)
11. Hold your monster truck at the top of the fourth ramp.

12. Ask students: ***If we all release our vehicles at the same time, what do you think will happen? Will they all go the same distance?***

13. Count down from 3, then release all four vehicles. You may want to mark the distance each vehicle goes with a piece of tape.
14. Run additional trials until all the students have had a chance to test their vehicle against the Monster Truck.

    Discussion Prompt:
    - ***What did you notice?*** *(The Monster Truck went farther than the finger skateboards.)*

Activity Six – Daily Debrief — Time: 5 Minutes

Supplies	**#**
Lab Notebooks	16
Pencils	16

Goal: To draw today's activities together through a thoughtful question and give students an opportunity to ask their own questions.

Procedure:
1. Encourage students to reflect on what they learned in today's class and what new questions they might have.
2. Allow students a few seconds to think. Have them discuss their thoughts and questions with a partner, then share with the rest of the class and/or write down in their lab notebook.
3. If needed, feel free to offer prompts like:
    - ***What do you think would happen if we changed one thing about today's activities (for example: materials, speed, temperature, etc.)?***
    - ***If you could investigate (explore) one more thing about today's activities, what would you like to find out?***

4. If time allows, ask the following question:
    - ***If bigger wheels are better, why don't all vehicles have huge wheels?*** *(Bigger wheels are also heavier and harder to control. To pick the right wheel for a vehicle, it has to be big enough to provide speed and stability, but not so big that it's too heavy or takes up too much space.)*

Clean up: Make sure students help clean the room before they leave.

What to save:

Materials used	#	SAVE	Materials used	#	SAVE
Binder clips (large)	16	0	Straw pieces (2in, "for axles")	32	0
Cardboard rectangles (large, 7inx14in)	4	4	Straws (clear, full size)	1	0
Pencils	16	16	Straws (jumbo boba)	1	0
Pennies	16	0	String (1.5ft pieces)	16	0
Planter boxes (plastic)	4	4	Tape (rolls, masking)	1	1
Popsicle sticks (jumbo, bubble tea)	17	0	Tape (rolls, painter's)	1	1
Scissors (site provides)	1	1	Wheels (large, wooden)	4	0
Stir sticks (half pieces)	32	0	Wheels (small, wooden)	64	0

What goes home: Penny Pendulum & Finger Skateboard

(Review safety guidelines with students: binder clips on strings should not be swung at other people; students should be careful not to pinch their fingers in the binder clips; small items should always be kept away from children ages 3 and younger to avoid the risk of choking)

If possible, you may want to keep the ramps intact for the next class.

Fun Physics: Forces & Motion (Grades K-3)

Class 4: Spring is in the Air

Supplies	#
Balls (small, bouncy rubber)	8
Balls (small, Styrofoam)	8
Cardboard rectangles (large, 7inx14in)	4
Frogs (plastic, hopping)	16
Marbles (large)	16
Marbles (small)	16
Pencils	16
Planter boxes (plastic)	4
Play dough containers (from Class 2)	8
Pop-ups (spring toy)	16
Rubber bands (size 32)	32
Tape (rolls, masking)	1
Tape (rolls, Scotch)	4
Felt (4inx9in rectangles)	4
Transparency sheets (plastic, clear or tinted)	8
Trays (Paper)	8

Prep (prior to class) Time: 15-30 Minutes

- **Act. 3a (OPTIONAL):** You may want to construct the rubber band "trampolines" as prep (see Step 11 of Activity 3).
- **Act. 3b (OPTIONAL):** You may want to tape the pencil "channels" to the ramps as prep (see Step 15 of Activity 3).

Activity One – Pair & Share Time: 10 Minutes

Supplies	#	Supplies	#
Pencils	16	Lab notebooks	16

Goal: To engage students' thinking and questioning related to the day's activities.

Suggested Reading: *The Thingity-Jig* by Kathleen Doherty

Procedure:

13. Prepare a quiet space for students to give them a physical area to think. The space can be an area set aside from the activity area, where students sit in a circle to ponder the *Pair & Share* question.

14. Make lab notebooks and pencils available.

15. Ask students a *Pair & Share* question. For example:
    - ***What is energy?*** *(The ability to make things happen. It's not created or destroyed—just transferred from one form to another.)*

16. Ask students to discuss their ideas with their neighbor before inviting students to share what they came up with. This is a "challenge by choice" opportunity and no one is required to share with the class if they are not comfortable.

Activity Two — Frog Olympics Time: 15 Minutes

Supplies	#	Supplies	#
Frogs (plastic, hopping)	16	Tape (rolls, masking)	1
Pencils	16	Trays (Paper)	8

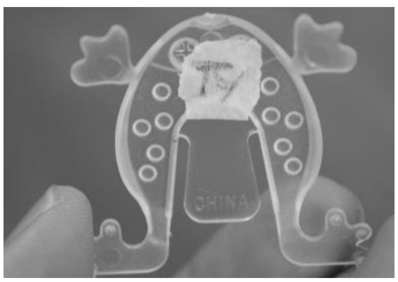
Goal: To introduce potential and kinetic energy using hopping toy frogs.

Source: Sarah Andersen, Oregon Health Career Center

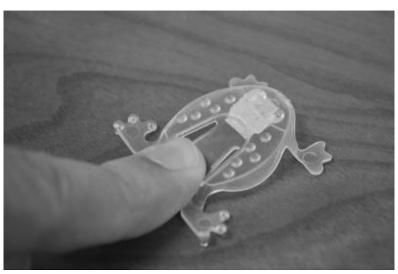
Background:

Energy is always changing into different forms! Potential energy is energy that can be used in the future. When you press down on the back of the frog, you're storing potential energy. The harder you press down on the frog, the more potential energy you store—up to a point. There's a limit to how much potential energy how you can store because of the frog's size and what it's made of.

After you let go of the frog, the potential energy turns into kinetic energy! Kinetic energy is the energy of motion, and it allows the frog to leap into the air. The frogs stop moving up and forward once its kinetic energy is used up. Then gravity takes over, causing it to fall back down. (Interactive Science for Inquiring Minds Volume B, Volume 2 by Tho Lai Hoong, Tho Mun Yi, & Josephine Fong pg. 5)



Frog Olympics. Place a small piece of masking tape on the underside of the frog (near the eyes) to label it with a student's initials.



Frog Olympics. Press down on the "tail" of the frog, then release to make the frog hop.

Procedure:

1. Show students a plastic frog.
2. Ask students: ***Do you think this frog can hop? How?***

3. Give each student a pencil, a plastic frog, and a very small piece of masking tape.
4. Have each student write their initials on the piece of masking tape and stick the tape on underside of their frog, close to the eyes (see photo at left).
5. Allow students time to explore ways to make the frog hop. They can press down on the frog's "tail" and then let their finger slip off the back of the "tail" to make the frog jump (see top photo on next page).

   Discussion Prompt:
   - ***What makes the frog hop?*** *(When you press down on the frog's tail, the frog stores up potential energy, which is energy that can be used in the future. When you let go of the tail, the potential energy turns into kinetic energy. Kinetic energy is the energy of motion!)*

6. Place a long piece of masking tape on the floor about 2 feet from a wall. The tape should be parallel to the wall. Place another long piece of masking tape on the floor about 5-10 feet from the wall. The tape should be parallel to the wall and the first strip of tape. (Feel free to modify as needed for your classroom space.)
7. Have students line up at the wall, facing the masking tape lines.
8. Tell students: ***Let's see what these frogs can do, with you helping them store and release energy! Are you ready for the First Annual Frog Olympics?***

9. Tell students they'll participate in four events. Lead the following activities:
   a. **The Long Jump:** Have students place their frog on the tape line closest to the wall, facing away from the wall. Then, *with a*

single jump, challenge them to get their frog to go the farthest distance in the class.

b. **<u>The High Jump</u>:** Have students place their frog on the tape line closest to the wall, facing the wall. Then, *with a single jump*, challenge them to get their frog to jump the highest up the wall.

c. **<u>Race to the Finish</u>:** Have students place their frog on the tape line closest to the wall. Then, have them race their frogs to see whose frog reaches the "finish" line (the tape strip furthest from the wall) the fastest. Students should follow behind their frog and continue making it hop until it reaches the finish line. You may want to do this in "heats," with just a few students in each race, depending on your classroom size.

d. **<u>Lily Pad Landing</u>:** Put students in four groups. Give each group a paper tray. Have students form a circle around the tray and start their frog about a foot back from the tray (create a masking tape circle if needed). Students should try to aim their frog so it lands in the tray.

10. <u>After each event, ask questions like:</u>
    - ***Which frog won?***
    - ***Why did it win?***
    - ***Is it made differently than the others?***
    - ***Was there a difference in how its owner made it hop?***

11. <u>Once the Olympics are over, ask students:</u> ***Can you hop like a frog?***

12. Allow students time to try hopping like a frog.

    <u>Discussion Prompts:</u>
    - ***How do you move when you hop like a frog?*** *(You crouch down with your legs bent, then push against the ground with your hands and feet to spring up and forward.)*
    - ***How is that like your hopping frog?*** *(The tail of the frog gets pressed down, and when it's released, the frog springs up and forward.)*

Activity Three – Balls, Bounce & Billiards Time: 20 Minutes

Supplies	#	Supplies	#
Balls (small, bouncy rubber)	8	Play dough containers (from Class 2)	8
Balls (small, Styrofoam)	8	Rubber bands (size 32)	32
Cardboard rectangles (large, 7inx14in)	4	Tape (rolls, masking)	1
Marbles (large)	16	Tape (rolls, Scotch)	4
Marbles (small)	16	Felt (4inx9in rectangles)	4
Pencils	16	Transparency sheets (plastic, clear or tinted)	8
Planter boxes (plastic)	4		

Fun Physics: Forces & Motion (Grades K-3)

Class 4: Spring is in the Air

Goal: To compare how balls made of different materials bounce and transfer energy.

Source: Hands on Science Outreach & Tyler Oshiro, AKA Science

Background:

In your experiment, you tested three materials: glass (marble), Styrofoam, and rubber. By comparing how those materials bounced and transferred energy, you learned about their properties. A property is a trait or feature—it's a way you can describe something. You can learn about a material's properties through testing. For example, we learned that rubber is bouncy—bounciness is a property of rubber! We also found that a property of glass is that it's heavy, and a property of Styrofoam is that it's light.

The study of what things are made of is called materials science. Materials scientists work in lots of different places, from laboratories to factories. Materials scientists at places like Nike and Adidas use the properties of materials to create things like shoes that help you jump higher and balls that bounce better for sports! (https://bit.ly/3x5QAsH)

Procedure:

1. Pair students. Give each pair a Styrofoam ball, a rubber ball, and a large marble.
2. Have students observe the similarities and differences between the three items.
3. Ask students:
    - ***How are the items similar to each other?*** *(They're the same shape—balls/spheres—and roughly the same size.)*
    - ***How are they different from each other?*** *(They have different weights and textures. They're made of different materials.)*
    - ***How do the materials they're made of look and feel different?*** *(The marble is heavy and shiny. The rubber ball is slightly squishy. The Styrofoam ball is light.)* ***Let's test whether the materials they're made of react in different ways!***

4. Give each pair a piece of felt, a transparency sheet, and an empty play dough container (no lid needed). Make Scotch tape available.
5. Have pairs use the play dough container as a guide to roll the transparency sheet into a tall tube that's slightly wider than the container. Tape the tube so it can stand upright. Remove the play dough container and set it aside. Tell students the tube will be the "test chamber" for their experiments.
6. Ask students: ***How can you use your test chamber to learn more about the materials these balls are made of?***

7. Have pairs fold the piece of felt in half to form a square.
8. Have one student in each pair hold the test chamber upright so the bottom opening of the tube rests on the folded piece of felt (see top photo at left).

Balls, Bounce & Billiards. The "test chamber" stands upright, with one opening on a folded piece of felt. Drop each ball from the top.

9. Have the other student hold the Styrofoam ball over the top opening of the tube.

   Discussion Prompt:
   - ***What do you think will happen to each of the balls if you drop them into the chamber?***

10. Have the student holding the Styrofoam ball drop it through the top of the tube.

    Discussion Prompt:
    - ***What happened?*** *(The Styrofoam ball landed softly and bounced slightly.)*

11. Remove the Styrofoam ball from the test chamber. Have pairs take turns testing the rubber ball and large marble, removing each ball after it lands on the cloth. Make sure students notice what happens to each of the balls.

    Discussion Prompts:
    - ***Which ball bounced the least?*** *(The large marble. It dropped heavily and didn't bounce much.)*
    - ***Which one bounced the highest?*** *(The rubber ball)*
    - ***Why?***

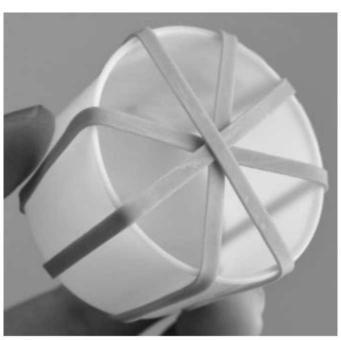
12. Tell students: ***The rubber ball is made of rubber which has the ability to absorb and release energy – when it bounces, it saves the energy from the drop to bounce back up!***

13. Ask students: ***Do you think you can use rubber to make your marble bounce, too? Let's try it!***

14. Give each pair four size 32 rubber bands.
15. Have students help each other stretch the rubber bands across the opening of the play dough container. The rubber bands should be spaced evenly so they create eight "pizza slices" when you're looking from the top (see middle photo at left).

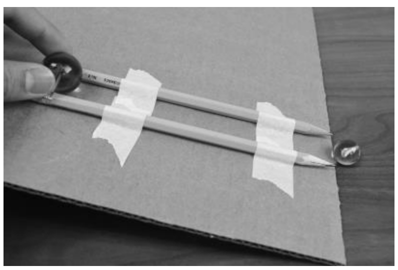
    Discussion Prompts:
    - ***What did you create with your rubber bands?*** *(A mini trampoline!)*
    - ***What do you think will happen if you place the mini trampoline at the bottom of the of the test chamber?***

16. Have students place the trampoline inside the bottom of the chamber (with the rubber bands facing up—see bottom photo at left).
17. Have students drop each of the balls into the chamber, one by one.



Balls, Bounce & Billiards. Create a mini trampoline using four size 32 rubber bands stretched over an empty play dough container.

Balls, Bounce & Billiards. Place the mini trampoline in the base of the "test chamber."



Balls, Bounce & Billiards. Tape down pencils to create a "channel" on the ramp. Roll each ball down the ramp to hit the small marble.

Discussion Prompts:

- ***What happened?*** *(The marble bounced the highest! The Styrofoam ball bounced the least.)*
- ***Why?***

18. Tell students: ***The marble is heavier than the other balls, which meant it had the most potential energy when it was held at the top of the tube. When it fell, it gained momentum, and that momentum got converted into a big bounce off the trampoline. The opposite was true for the Styrofoam ball. Its light weight meant that it picked up less momentum, so it got less of a bounce.***

19. Ask students: ***What's another way we can use the balls to transfer kinetic energy? Let's roll them into each other!***

20. Put students in groups of four. Give each group a ramp (a cardboard rectangle taped to a planter box from Class 3), four pencils, and four small marbles. Make masking tape available.
21. Have each group use two pencils to create a "channel" on the ramp. To create the channel, place two pencils side by side with their tips lined up where the ramp meets the table/floor and their erasers pointing up. The space between the pencils should be about the width of a large marble. Tape the pencils in place.
22. Have students set a small marble at the base of the channel (on the table/floor, touching the bottom of the ramp).
23. Ask students: ***What do you think will happen if we roll one of the balls down the channel and it hits the small marble? Which ball will make the small marble roll furthest?***

24. Have students take turns rolling each ball down the ramp to hit the small marble, replacing the small marble after each test (see top photo at left). Students can label pieces of masking tape and mark the distance each large ball caused the small marble to roll. If time allows, have each student test all three of their balls so students can look for patterns in the data across the whole group.

Discussion Prompts:

- ***Which ball made the small marble roll the furthest?*** *(The large marble!)*
- ***Which ball made the small marble roll the least far?*** *(The Styrofoam ball)*
- ***Why?***

25. Tell students: ***The large marble was the heaviest, so it gained a lot of momentum as it rolled down the ramp (similar to how it gained a lot of momentum as it fell inside the test chamber). That meant that it***

had the most energy to transfer when it knocked into the small marble.

26. OPTIONAL: If you have extra time, students can test new combinations (for instance, they can put the Styrofoam ball at the bottom of the ramp and compare how far it travels when hit by the small marble, the large marble, and the Styrofoam ball).

Activity Four – Once You Pop… Time: 15 Minutes

Supplies	#	Supplies	#
Play dough containers (from Class 2)	8	Pop-ups (spring toy)	16
Rubber bands (size 32)	32	Transparency sheets (plastic, clear or tinted)	8
Pencils	1	Tape (rolls, Scotch)	4

Goal: To learn about storing potential energy by experimenting with pop-up toys.

Source: Tyler Oshiro, AKA Science

Background:
Unlike your hopping frog and trampoline, your pop-up was able to hold onto potential energy for a little while before springing up. How? The pop-up toy is designed to set two forces against each other: suction vs. spring! It took a little while, but eventually, the force of the spring overcame the force of the suction, and the pop-up sprang into the air.
Stored potential energy can be useful: you can put energy in when you have it, then release it when you need it! It's like drawing back a bow and arrow and releasing it when you're set on your target, or blowing up the energy stored in a stick of dynamite to clear rock! Potential energy has the potential to do big things! (http://bit.ly/3jGH9wK)


Once You Pop. Make sure each pair gets at least one bunny holding an egg (right). Kicking bunnies (left) won't fit in the "test chamber" for the second part of the activity.

Procedure:
1. Ask students: ***So far you've experimented with things that transfer energy very quickly. As soon as you let go of your frog, it hopped! As soon as you dropped a ball, it bounced. Do you think something can store energy for a little while before releasing it? Let's find out!***

2. Keep students in their pairs from the last activity. Have pairs keep their transparency test chambers and mini trampolines handy.
3. Give each student a pop-up toy. If you have ninja bunny pop ups, make sure one student in each pair gets a bunny holding an egg (i.e., there shouldn't be two "kicking bunnies" in the same pair—see bottom photo at left). Zoo animal pop ups have no restrictions.
4. Ask students:

Once You Pop. Press the bunny down so the suction cup seals around the plastic base. Let go, then wait—the pop-up will jump into the air!

Once You Pop. Set the pop-up so it's ready to spring, then drop it through the test chamber to test how high the bunny jumps on the trampoline. (If you have bunny pop ups, use a bunny holding an egg for this step. If you have zoo animal pop ups, any one will work.)

- ***What are the parts of this toy?*** *(Ninja bunny or other animal, suction cup, spring, and base.)*
- ***How do you think the parts of the toy work together to store and release energy? Let's find out!***

5. Have students:
    a. Place their pop-up in front of them. MAKE SURE STUDENTS DON'T LEAN OVER THEIR POP-UP (otherwise it could hit them in the face.)
    b. Press down on the bunny so the suction cup seals over the plastic base.
    c. Wait and observe what happens (see top photo at left).

Discussion Prompts:

- ***What happened?*** *(The pop-up flew into the air!)*
- ***How did your pop-up store energy and then release it?*** *(When you pressed down on the ninja bunny, you squished together the metal spring. The metal spring wanted to stretch out to its normal size, but it was temporarily held in place by the suction cup. As the energy in the coiled spring finally overcame the grip of the suction cup, the spring expanded and pushed the pop-up upwards.)*
- ***Can we measure how high the pop ups are jumping?***

6. Have pairs retrieve their test chamber from the last activity.
7. Have the student whose bunny is holding an egg set the pop-up so it's ready to spring. Have the other student quickly place the test chamber over the pop-up.
8. Have students observe how high the pop-up jumps in the test chamber.
9. Ask students: ***If we set the pop-up on the trampoline from the last activity, do you think the pop-up will jump higher or lower than it did on the table? Let's find out!***
10. Have pairs:
    a. Retrieve their mini trampolines from the last activity.
    b. Place the trampoline inside the bottom of the test chamber.
    c. Set the bunny holding an egg so it's ready to spring, then gently drop it right-side up through the top opening in the chamber (see bottom photo at left). For the zoo animal pop ups, any can be used.
    d. Observe how high the pop-up jumps in the test chamber.

TIP:
- **If a pop-up isn't working well, try dipping a finger in water and running it along the bottom rim of the suction cup.**

Discussion Prompts:

- ***What happened?*** *(The pop-up barely jumped.)*

- ***Why didn't the pop-up jump higher on the trampoline?*** *(The pop-up toy works best when the spring pushes down against a flat, solid surface—like a desk or table—and forces the toy upwards. When the surface beneath the base is soft and absorbent, like the trampoline, the pop-up has nothing to push off of, so it can't jump up.)*

Activity Five – Daily Debrief Time: 5 Minutes

Supplies	**#**
Lab Notebooks	16
Pencils	16

Goal: To draw today's activities together through a thoughtful question and give students an opportunity to ask their own questions.

Procedure:

1. Encourage students to reflect on what they learned in today's class and what new questions they might have.
2. Allow students a few seconds to think. Have them discuss their thoughts and questions with a partner, then share with the rest of the class and/or write down in their lab notebook.
3. If needed, feel free to offer prompts like:
   - ***What do you think would happen if we changed one thing about today's activities (for example: materials, speed, temperature, etc.)?***
   - ***If you could investigate (explore) one more thing about today's activities, what would you like to find out?***

4. If time allows, ask the following question:
   - ***If you could store a LOT of potential energy to use later, how would you store it? What would you use it for?"***

Clean up: Make sure students help clean the room before they leave.

What to save:

Materials used	#	SAVE	Materials used	#	SAVE
Balls (small, bouncy rubber)	8	8	Play dough containers (from Class 2)	8	8
Balls (small, Styrofoam)	8	8	Pop-ups (spring toy)	16	0
Cardboard rectangles (large, 7inx14in)	4	4	Rubber bands (size 32)	32	32
Frogs (plastic, hopping)	16	0	Tape (rolls, masking)	1	1
Marbles (large)	16	16*	Tape (rolls, Scotch)	4	4
Marbles (small)	16	16*	Felt (4inx9in rectangles)	4	4
Pencils	16	16	Transparency sheets (plastic, clear or tinted)	8	8
Planter boxes (plastic)	4	4	Trays (Styrofoam)	8	8

What goes home: Hopping frogs & Pop-Ups

(Review safety guidelines with students: small items should always be kept away from children ages 3 and younger to avoid the risk of choking)

*There are enough marbles to send a large marble and a small marble home with each student. Students have two fun take-home items already this day, though, so you may want to reserve the marbles to take home another day (such as Class 7).

(Review safety guidelines with students if/when you send marbles home: marbles should not be handled roughly because they can chip or break, and they should not be thrown at people or pets; small items should always be kept away from children ages 3 and younger to avoid the risk of choking)

If possible, you may want to keep the ramps intact for the next class.

Fun Physics: Forces & Motion (Grades K-3)

Class 5: Feel the Friction

Supplies	#
Beads (wood, large center hole)	8
Cardboard rectangles (large, 7inx14in)	4
Cars (toy)	16
Fishing line (5ft pieces)	16
Paper towels (sheets, white quilted)	8
Pebble weight bags	8
Pencils	16
Planter boxes (plastic)	4
Rubber bands (size 16)	16
Sandpaper (2inx2in squares)	16
Straws (jumbo, bubble tea, half pieces)	32
Tape (rolls, masking)	1
Tape (rolls, painter's)	1
Felt (4inx9in rectangles)	4
Trays (Styrofoam)	8

Prep (prior to class) Time: 15-30 Minutes

- **Act. 4a:** The red and purple toy cars have a small nub on the back underside. To correct for this, add a small piece of Scotch tape that starts behind the back wheels of each car and wraps up around the trunk of the car. *(You only need to add tape to red and purple cars—see photo on Act.4 sideline.)*
- **Act. 4b:** Make sure the cardboard-and-planter-box ramps are still intact from the last class (or reconstruct them).
- **Act. 4c (OPTIONAL):** If desired, you could fully set up the ramps with the felt and paper towels.
- **Act. 5 (OPTIONAL):** You may want to construct the Zoom Beads as prep if you think students will struggle to make them and/or if you want to save time.

Activity One – Pair & Share Time: 10 Minutes

Supplies	#	Supplies	#
Pencils	16	Lab notebooks	16

Goal: To engage students' thinking and questioning related to the day's activities.

Suggested Reading: *How Do You Stop a Moving Train?* by Lucy D Hayes

Procedure:

1. Prepare a quiet space for students to give them a physical area to think. The space can be an area set aside from the activity area, where students sit in a circle to ponder the *Pair & Share* question.
2. Make lab notebooks and pencils available.
3. Ask students a *Pair & Share* question. For example:
   - ***How is walking on ice different than walking on a normal sidewalk?"*** *(It's harder to keep your balance because it's slippery.)*
4. Ask students to discuss their ideas with their neighbor before inviting students to share what they came up with. This is a "challenge by choice" opportunity and no one is required to share with the class if they are not comfortable.

Activity Two – Heat It Up Time: 5 Minutes

Supplies: None

Goal: To experience the heat that can be produced by friction by quickly rubbing hands together.

Source: http://bit.ly/3JP1V83

Background:

When you rub your hands together, you feel a little bit of resistance or a feeling of "stickiness." That resistance is friction! Friction is known as "the stopping force" because it resists and stops motion. If we didn't have friction, walking on the road would be like trying to skate on ice, and holding an object would be like trying to hang onto a wet bar of soap (slippery!).

Friction is caused by the surfaces of two objects rubbing together and getting a little stuck because both surfaces (on a tiny level) are rough. Your hands, for example, have lots of tiny ridges on them to help you grip things. When you rub your hands together, the tiny ridges crash into each other and give off that crashing energy as heat! Because friction gives off heat, people can actually create a fire by rubbing sticks together very quickly. (http://bit.ly/3YBPlxi)

Procedure:

1. Have students quickly rub their hands together for several seconds.
2. Ask students:
   - ***What do you feel?*** *(Heat.)*
   - ***What creates the heat?***
3. Tell students: ***Friction creates the heat! Friction is the force that opposes motion. It's what makes it difficult for an object to move across a surface.***
4. Ask students: ***Can you think of some other examples of friction?*** *(Brakes on a car, snow boots on ice, etc.)*
5. If you have access to a projector or video screen, you can play the video about friction found here: **http://bit.ly/3XhPAwv**

Activity Three – What's Friction? Time: 15 Minutes

Supplies	#	Supplies	#
Pebble weight bags	8	Straws (jumbo, bubble tea, half pieces)	32
Rubber bands (size 16)	16	Trays (Styrofoam or other material)	8
Sandpaper (2inx2in squares)	16		

Goal: To understand how rolling an object can overcome the power of friction by using jumbo straws as "logs" to move a Styrofoam tray carrying a weight.

Source: Hands on Science Outreach

Background:

One of the best ways to overcome friction is to roll over a surface instead of trying to slide across it. When you added the straws underneath your heavy tray, you were able to roll the tray forward instead of sliding it—and that made the tray much easier to move.

It is believed that the ancient Egyptians may have transported the stones used to build the Pyramids by rolling them on logs, just like you rolled your tray of pebbles on straws! A similar technique may have been used to transport the marble used to build the Parthenon (a large ancient building in Greece). (http://bit.ly/3Yn8inO, http://bit.ly/3IbCInj)

Procedure:

1. Ask students: ***How does friction affect the way things move? Let's find out!***

2. Pair students. Give each pair a tray and two squares of sandpaper.
3. Have students rub the sandpaper on the bottom of the tray, first with the back of the sandpaper (smooth side), then with the sandy side (rough side).

   Discussion Prompt:
   - ***Which side of the sandpaper was harder to rub on the Styrofoam tray?*** *(The rough side. It got stuck on the Styrofoam.)*

4. Tell students: ***The "stickiness" when you try to rub two things together is friction! It results from the surfaces of objects catching on each other. Sandpaper causes a lot of friction because of how rough and uneven its surface is. Let's see what else affects friction!***

5. Give each pair a pebble weight bag.

TIP:	• **This activity works just fine on a smooth surface—but if you happen to have a large, carpeted area, it works especially well on carpet.**


What's Friction? Push the tray (weighed down by the pebble bag) so it slides across the desk.


What's Friction? Place the tray on a bed of jumbo straw half-pieces. The tray should roll over the straws.

6. <u>Have students</u>:
    a. Place the tray on a flat surface (like a table or desk).
    b. Push one side of the tray to make the bottom of the tray slide across the desk. (Don't lift the tray—just push from one side.)
    c. Place the pebble weight bag on top of the tray.
    d. Again, push one side of the tray to make it slide across the desk (see top photo at left).

<u>Discussion Prompt:</u>

- ***Was it harder to slide the tray by itself, or with the weight on top?*** *(It was harder with the weight on top.)*
- ***Why?***

7. <u>Tell/ Ask students:</u> ***When an object is heavy, its surface pushes down harder against the surface it's sitting on. This creates more friction between them. If you want to move a heavy object, how can you overcome friction?***

8. Give each pair four half-pieces of jumbo straw.
9. Have pairs line up their jumbo straw half-pieces parallel to each other, about one inch apart (see bottom photo at left).

<u>Discussion Prompts:</u>

- ***What do you think will happen if you put the heavy tray on top of these straws?***
- ***Will the straws make it easier or harder to move the tray across the desk?***

7. Have pairs place their tray (with the weight on it) on top of the bed of straws.
8. Allow students to experiment with pushing the side of the tray so the bottom of the tray rolls across the tops of the straws.

<u>Discussion Prompts:</u>

- ***What did you notice?*** *(The tray was easier to move.)*
- ***Why did the straws make it easier to move the tray?*** *(The straws rolled over the desk. They allowed the tray to roll on top of them instead of having to slide along the surface of the desk directly).*

9. <u>*Tell/ Ask students:*</u> ***Sometimes, to move a heavy object, people use a row of tree logs underneath the heavy object. The round shape of the logs allows them to roll, even with a heavy weight on top of them. If you needed to move your heavy tray a longer distance, what could you do?***

9. Put students in four groups.

10. Have each group line up all eight of their straws parallel to each other, about 1-2 inches apart. If space allows, create a "starting line" on the floor, and have all four groups set up their straws from the same starting line.
11. Have each group set a tray (with a weight on it) on top of the straws at one end of their straw "track."
12. Ask students: ***How far can you move your heavy tray if you work as a team?***

13. Give students time to try moving the tray as far as possible. They may discover that they can move straws from the back of the line (after the tray has passed over them) and put them in front of the tray to keep extending the "track."
14. Have groups keep their pieces of sandpaper available for the next activity.

Activity Four – Friction Roll — Time: 20 Minutes

Supplies	#	Supplies	#
Cardboard rectangles (large, 7inx14in)	4	Planter boxes (plastic)	4
Cars (toy)	16	Sandpaper (2inx2in squares)	16
Paper towels (sheets, white quilted)		Tape (rolls, masking)	1
Pencils	16	Felt (4inx9in rectangles)	4

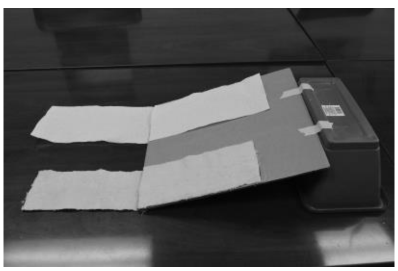
Goal: To observe how friction affects the distance a toy car rolls by creating tracks with different textures on a cardboard ramp.

Source: Sarah Andersen, Oregon Health Career Center

Background:
You will learn today that friction is a force that resists (works against) motion. You will also learn that different surfaces have different amounts of friction. The paper towel will cause your car to slow down and lose some distance compared to the ramp by itself—and the felt will *really* affect the car's speed and distance. Felt has more friction than cardboard, and even more than paper towel. Its rough surface works against the motion of the car.
Did you know that scientists have created a material—a type of film—that has almost zero friction? If you have this material, you can make things very slick and slippery! Many engineers were very happy when it was invented because they were able to use it to build better products. (http://bit.ly/3XIlua6)

Procedure:
1. Ask students: ***Remember when you rolled balls down a cardboard ramp to hit a marble? What would happen if you added a different***

Friction Roll. Prep step for red and purple cars: Add a small piece of Scotch tape that starts behind the back wheels of each car and wraps up around the trunk of the car.



Friction Roll. Create three "tracks" on the ramp: paper towel on one side, felt on the other side, and the regular cardboard ramp in the middle.

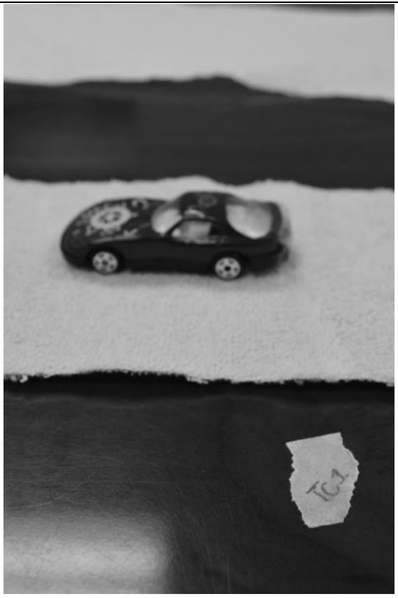
material on top of the ramp to change the friction of the surface? How far would things travel then? Let's find out!

2. Give each student a toy car and a pencil.
3. Keep students in four groups.
4. Give each group a cardboard-and-planter-box ramp. Make masking tape available.
5. Have each group set up their ramp on a long, smooth surface (like a hard floor).
6. <u>Ask students:</u>
   - ***What do you think would happen if you put a piece of paper towel on top of the ramp and rolled the car over it?***
   - ***What if you put a piece of felt on top?***

7. Give each group two pieces of felt and two sheets of quilted paper towel.
8. <u>Have each group create three "tracks" on the ramp:</u>
   - One side of the ramp = felt
   - Middle of the ramp = nothing (just the cardboard)
   - Other side of the ramp = paper towel

   (The goal is for the top and bottom edges of the felt and paper towel "tracks" to line up, but it's OK if they're not perfect—see bottom photo at left.)

9. <u>To create the tracks, have students</u>:
   a. Lay a piece of felt along on one side of the ramp, with the bottom edge of the cloth slightly sloping off the ramp and onto the floor. (This will help provide a smooth transition as the car rolls down the ramp.)
   b. Put a long piece of tape across the top edge of the felt (to attach it to the ramp and provide a smooth transition as the car rolls over the top).
   c. Lay a piece of paper towel on the other side of the ramp, with the bottom edge of the cloth slightly sloping off the ramp and onto the floor. Leave a wide space in between the felt and the paper towel for the car to run directly on the cardboard ramp.
   d. Put a long piece of tape across the top edge of the paper towel.
   e. Lay the second piece of felt on the floor in front of the ramp, lined up with the first piece of felt. Have one student lift the bottom of the ramp up slightly. Have another student scoot the piece of felt slightly toward the ramp (so the edge of the felt will be slightly under the bottom of the ramp). Tape that edge to the floor.
   f. Lay the second piece of paper towel on the floor in front of the ramp, lined up with the first piece of paper towel. Have



Friction Roll. Use masking tape to mark the distance the car rolls on each track.

one student lift the bottom of the ramp up slightly. Have another student scoot the piece of paper towel slightly toward the ramp (so the edge of the paper towel will be slightly under the bottom of the ramp). Tape that edge to the floor.

10. <u>Ask students</u>***: Which track do you think will make the car roll the longest distance? Which track will make it roll the shortest distance?***

11. <u>Have one student in each group</u>:
    a. Place their car at the top of the ramp, lined up with the cardboard track.
    b. Release the car so it rolls down the <u>cardboard track</u> and onto the floor.
    c. Have another group member mark how far the car went with a piece of masking tape (see photo at left), then return the car to its owner.
    d. Have the first student repeat the activity on the paper <u>towel track</u>, followed by the <u>felt track</u>.

    <u>Discussion Prompts:</u>
    - ***Was there a difference in how far the car rolled on each of the three tracks?*** *(Yes.)*
    - ***Do you think the other cars in the group will have the same results? Let's find out!***

12. One at a time, have each student in the group test their car by rolling it down each of the three tracks. Students can take turns marking each other's distances with masking tape. (Have groups decide whether to mark where the front versus the back of each car stopped and use that method consistently. Place the tape in line with the car, off to the side of the tracks.)

<u>TIP</u>:
- **It's important to have <u>one</u> student test their car on each of the three tracks before letting the next student test their car.** (The cars don't all roll the same, so it works best to compare the effect of friction on each individual car, rather than comparing cars to each other.)

<u>Discussion Prompts:</u>
- ***What happened?***
- ***How did the surfaces of the different tracks affect how far your car rolled?*** *(The car rolled the farthest on the regular cardboard ramp, less far on the paper towel, and least far on the felt.)*
- ***Which surface had the most friction?*** *(The felt. The rougher the surface, the more friction it has, and the more it resists the movement of the car.)*
- ***Could you add even more friction to slow your car down?***

13. If time allows, have each group retrieve their four pieces of 2inx2in sandpaper.
14. Allow groups to experiment with placing the pieces of sandpaper on or near the ramp to slow the cars down even further.

<u>Discussion Prompts:</u>

- ***If you had access to other supplies, how could you reduce the friction on the ramp to make your car go faster and further?*** *(You could make the ramp surface smoother by sanding it, adding a slick layer of oil on top, etc.)*
- ***Does the angle of your ramp make a difference in how far your car travels? Let's find out!***

15. <u>OPTIONAL:</u> If you have extra time, have students either raise or lower their cardboard ramp. It's easiest to do this by raising the planter box on a stack of books or other objects. Students can then repeat the experiment to determine if the height of the ramp makes a difference in how far the car can travel.

Activity Five – Zoom Bead **Time: 5 Minutes**

Supplies	#
Beads (wood, large center hole)	8
Fishing line (5ft pieces)	16
Tape (rolls, masking)	1
Tape (rolls, painter's)	1

<u>Goal</u>: To observe how kinetic energy can be transferred using a zooming bead.

<u>Source</u>: http://bit.ly/3DRUeu0

<u>Background:</u>

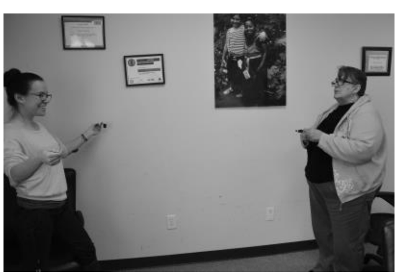
Forces, as you have learned, are all around us, acting in different directions. With your Zoom Bead, you will learn that an applied force in one direction can cause motion in a different direction! By using kinetic energy to pull your hands apart, you create tension on your side of the fishing lines, which results in a push on your end of the bead. This causes the bead to move towards your partner's side, where there is less tension.

In some ways, this is similar to what you observed with Newton's Cradle. When you hit one marble against another marble, the kinetic energy of the moving marble got transferred directly to another marble, causing it to move.

As cool as the Zoom Bead is, though, it's probably not useful on a large scale. Think about it: how long would the fishing lines have to be—and how


Zoom Bead. Place two pieces of masking tape or painter's tape on each of the ends of the fishing line.


Zoom Bead. Pull your hands apart to make the zoom bead shoot forward along the fishing line.


Zoom Bead. Have students hold the fishing lines taut between them and alternate who spreads their hands apart to make the bead move.

far apart would you need to spread them—to send a wagon zooming along a road, or a jet zooming into the sky?

<u>Procedure</u>:

1. <u>Ask students:</u> ***In last week's activities, you used kinetic energy (the pop up) to store up potential energy. When you released that potential energy, it turned back into kinetic energy that made things move. Do you think you could quickly and directly transfer kinetic energy from one object to another? Let's find out!***

2. Pair students. Give each pair two 5ft pieces of fishing line and one wooden bead. Make masking tape and painter's tape available (both types will work).
3. Have students thread both pieces of fishing line through the hole in the bead.
4. Have students place one piece of tape on each of the four ends of the fishing line, and a second piece of tape a few inches in front of the first piece, for eight pieces of tape total (see top photo at left). *(The inner pieces of tape on the fishing line are to protect students' fingers as the wooden bead zooms back and forth.)*
5. Have pairs spread out in the room. In each pair, one student should hold the two pieces of fishing line threaded through one side of the bead, and the other student should hold the two ends of the fishing line threaded through the other side of the bead.
6. Have students hold their ends of the line by the pieces of tape closest to the ends, with one line in each hand. (The second set of tape should be a few inches in front of their fingers when holding the line.)
7. Have students stretch the lines taut between them. Slide the bead so that it's closer to one student than the other.

   <u>Discussion Prompt:</u>
   - ***How can you send the bead from one side to the other while holding the taped ends of the line (without touching the bead directly)?***

8. Allow students to experiment. The most effective way to send the bead zooming is for the student on the receiving end to hold their lines close together while the student closest to the bead quickly pulls their hands apart to separate the lines (see bottom two photos at left). Students can alternate whose hands are close together and who pulls their hands apart to send the bead back and forth.

Activity Six – Daily Debrief

Time: 5 Minutes

Supplies	#
Lab Notebooks	16
Pencils	16

Goal: To draw today's activities together through a thoughtful question and give students an opportunity to ask their own questions.

Procedure:

1. Encourage students to reflect on what they learned in today's class and what new questions they might have.
2. Allow students a few seconds to think. Have them discuss their thoughts and questions with a partner, then share with the rest of the class and/or write down in their lab notebook.
3. If needed, feel free to offer prompts like:
   - ***What do you think would happen if we changed one thing about today's activities (for example: materials, speed, temperature, etc.)?***
   - ***If you could investigate (explore) one more thing about today's activities, what would you like to find out?***
4. If time allows, ask the following question:
   - ***If you wanted to make the slipperiest slide in the world, how could you make sure there's as little friction as possible?***

Clean up: Make sure students help clean the room before they leave.

What to save:

Materials used	#	SAVE	Materials used	#	SAVE
Beads (wood, large center hole)	8	8	Rubber bands (size 16)	16	0*
Cardboard rectangles (large, 7inx14in)	4	4	Sandpaper (2inx2in squares)	16	0
Cars (toy)	16	0	Straws (jumbo, bubble tea half pieces)	32	0*
Fishing line (5ft pieces)	16	16	Tape (rolls, masking)	1	1
Paper towels (sheets, white quilted)	8	8	Tape (rolls, painter's)	1	1
Pebble weight bags	8	8	Felt (4inx9in rectangles)	4	4
Pencils	16	16	Trays (various materials)	8	8
Planter boxes (plastic)	4	4			

What goes home: Toy cars

(Review safety guidelines with students: small items should always be kept away from children ages 3 and younger to avoid the risk of choking)

*If desired, each student can also take home two jumbo straw pieces (though you may want to check that the pieces don't have sharp points). The rubber bands can be used to bundle the straws together.

You can take the ramps apart after today's class (but hold on to the planter boxes—you'll use them on their own in Class 8.)

Supplies	#
Binder clips (medium)	16
Cotton balls	32
Pencils	16
Pennies	64
Popsicle sticks (jumbo)	16
Rubber bands (size 33)	32
Spoons (plastic)	32
Tape (rolls, masking)	1
Tape (rolls, painter's)	1
Tape (rolls, Scotch)	4

Prep (prior to class)

- None

Activity One – Pair & Share Time: 10 Minutes

Supplies	#	Supplies	#
Pencils	16	Lab notebooks	16

Goal: To engage students' thinking and questioning related to the day's activities.

Suggested Reading: *How Toys Work: Levers* by Siân Smith

Procedure:

5. Prepare a quiet space for students to give them a physical area to think. The space can be an area set aside from the activity area, where students sit in a circle to ponder the *Pair & Share* question.
6. Make lab notebooks and pencils available.
7. Ask students a *Pair & Share* question. For example:
    - ***What are some ways you can launch an object farther and/or faster than you could throw it?"*** *(Bow and arrow, slingshot, cannon, pitching machine.)*
8. Ask students to discuss their ideas with their neighbor before inviting students to share what they came up with. This is a "challenge by choice" opportunity and no one is required to share with the class if they are not comfortable.

Activity Two – Levers Time: 15 Minutes

Supplies	#	Supplies	#
Pencils	16	Popsicle sticks (jumbo)	16
Pennies	64	Tape (rolls, Scotch)	4

Goal: To observe that the longer a lever is, the stronger it is, using a popsicle stick balanced on a pencil with pennies as weights.

Source: Hands on Science Outreach

Background:

Levers are a type of simple machine. A lever is a bar that moves around a fixed point called a fulcrum. Using a lever involves some weight or resistance that needs to be moved, and an effort to move the weight. By using a lever, you could lift an object (like a baby elephant) that you normally wouldn't be able to lift by taking advantage of the longer arm=stronger arm rule!

There are three types of levers. A Class 1 lever is a teeter-totter or see-saw, just like you created with your popsicle stick. The fulcrum is in between the weight and the force being used to move the weight. The other two classes of levers have the fulcrum at one end instead of in the middle, and the weight is either closer than the applied force (Class 2) or farther from the applied force (Class 3). Class 2 levers need less effort to lift the weight and Class 3 levers need more effort to lift the weight.

Some examples of levers in your everyday life are a balance scale (Class 1), a wheelbarrow (Class 2), and your forearm (Class 3)! (http://bit.ly/3llgZAi)

Procedure:

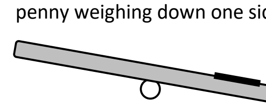
1. Ask students: ***Imagine you're at the playground, and you meet a baby elephant! The baby elephant is heavier than you.***
    - ***How could you lift it up?*** *(If students are stuck, encourage them to think about a teeter-totter or see-saw.)*
    - ***What type of simple machine is a see-saw?*** *(A lever.)*

2. Give each student a pencil and a jumbo popsicle stick. Make tape available.
3. Ask students: ***How can you make a lever (or see-saw) with these materials? Let's try!***

4. Have students:
    a. Tape the pencil onto the table with the eraser pointing straight toward them. Make sure the pencil lays flat.
    b. Place the popsicle stick across the pencil, perpendicular to the pencil.
    c. Adjust the popsicle stick until it balances on the pencil.

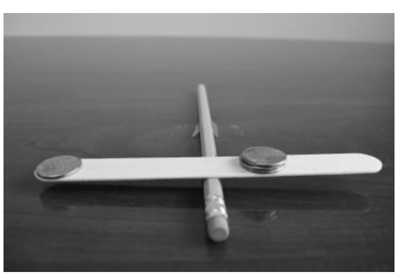
5. Tell/Ask students: ***Congratulations—you found the balance point! A lever is a stiff bar that pivots—or moves back and forth—on a support. The point where the bar moves back and forth is called the "fulcrum."***
    - ***In the see-saw lever you made, which part is the bar that moves back and forth?*** *(The popsicle stick)*
    - ***Where is the fulcrum?*** *(The fulcrum is the point where the popsicle stick meets the pencil. When the popsicle stick is balanced without any weight on it, the fulcrum is in the center of the stick.)*

Side view of a popsicle stick laid across a taped-down pencil, with a penny weighing down one side:



6. Give each student 4 pennies.
7. Ask students: ***What will happen to the popsicle stick if you place a penny on one end? Try it!***

8. Have students place a penny at one end of the balanced popsicle stick (see diagram at right).



Levers. Place a popsicle stick across a taped-down pencil. To balance three pennies with one, move the stack of three pennies closer to the fulcrum and the single penny further from the fulcrum.

Discussion Prompts:

- ***What happened?*** *(The popsicle stick became off-balanced.)*
- ***How can you change the position of the popsicle stick to balance the penny?***

9. Allow students time to readjust the popsicle stick (without moving the penny!) so that it balances again with a penny on one end. (Hint: they need to shift the side with the penny closer to the pencil.)
10. Ask students: ***How did you balance the penny?*** *(By shifting the popsicle stick and changing the position of the fulcrum!)* ***What would happen if you added a penny to the other side of the popsicle stick? Let's try!***

11. Have students add a second penny to the other end of the popsicle stick.

    Discussion Prompts:

    - ***What happened?***
    - ***Is the popsicle stick balanced?***

12. Allow students time to adjust the popsicle stick so it balances with a penny on each end.

    Discussion Prompts:

    - ***Does the popsicle stick balance at the same point as it did when no pennies were on it?*** *(Yes, in the center.)*
    - ***What would happen if you moved one of the pennies closer to the pencil? Would the popsicle stick still balance? Try it!***

13. Have students shift one of the pennies to halfway between the pencil and the end of the popsicle stick.

    Discussion Prompts:

    - ***Is your lever still balanced?*** *(No.)*
    - ***Could you balance it by adding more weight? Try it!***

14. Allow students to add another penny on top of the penny that's halfway between the pencil and the end of the popsicle stick. They may need to shift the stack of two pennies slightly to achieve balance again.

    Discussion Prompts:

    - ***Did it take more or less weight to balance out the longer arm of the lever?*** *(It took more weight to balance out the longer arm.)*
    - ***Does that mean the longer arm can lift more or less weight than the shorter arm? Is the longer arm stronger or weaker?***

(Longer arm=stronger arm! The longer arm is able to lift two pennies while the shorter one is only lifting one.)

- ***Knowing that, do you think you can balance a stack of 3 pennies on one side with one penny on the other side, just by changing where the pennies are placed on each side and shifting the location of the fulcrum?***

15. Have students place three pennies on one side and one penny on the other. Allow them to experiment with shifting the pennies and popsicle stick to get their lever to balance (see photo at left). Takeaway: the longer arm is the stronger arm!

    Discussion Prompts:
    - ***So, if you were to set up a lever to lift a baby elephant, where would you set up the fulcrum?***
    - ***Would you want it to be in the middle, like a see-saw?*** *(No. Your side would need to be longer in order to balance the elephant's heavier weight. The fulcrum would need to be closer to the elephant, so that its side would be shorter. In other words, you would need a longer lever—a stronger lever—to lift the elephant's heavier weight.)*

16. Leave the taped-down pencils and popsicle sticks set up for the next activity. You can collect the pennies if they will be a distraction.

Activity Three – Lever Launch — Time: 10 Minutes

Supplies	#	Supplies	#
Cotton balls	16	Popsicle sticks (jumbo)	16
Pencils	16	Tape (rolls, Scotch)	4

Goal: To experiment further with lever arm length by using a popsicle stick and pencil to launch a cotton ball.

Source: Hands on Science Outreach

Background:
In this activity, students will create a lever for launching cotton balls. By making the cotton ball arm as long as possible, you'll increase the distance the cotton ball is pushed by the popsicle stick. When the cotton ball arm is relatively short, the popsicle stick can only push the cotton ball upward by about an inch. When the cotton ball arm is as long as possible, the end of popsicle stick is able to lift up by several inches, giving the cotton ball a bigger upward push! That fits with what you learned about "longer arm = stronger arm." (http://bit.ly/3llgZAi)

Procedure:

Fun Physics: Forces & Motion (Grades K-3)

Class 6: Catapult Launch

1. Ask students: ***You just learned that you can use a lever to lift an object up. Do you think you can use a lever to lift an object up so fast that it flies into the air? Let's find out!***

2. Give each student a cotton ball. Make students have their popsicle stick and their pencil taped down to the table from the last activity.
3. Have students place their cotton ball on one side of the popsicle stick, then shift the popsicle stick so the cotton ball is as close to the pencil as possible, but still weighs its end of the popsicle stick down.
4. Ask students: ***In the last activity, you learned that a longer arm is a stronger arm. Do you think that this cotton ball on the short arm of the popsicle stick will fly high into the air? Let's see!***

5. Have students (in a controlled fashion!) bring their hand down onto the upturned end of the popsicle stick as if they were giving it a low five (see photo at left).

   Discussion Prompts:
   - ***What happened?*** *(The cotton ball flew into the air, but not very high.)*
   - ***If we make the cotton ball arm slightly longer, do you think the cotton ball will fly higher or lower?***

6. Have students shift the popsicle stick over slightly so the middle of the popsicle stick is on the fulcrum. Have them repeat step 3.

   Discussion Prompts:
   - ***Did the cotton ball fly higher or lower?*** *(Higher.)*
   - ***Why?*** *(The longer arm is the stronger arm! We made the arm holding the cotton ball longer, so it was stronger when launching the cotton ball.)*
   - ***Can we confirm our observations by making the cotton ball arm as long as possible?***
   - ***Should this be the lowest or highest jump?*** *(The highest!)*

7. Have students shift the popsicle stick over so most of it is on the side with the cotton ball and just a small part (about an inch) is on the other side of the pencil. Have them repeat step 3.

   Discussion Prompts:
   - ***Did your experiment confirm your hypothesis?*** *(Yes! The cotton ball flew the highest this time.)*
   - ***Why did that happen?***

8. Tell students:
   - ***In the last activity, we learned that it takes less weight—or less force—to use the longer arm of a lever to move something on the shorter end. The reverse is also true! You have to apply***

Lever Launch. With the cotton ball on one side of the popsicle stick, bring your hand down on the other side to launch the cotton ball. Repeat with different lengths of popsicle stick on each side of the fulcrum.

***more* force to the shorter end of a lever to move something on the longer arm…but if you're able to use more force, you can make the object on the longer arm move faster and farther!**

- ***Your hand is much heavier and more powerful than the weight of a cotton ball, so you could make the lever arm as long as you wanted and still be able to launch the cotton ball.***
- ***Your launcher uses the power of the longer arm in a special way: you have to apply more force to the shorter arm—but because you can do that, the cotton ball on the longer arm moves faster and flies higher!***

9. If time allows, let students experiment with placing the cotton ball closer to or farther from the pencil (without shifting the popsicle stick), changing where they hit the popsicle stick with their hand, and any other variables they'd like to test. Throughout their experimentation, they should see if they can ever violate the rule "the longer arm is the stronger arm." (Hint: nope.)

Activity Four – Cotton Ball Catapult Time: 25 Minutes

Supplies	#	Supplies	#
Binder clips (medium)	16	Spoons (plastic)	32
Cotton balls	32	Tape (rolls, masking)	1
Popsicle sticks (jumbo)	16	Tape (rolls, painter's)	1
Rubber bands (size 33)	32		

Goal: To use a basic understanding of a lever arm to create a catapult using office supplies.

Source: http://bit.ly/3lboXf6

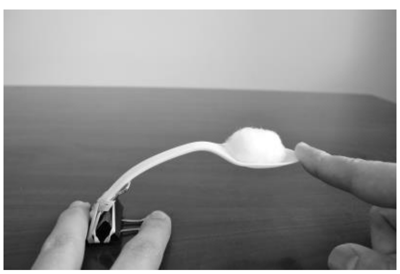
Background:

A catapult is used to launch items (like cotton balls!) toward a target. A catapult is a special kind of lever. Some catapults use a springing action, which makes them a Class 3 lever. Other types of catapults, like a trebuchet, use weights to be more energy efficient, so they're considered a Class 1 lever. The binder clip you used for your catapult has a springing action, so it's a Class 3 lever (which is a different type of lever than you used in the "Lever Launch" activity).

Did you know that catapults were first used in battle around 400 B.C.? Because a spring-style catapult was less energy efficient, it was used to smash through walls. The Class 1 trebuchet, however, was powerful enough to hurl objects over walls!

You can see the physics concept of a spring-action lever at work in a

Cotton Ball Catapult. Basic model of a catapult.



Cotton Ball Catapult. Load the catapult with a cotton ball and pull it back by the bowl of the spoon. Release to launch the cotton ball.

diving board. Where do you get the biggest bounce from the board? At the very edge, of course, where the lever arm is the longest and the strongest! (http://bit.ly/3lkLfLD)

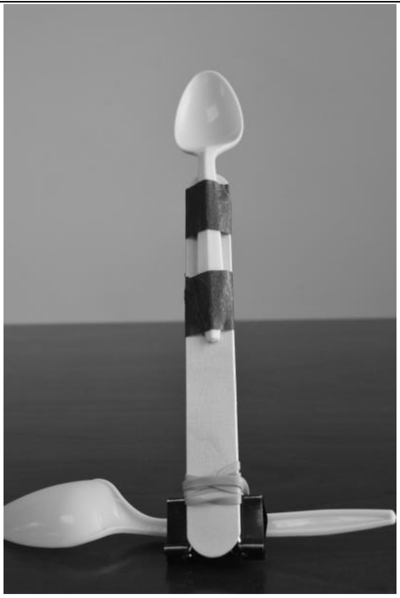
Procedure:

1. Ask students***: In the last activity, you used a popsicle stick lever to launch a cotton ball. This is a basic form of a catapult! A catapult is a machine that uses a lever to launch an object. Do you think you could create an even better catapult using different supplies? Let's try!***

2. Give each student two plastic spoons, a medium binder clip, and two size 33 rubber bands. Make sure they still have their jumbo popsicle stick and cotton ball from the previous activity. Make scissors, masking tape and painter's tape available (both types of tape work).
3. Give students time to explore using the supplies to launch their cotton ball.
4. After students have tried their own methods for a few minutes, show students how to create a basic catapult model (see top photo at left).
5. Have students:
   a. Line up the bottom of the spoon handle with the outside of the mouth of the binder clip. The spoon should be centered on the binder clip so that the back of the spoon handle leans against the silver part of the clip.
   b. Attach the handle of one spoon to the binder clip using one of the rubber bands. The rubber band should be wrapped around the spoon and binder clip multiple times to hold the spoon in place securely. One option is to attach the spoon to the binder clip with the rubber band in a crisscross or 'X' shaped pattern.
   c. Set the flat base of the binder clip on a table so the spoon sticks almost straight up.
   d. Place the cotton ball into the bowl of the spoon (students may need to bend the spoon back slightly to hold the cotton ball).
   e. With one hand on the base of the binder clip, use the other hand to pull the bowl of the spoon backwards then release (see bottom photo at left). You may want to have students take turns launching their catapults.

Discussion Prompts:

- ***What happens?*** *(The catapult launches the cotton ball into the air!)*
- ***How is that like the lever experiment you did?*** *(The spoon acts like the lever arm and stores potential energy when it's pulled*


Cotton Ball Catapult. Example of a modified catapult. Note that the spoon is sturdily secured to the popsicle stick.

back. When it's released, it springs forward and launches the cotton ball!)

- ***Can you modify your catapult to launch your cotton ball higher and/or further? Remember, a longer arm is a stronger arm!***

6. Allow students to explore modifying their basic catapult with the additional spoon, the popsicle stick, and the rubber band. Ask them to test their catapults gently for now so that they're not constantly chasing their cotton balls all over the classroom.
7. As students are making their modifications, remind them that they don't have to use all the supplies. Also, if students want to make a longer catapult arm—for instance, by adding the popsicle stick in addition to the spoon—the entire arm needs to be as stiff as possible, meaning that supplies have to be overlapped and taped together in a sturdy way (see photo at left).
8. Have students do a full test of their catapult. You can hold a competition for the highest cotton ball and the farthest cotton ball.
9. If time allows, students can compare launching a normal cotton ball to launching a cotton ball with pieces of tape wrapped around it. The extra mass and reduced drag of the taped-up cotton ball should result in a farther launch.

Activity Five – Daily Debrief Time: 5 Minutes

Supplies	#
Lab Notebooks	16
Pencils	16

Goal: To draw today's activities together through a thoughtful question and give students an opportunity to ask their own questions.

Procedure:

1. Encourage students to reflect on what they learned in today's class and what new questions they might have.
2. Allow students a few seconds to think. Have them discuss their thoughts and questions with a partner, then share with the rest of the class and/or write down in their lab notebook.
3. If needed, feel free to offer prompts like:
    - ***What do you think would happen if we changed one thing about today's activities (for example: materials, speed, temperature, etc.)?***
    - ***If you could investigate (explore) one more thing about today's activities, what would you like to find out?***

4. If time allows, ask the following question:

- ***What are some things we could launch using a catapult? How big would the catapult have to be?***

<u>Clean up</u>: Make sure students help clean the room before they leave.

<u>What to save</u>:

Materials used	#	SAVE	Materials used	#	SAVE
Binder clips (medium)	16	0	Rubber bands (size 33)	32	0
Cotton balls	32	0	Spoons (plastic)	32	0
Pencils	16	16	Tape (rolls, masking)	1	1
Pennies	64	64	Tape (rolls, painter's)	1	1
Popsicle sticks (jumbo)	16	0	Tape (rolls, Scotch)	4	4

<u>What goes home</u>: Cotton Ball Catapult
(Review safety guidelines with students: catapults should not be aimed at people or pets; small items should always be kept away from children ages 3 and younger to avoid the risk of choking)

<u>General note</u>: You may not have time to do all of today's activities with your class. For reference, the main take-home item from today's class is the Centripetal Force cup from Activity Six. If you want to make sure students receive a take-home item, you may want to pick and choose among the magnet activities to make sure you leave time for Activity Six.

Supplies	#
Cups (9oz paper)	16
Magnets (ring-shaped, colorful)	16
Nuts (metal hexagon)	32
Paper clips (regular size)	16
Pencils	16
Pennies	64
Pipe cleaners (Ziploc bags of small pieces)	16
Scissors (site provides)	16
String (6in pieces)	16
Tape (rolls, masking)	1
Tape (rolls, painter's)	1
Yarn (1ft pieces)	4
Yarn (2ft pieces)	16
Ziploc snack bags	16

Worksheets:

Worksheets: Fuzzy Face (small slips on cardstock)	16
Worksheets: Magnet Maze (half-sheets on cardstock)	16

Prep (prior to class) — Time: 15-30 Minutes

- **Act. 4:** Insert a Fuzzy Face worksheet into each of the sixteen Ziplock snack bags and empty 1 bag of pipe cleaner pieces into the snack bag. Place the worksheet behind the pipe cleaner pieces (so the pieces go in front of the face). Seal the bags.
- **Act. 6 (OPTIONAL):** You may want to construct the "Centripetal Force" cups as prep to save time.

Activity One – Pair & Share — Time: 10 Minutes

Supplies	#	Supplies	#
Pencils	16	Lab notebooks	16

Goal: To engage students' thinking and questioning related to the day's activities.

Suggested Reading: *Forces* by Andi Diehn

Procedure:

9. Prepare a quiet space for students to give them a physical area to think. The space can be an area set aside from the activity area, where students sit in a circle to ponder the *Pair & Share* question.
10. Make lab notebooks and pencils available.
11. Ask students a *Pair & Share* question. For example:
    - ***Where can you find magnets in your everyday life?"*** *(On the refrigerator, on the white board, inside most electronic devices like cell phones, computers, etc.)*
12. Ask students to discuss their ideas with their neighbor before inviting students to share what they came up with. This is a "challenge by choice" opportunity and no one is required to share with the class if they are not comfortable.

Activity Two – Floating on Air — Time: 15 Minutes

Supplies	#	Supplies	#
Magnets (ring-shaped, colorful)	16	String (6in pieces)	16
Pencils	16	Paper clips (regular size)	16
Scissors (site provides)	16		

Goal: To learn about magnetic fields by making ring magnets float on top of each other and causing a paper clip to float in the air near a magnet.

Class 7: Magnet Madness

Source: Lisa Pitts, OHCC & http://bit.ly/3lhSXpM

Background:
In this activity, you'll experiment with the power of magnets. You'll observe that when a paper clip is very close to the magnet, it is pulled toward the magnet, even without touching it directly. A magnetic field is the invisible space around a magnet in which a magnet can exert a force! Within the magnetic field, other magnets can be attracted or repelled, and metals like paper clips can be pulled toward the magnet.

In your experiment, the magnetic field causes the paper clip to store up potential energy. When the string is cut, the paper clip flies toward the magnet and sticks to it. The paper clip's potential energy is converted into kinetic (motion) energy.

Did you know that some species of sharks can detect magnetic fields? Scientist are creating a fake kelp field made of magnets that stops sharks from wanting to enter parts of the ocean where there are a lot of humans in the water. This method is better than nets because it leaves sharks unharmed. (http://bit.ly/3RKhxvD)

Procedure:
1. Give each student a ring magnet.
2. Tell students that they will be exploring whether the magnet will stick to certain things in the room.
3. Give students instructions about areas of the room to avoid if you're in someone else's space. Allow students to try to get the magnet to stick to things in the room.

WARNING: Don't allow students to use the magnets near computers! Magnets should also be kept away from cell phones, credit cards & pacemakers.

Discussion Prompts:
- ***What happened?***
- ***What did the magnet stick to?***

Floating on Air. Stack two ring magnets on a pencil so one floats above the other.

4. Tell students: ***Magnets are pulled toward certain types of metals, particularly iron, nickel and cobalt. This pull is called magnetic attraction. The area around a magnet where you can feel the pull is called a magnetic field.***

5. Pair students. Give each pair a pencil.
6. Have pairs stand their pencil upright on the table, then stack their ring magnets on the pencil (so the pencil sticks up through their centers—see photo at left).

Discussion Prompts:
- ***What happened?*** *(Either the magnets stuck together, or the top magnet floated above the bottom magnet.)*
- ***If your top magnet didn't float, can you make it float? Try it!***

7. If a pair's top magnet didn't float, flip it over and slide it back onto the pencil.

   <u>Discussion Prompts:</u>
   - ***Does it matter which direction you stack the rings?*** *(Yes.)*
   - ***Why?***
   - ***Why does the top magnet float when one side is facing down, but stick to the other magnet when the other side is facing down?***

8. <u>Tell students:</u>
   - ***Every magnet has two opposite sides: a North Pole and a South Pole. The <u>magnetic field</u> of a magnet is strongest at its poles.***
   - ***Opposite poles attract, which pulls them toward each other and makes them stick together. But if two poles are the same, they repel each other, which means they push each other away. North Poles stick to South Poles, but repel other North Poles.***

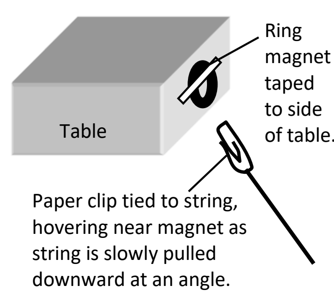
   <u>Discussion Prompts:</u>
   - ***Why doesn't gravity hold the top magnet down?*** *(The repelling force is stronger than the force of gravity for the ring magnets!)*
   - ***Could you float more than one magnet at a time? Let's find out!***

9. Put students in four groups. Have them combine their magnets on one pencil.

   <u>Discussion Prompts:</u>
   - ***Did it work?*** *(Yes!)*
   - ***Can you use a magnet to make a paper clip float in the air? Let's find out!***

Floating on Air. The paper clip will levitate if held within the magnet's magnetic field. (Scotch tape is pictured instead of masking or painter's tape so that the magnet is visible.)

10. Give each student a 6in piece of string and a paper clip. Make sure each student has their ring magnet from the previous activity. Make scissors, masking tape and painter's tape available (both types of tape work).



11. <u>Have students</u>:
    a. Tie the paper clip to one end of string.
    b. Tape the magnet flat against the side of a table or desk.

c. Place the tip of the paper clip against the magnet (so that it sticks to the magnet) and let the free end of the string hang down.
d. Grasp the free end of the string (the one without the paper clip).
e. SLOWLY and GENTLY, pull the free end of string downward, angled outward from the table. Pull just until the paper clip detaches from the magnet but remains suspended in the air near the magnet (see diagram above and photo at left).

Discussion Prompts:

- ***What keeps the paper clip floating?*** *(The paper clip is within the magnet's magnetic field, so it is pulled to the magnet, even without touching it directly.)*
- ***What type of energy does the paper clip have here?*** *(Potential energy—it has energy stored up to move if the string gets cut or the magnet moves closer or farther away.)*

12. Pair students. Have one student make the paper clip float while the other student carefully cuts the string (without jarring the string and disturbing the paper clip.)

Discussion Prompts:

- ***What happened?*** *(The paper clip flew to the magnet and stuck. Its potential energy was converted into kinetic energy—the energy of motion.)*
- ***Why did the paper clip fly to the magnet instead of falling to the ground?***

13. Tell students: ***The paper clip was still in the magnet's magnetic field, and the magnetic force attracting the paper clip was stronger than the downward pull of gravity.)***

14. Have students remove the string from their paper clips (slide the string along the paper clip until it slips off). Keep the paper clips handy for the next activity.

Activity Three – Magnet Chain & Stack Time: 10 Minutes

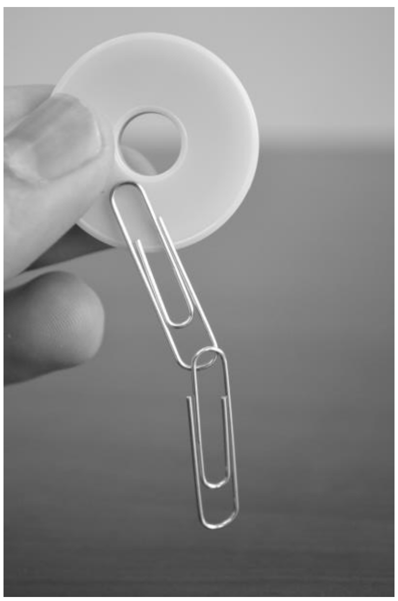
Supplies	#
Magnets (ring-shaped, colorful)	16
Nuts (metal hexagons)	32
Paper clips (regular size)	16

Goal: To observe that magnets can temporarily magnetize metals using a ring magnet, metal nuts, and paper clips.

Source: https://bit.ly/3YzB84t

Fun Physics: Forces & Motion (Grades K-3)

Class 7: Magnet Madness



Magnet Chain & Stack. Touch a second paper clip to the paper clip that's on the magnet. The second paper clip is magnetized without directly touching the magnet.

Background:

Many magnets are strong enough to make metal objects become magnetic—as long as the metal objects stay in contact with the magnet. If the magnet is strong enough, the metal objects may still be magnetic for a little while even when they're no longer touching the magnet. The ability of a magnet to magnetize a metal is called "induction." As you saw in the experiment, induction can be achieved by keeping the metal object in contact with one of the poles on the magnet. It can also be achieved using an electric current (but that's a more advanced technique).

It's pretty cool that magnets can cause metal objects to temporarily act like magnets. Usually, metal objects aren't magnetic themselves—they're just attracted to magnets. However, if you heat a piece of iron to a high enough temperature—called the Curie Point—the iron will actually lose its ability to be attracted to a magnet, let alone the ability to act like one! (Physics for Kids: 49 Easy Experiments with Electricity and Magnetism by Robert W. Wood, http://bit.ly/3HMz4yQ)

Procedure:

1. Ask students: ***In the previous activity, you learned that magnets attract metals, which means that metals like to stick to magnets. Do you think you can make a metal object to stick to another metal object using magnetic force?***

2. Pair students. Make sure each pair has two paper clips and at least one magnet.
3. Ask students: ***You already know that a paper clip will stick to a magnet. If a paper clip is stuck to a magnet, do you think you could get a second paper clip to stick to the first one, without letting it touch the magnet directly? Try it!***

4. Have pairs add one paper clip to one magnet.
5. While one student holds the magnet with the paper clip on it, have the other student touch a paper clip to the end of the first paper clip (see top photo at left).

   Discussion Prompts:
   - ***What happens?*** *(The second paper clip sticks to the first paper clip as if it's magnetic!)*
   - ***What do you think will happen if we take the first paper clip off the magnet? Will the second paper clip still stick to it, or will it fall off? Try it!***

6. Have students hold the paper clip that's touching the magnet, with the second paper clip dangling freely.
7. Have students gently slide the first paper clip off the magnet and hold it in midair (see bottom photo at left).

   Discussion Prompts:

- ***What happened?*** *(The second paper clip is still stuck to the first paper clip!)*
- ***Is the paper clip a magnet now?***
- ***What would happen if you pulled the paper clips apart, then touched them together again?***
- ***Would they still be magnetic?***

8. Allow students to experiment with separating and rejoining the paper clips. They can also explore touching the one or both paper clips to the magnet before trying to connect them to see whether that matters (hint: it does!).

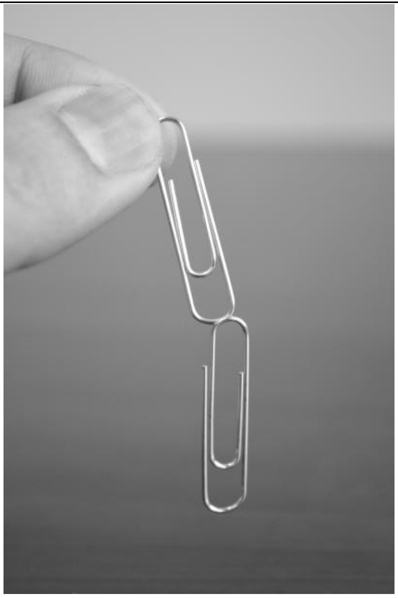
   Discussion Prompts:
   - ***Do the paper clips stay magnetic forever?*** *(No.)*
   - ***Why not?***

9. Tell students:
   - ***If a magnet is strong enough, it can give a metal object magnetic properties for a short time. Soon, though, the metal object returns to its normal, non-magnetic state. However, as long as a metal is directly touching a magnet, the magnetic force from the magnet will make the metal magnetic as well.)***
   - ***The ability of a magnet to make metals magnetic is called "induction." Can we use induction to overcome other forces, like gravity? Let's try!***

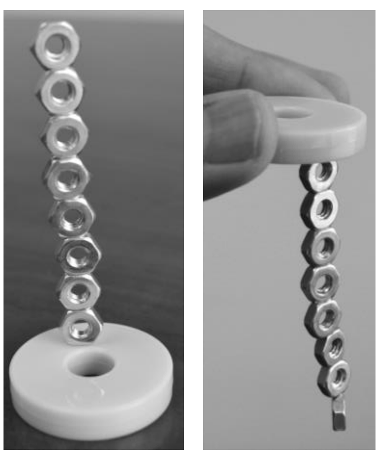
10. Put students in four groups.
11. Give each group eight metal nuts. Keep the nuts away from the magnets in preparation for the next step. (Tip: if you think students will giggle at the phrase "stack the nuts," you may want to call them "hex nuts.")
12. Ask students: ***Without using magnets, how high can you stack the nuts edge-to-edge on the table if you take turns placing them one at a time? Try it!***

13. Have students take turns adding nuts to the stack, standing the nuts on top of each other to make the highest possible tower. Have students count the number of nuts in the final stack. (Tip: if students don't seem to find the task challenging, you might want to give them a time limit.)

   Discussion Prompts:
   - ***How hard was it to stack the nuts?***
   - ***What happens if you try to move your stack sideways?*** *(The stack falls down.)*
   - ***Do you think it would be easier or harder if you built your stack of nuts on top of a magnet?***



Magnet Chain & Stack. After slipping the first paper clip off the magnet, the second paper clip should remain attracted to the first paper clip.



Magnet Chain & Stack. Stack metal nuts upwards or downwards on a magnet.

14. Have students stand the first nut up on its edge on one magnet, then continue the stacking process, taking turns adding nuts to the stack. Again, have students count how many nuts they can stack (see photo at left).

    Discussion Prompts:
    - ***Was it easier or harder to stack the metal nuts on the magnet?*** *(Easier.)*
    - ***Could you feel the pull of the magnet through the metal nuts?*** *(Yes.)*
    - ***Did the pull get stronger or weaker as the stack got higher?*** *(Weaker.)*
    - ***What happens if you try to move your stack by sliding the magnet sideways on the table?*** *(The stack stays standing!)*

15. Allow students to experiment with repeating the stacking process. They may want to add additional magnets or nuts or try making different shapes.
16. OPTIONAL: Allow students to try stacking their nuts upside down! Have one student hold the magnet while other students add nuts from the bottom.

Activity Four – Fuzzy Face Time: 5 Minutes

Supplies	#	Supplies	#
Magnets (ring-shaped, colorful)	16	Worksheets: Fuzzy Face (small slips on cardstock)	16
Pipe cleaners (Ziploc bags of small pieces)	16	Ziploc snack bags	16

Goal: To observe that magnets can attract objects through other materials by using a magnet through a piece of cardstock to move pieces of pipe cleaner around a "fuzzy face."

Source: Adapted from: http://bit.ly/3lpvJhy

Background:
In this activity, the magnet is able to move pipe cleaner pieces through a piece of cardstock and a plastic bag! How is that even possible? As you learned in previous activities, every magnet is surrounded by a magnetic field that can push or pull other magnets and pull in metal objects. If you look closely at a pipe cleaner, you'll see a metal wire in the middle of it. The magnet was able to attract this metal wire so that you could give your face some funny hair!
If you test your magnet through other materials, you'll notice that its magnetic field is strong enough to pull metal objects through a thin layer of plastic or several sheets of paper—but there are limits to its strength. For example, your magnet won't work through your hand or a desk! If you're

interested, test out the strength of your magnet's magnetic field—just stay away from any electronics, since magnets can ruin them. A good way to test your magnet is to see how many pieces of paper it can hold to a metal surface like a file cabinet or a refrigerator. (http://bit.ly/3YIDSCj)

Fuzzy Face. Use the magnet to move the pipe cleaner pieces around on the face. (Also try using the magnet from underneath the cardstock to observe that the magnet works through a barrier.)

Procedure:

1. Ask students:
   - ***Have you ever seen the toy where you use a small wand to draw hair on a drawing of a bald man (often called "Woolly Willy" or "Hairy Harry?")?***
   - ***How do you think that toy works?*** *(The wand has a magnet in it, and the "hair" is actually iron filings that are attracted to the magnet in the wand.)* ***Let's try our own version!***

2. Give each student a sealed Ziploc bag with a Fuzzy Face worksheet and small pieces of pipe cleaner inside (from prep). Make sure each student has a magnet.
3. Ask students:
   - ***How could you use your magnet to give your "fuzzy face" some hair?***
   - ***Can you add a mustache or beard?***

4. Have students:
   a. Hold their Ziploc bag flat so the pipe cleaner pieces are sitting on top of the worksheet.
   b. Hold their magnet flat against the underside of the worksheet (outside the Ziploc bag).
   c. Use the magnet to guide the pipe cleaner pieces into place to create "hair" around the face (see photo at left).

   Discussion Prompts:
   - ***Did your magnet still work through the barrier of the cardstock and the Ziploc bag?*** *(Yes!)*
   - ***When you wanted the magnet to let go of the pipe cleaner pieces so you could drop them into place, what did you have to do?*** *(Pull the magnet farther away from the pieces.)*
   - ***Why did that work?*** *(A magnet's magnetic field gets weaker with distance.)*

5. For a fun visual effect, have students place their magnet flat against the underside of the worksheet (outside the Ziploc bag) and swirl the magnet in circles. This will make the pipe cleaner pieces "dance" in a ring.
6. If you have extra time, students can draw their own picture on the other side of the "Fuzzy Face" worksheet, then reinsert the worksheet into the bag.

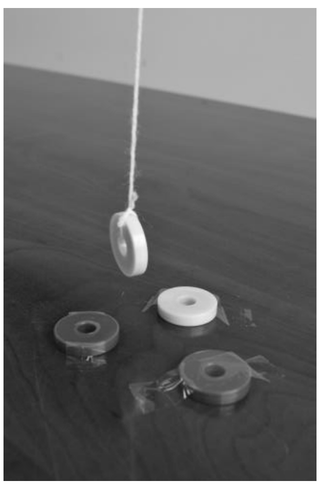
Activity Five – Swinging Magnet Time: 10 Minutes

Supplies	#	Supplies	#
Magnets (ring-shaped, plastic)	16	Tape (rolls, painter's)	1
Tape (rolls, masking)	1	Yarn (1ft pieces)	4

Goal: To observe how magnetic forces can act at a distance by allowing a free-swinging magnet to be swayed by fixed magnets.

Source: *Physics for Kids: 49 Easy Experiments with Electricity and Magnets*, Robert W. Wood

Background:
Each magnet has a magnetic field. In this activity, when you tape the three magnets in a triangle, their magnetic fields overlap. Some areas where the fields overlap has the effect of repelling—or pushing away—another magnet, and other areas had the effect of attracting—or pulling—another magnet. When you swing the hanging magnet over the tops of the taped magnets, the hanging magnet gets pushed and pulled in crazy patterns by the different overlapping magnetic fields. (http://bit.ly/3YIDSCj)


Swinging Magnet. Dangle a magnet from a piece of yarn above three taped-down magnets. (Scotch tape is pictured instead of masking or painter's tape for visibility.)

Procedure:
1. Ask students: ***Earlier today, you learned that the force of a magnetic field can act on metals at a distance, like when your paper clip floated in the air near your magnet. Can magnets also act on other magnets at a distance? Let's find out!***

2. Keep students in four groups. Make sure each group has four magnets (if you have fewer than 16 students, you may need to hand out additional magnets).
3. Give each group a 1ft piece of yarn and make tape available (both types will work).
4. Have students tape three of their magnets flat on the table so they form a triangle. There should be about one to two inches of space between each of the three taped magnets.
5. Have another student tie or tape the 1ft piece of yarn to the fourth magnet.
6. Ask students: ***What do you think will happen if we let the fourth magnet dangle over the three taped magnets? How will the dangling magnet react? Try it!***

7. Have one student hold the free end of the yarn, letting the magnet hang down about an inch above the three taped magnets (see top photo at left).
8. Allow the other students to take turns gently pushing the hanging magnet so it swings above the taped magnets.

Discussion Prompts:

- ***What happens?*** *(The hanging magnet zigzags wildly in the area above the taped magnets.)*
- ***What's making the magnet move?*** *(Magnetic forces are pushing and pulling the hanging magnet as it moves in and out of the magnetic fields of the taped magnets.)*

9. Have students switch roles and repeat the experiment.

Activity Six – Centripetal Force   Time: 10 Minutes

Supplies	#	Supplies	#
Cups (9oz paper)	16	Yarn (2ft pieces)	16
Pennies	64	Pencils	16

Goal: To observe centripetal force by swinging a cup of pennies in a circle.

Source: http://bit.ly/3JRbnrH

Background:

Have you ever felt like you were being pushed or pulled in a car when it made a sharp turn? That's because the flipside of Newton's First Law (an object at rest will stay at rest unless a force acts on it) is that an object in motion will continue in the same direction unless a force acts on it. When your car takes a turn, it's changing directions and requires a force to do so. You're feeling the inertia of your body that wants to continue in the same direction being pushed in a new direction.

Now, imagine riding in a car that's constantly driving in circles. You would constantly feel that force pressing you against the outer side of the car as your body wants to continue in the straight path it's not allowed to take. That's what's happening to the penny in your cup! The constant change in direction keeps the penny from traveling in the straight direction it wants to. Instead, centripetal force pushes the penny against the far edge of the cup. That force is so strong that it can overcome gravity, which is trying to pull the penny toward the ground.

If you've ever wondered why roller coasters can flip upside down and no one falls out, now you know! Centripetal force keeps people pushed into their seats—and of course, there are seat belts just in case. (http://bit.ly/3YhUVVz)

Procedure:

1. Ask students: ***Earlier today, we learned that magnetic forces can sometimes overcome the force of gravity. What is another invisible force that can overcome gravity? Let's find out!***

2. Pair students.
3. Give each pair two paper cups, two 2ft pieces of yarn, and two pencils.


Centripetal Force. Thread the yarn through the holes in the paper cup and tie the two ends into a knot.


Centripetal Force. Swing the cup (with pennies inside) around by the yarn handle.

4. Have students:
   a. Use a pencil to poke two small holes across from each other near the rim of their paper cup (leave a little space under the rim for ease of poking).
   b. Thread the piece of yarn through the holes in the top of the cup and bring the ends of the yarn together above the opening of the cup.
   c. Tie the two ends of the yarn together to form a handle (like the handle of a bucket). (See bottom photo at left, though yours might look different). Pull the yarn through so the knot is as far as possible from the cup.

5. Give each pair of students a penny. Have them put the penny in one of the cups.
6. Ask students: ***What would happen if you turned the cup upside down?*** *(The penny would fall out.)*

7. Have students turn the cup upside down.

   Discussion Prompts:
   - ***What happened?*** *(The penny fell out and hit the floor.)*
   - ***Why did that happen?*** *(Gravity pulled the penny toward the earth.)*
   - ***How could you prevent the penny from falling out of the cup when you turn the cup upside down? Let's find out!***

8. Have one student in each pair put the penny back in the cup.
9. Hold the knotted ends of the yarn handle bunched together in one hand. The cup should hang down, weighted by the penny.
10. Have the students who are holding the cups spread out so they each have at least a 2ft circle around them. Have the other students from each pair stand to one side of the room for this round of the experiment.
11. Ask students: ***What do you think will happen if you swing the cup around in a circle (like a Ferris wheel)? Will the penny fall out when the cup is upside down?***

12. Let students try swinging the cup around in a smooth circular motion. It may take a little practice (see photo at left).

    Discussion Prompts:
    - ***What happens?*** *(As long as the cup is swung in a smooth circle, the penny stays in the bottom of the cup!)*
    - ***Is there a force acting on the penny? Let's watch closely!***

13. Have students switch roles. Allow the second group of students to swing the cup around in a circle.

Discussion Prompts:
- ***Can you see the force keeping the penny in the cup?*** *(No.)*
- ***Why not?***

14. Tell students:
    - ***The action of swinging the cup around in a circle is what pushes the penny against the bottom of the cup. The force can't be seen!)***
    - ***This force is called centripetal force. Centripetal force is created when things are swung in a circle. Centripetal force pushes away from the center of the circle—in this case, it forced the penny to the bottom of the cup, which kept it from falling out of the cup.)***
    - ***What do you think will happen if we add more pennies to the cup?***

15. Give each pair three more pennies (so that each pair has four pennies total).
16. Have students repeat the activity with additional pennies in the cup.

Discussion Prompts:
- ***What happened?*** *(The pennies still stayed in the cup!)*
- ***Could you feel any difference between swinging one penny and swinging four pennies?*** *(You could probably feel centripetal force pushing outward around the circle more strongly with four pennies.)*

Activity 7 (OPTIONAL) – Magnet Maze   Time: 5 Minutes

Supplies	#	Supplies	#
Magnets (ring-shaped, colorful)	16	Worksheets: Magnet Maze (half-sheets on cardstock)	16
Nuts (metal hexagons)	16		

Goal: To further observe that magnets can attract objects through other materials by using a magnet through a piece of cardstock to guide a metal nut through a maze.

Source: http://bit.ly/3JXM3QO

Procedure:
1. Tell students: ***In the "Fuzzy Face" activity, you learned that a magnet can pull on a metal object even when there's a thin barrier in between them (like a piece of cardstock). Let's use that knowledge to play a game!***

Magnet Maze. Use a magnet beneath the cardstock maze to move the nut above the maze.

2. Give each student a Magnet Maze worksheet and a metal nut. Make sure each student has a magnet.
3. <u>Ask students:</u> ***Can you make the nut go through the maze without touching it? How?***

4. <u>Have students:</u>
    a. Hold the edge of the worksheet in one hand, with the nut sitting flat on top of the maze.
    b. Place the nut at the "Start" location.
    c. Hold the magnet flat underneath the maze, directly below the nut (see photo at left).

    <u>Discussion Prompt:</u>
    - ***What do you notice?*** *(The magnet is strong enough to pull the nut through cardstock.)*

5. Allow students time to run the nut through the maze without going over any of the solid black lines. As a variation, students could place the maze on the table and hover the magnet over the nut, making it move without direct contact.

    <u>Discussion Prompt:</u>
    - ***How did you get your nut through the maze? What would have made it easier?***

6. If time allows, students can flip the Magnet Maze over and draw their own maze on the back of the page. Students can exchange papers to try each other's mazes.

Activity Seven – Daily Debrief   Time: 5 Minutes

Supplies	#
Lab Notebooks	16
Pencils	16

<u>Goal</u>: To draw today's activities together through a thoughtful question and give students an opportunity to ask their own questions.

<u>Procedure</u>:
1. Encourage students to reflect on what they learned in today's class and what new questions they might have.
2. Allow students a few seconds to think. Have them discuss their thoughts and questions with a partner, then share with the rest of the class and/or write down in their lab notebook.
3. <u>If needed, feel free to offer prompts like:</u>

- ***What do you think would happen if we changed one thing about today's activities (for example: materials, speed, temperature, etc.)?***
- ***If you could investigate (explore) one more thing about today's activities, what would you like to find out?***

4. If time allows, ask the following question:
   - ***If you invented your own toy that used magnets, what would it be? How would it work?"***

Clean up: Make sure students help clean the room before they leave.

What to save:

Materials used	#	SAVE	Materials used	#	SAVE
Cups (9oz paper)	16	0	String (6in pieces)	16	0
Magnets (ring-shaped, colorful)	16	16	Tape (rolls, masking)	1	1
Nuts (metal hexagons)	32	0	Tape (rolls, painter's)	1	1
Paper clips (regular size)	16	0	Worksheets: Fuzzy Face (small slips on cardstock)	16	0
Pencils	16	16	Worksheets: Magnet Maze (half-sheets on cardstock)	16	0*
Pennies	64	0	Yarn (1ft pieces)	4	0
Pipe cleaners (Ziploc bags of small pieces)	16	0	Yarn (2ft pieces)	16	0
Scissors (site provides)	16	16	Ziploc snack bags	16	0

What goes home: Fuzzy Face bag, Centripetal Force cup & 4 pennies per student.

*If desired, students can take home the "Magnet Maze" worksheet by itself (if they have a medium-strong magnet and a paper clip at home, they can do the maze at home). The metal nuts don't go home; whether or not magnets go home in Class 8 depends on permission slips.

- REMINDER: If your Site Coordinator sent home Magnet Take-Home Permission Slips, remind students to get them signed and bring them back by the final class.

Fun Physics: Forces & Motion (Grades K-3)

Class 8: Big Finish

Supplies	#
Balloons (9in)*	17
Fishing line (ft)	32
Magnets (ring-shaped,colorful)	16
Newspaper (issues)	1
Paper clips (regular size)	16
Paper towels (roll)	1
Pitchers	1
Planter boxes (plastic)	4
Popsicle sticks (notched, "skill sticks")	32
Rubber bands (size 16)	16
Rubber bands with knots (size 16, "for boat")	16
Scissors (site provides)	1
Spoons (wooden ice cream)	16
Straws (bendy tip, striped, full size)	16
Straws (clear, full size)	2
Straws (colorful, full size)	16
Tape (rolls, masking)	1
Tape (rolls, painter's)	1
Vials (small plastic, with lid)	16

Prep (prior to class) Time: 15-30 Minutes

- **Act. 2a**: Place a piece of masking tape over each of the four circles on the bottom of each of the four planter boxes (to prevent leaks).
- **Act. 2c**: *Staying inside*: fill the four planter boxes three-quarters full with water. *Going outside*: fill the four planter boxes halfway with water & fill the pitcher w/water.
- **Act. 4:** Cut two clear straws in half.
- **SUGGESTED:** Prepare the fishing line for balloon rockets (see Steps 1-3 in Activity 4.)
- **GENERAL**: If your Site Coordinator sent home Magnet Take-Home Permission Slips, ask them which students returned a signed form.

***Your kit contains one extra balloon.** Please bring it to class.

Activity One – Pair & Share Time: 10 Minutes

Supplies	#	Supplies	#
Pencils	16	Lab notebooks	16

Goal: To engage students' thinking and questioning related to the day's activities.

Suggested Reading: *Gravity* by Jason Chin

Procedure:

13. Prepare a quiet space for students to give them a physical area to think. The space can be an area set aside from the activity area, where students sit in a circle to ponder the *Pair & Share* question.
14. Make lab notebooks and pencils available.
15. Ask students a *Pair & Share* question. For example:
    - ***What provides power for things you use every day, like vehicles, overhead lights, computers, phones, etc.?*** *(Gasoline, electricity, coal, batteries, wind, solar power, etc.)*

16. Ask students to discuss their ideas with their neighbor before inviting students to share what they came up with. This is a "challenge by choice" opportunity and no one is required to share with the class if they are not comfortable.

Activity Two – Rolling on the River Time: 20 Minutes

Supplies	#	Supplies	#
Newspaper (issues)	1	Rubber bands (size 16)	32
Paper clips (regular size)	16	Rubber bands with knots (size 16, "for boat")	16
Paper towels (sheets from roll)	32	Popsicle sticks (notched, "skill sticks")	32
Pitchers	1	Spoons (wooden ice cream)	16
Planter boxes (plastic)	4	Vials (small plastic, with lid)	16

Goal: To observe how rubber bands can store up potential energy and convert it to kinetic energy by building a small paddlewheel boat.

Source: Hands on Science Outreach

Background:

Earlier, by bouncing a marble on a rubber band trampoline, you learned that rubber bands can store up potential energy, then release that same energy as the kinetic energy of motion! That same concept is what powered your boat! This time, though, instead of making a marble bounce, the rubber band turned a spoon that pushed against the water and propelled your boat forward.

Do you remember how forces can be balanced? In your boat, the downward pull of gravity is balanced by the buoyant force of water—that's what keeps the boat afloat! There's one more concept at work here. Remember that for every action, there's an equal and opposite reaction. In this case, the action was winding the spoon and the reaction was the spoon turning like a paddle and causing the boat to move. This rubber band boat is a great reminder of many of the concepts you've learned so far! (http://bit.ly/3YyDorW, https://bit.ly/3ldiro7)

Procedure:

TIPS:
- **If you can go outside for this activity,** great! Just fill the planter boxes partway with water (up to a point that won't spill easily for carrying). Have a student carry a full pitcher of water to add to the planter boxes outside. Each box should be about three-quarters full of water to do the activity.
- **If it's not possible to go outside**, you'll want to bring newspapers to class to cover the floor under the pans of water. The water often splashes out, and newspaper will help minimize the mess.

1. Ask students: ***In an earlier class, you used rubber bands to make a marble bounce like a rubber ball. Do you think you can use a rubber band to power a boat? Let's try it!***

2. Give each student a vial with a lid on, two notched popsicle sticks ("skill sticks"), one size 16 rubber band (normal), one size 16 rubber band (with knots), and one wooden ice cream spoon. ***!***
3. Have students:

Rolling on the River. Finished "boat."

a. Make sure the vial has a lid on it and the lid is pressed firmly in place.
b. Place the vial sideways between the skill sticks, so that the first skill stick is pressed flat against the lid of the vial, and the second skill stick is pressed flat against the bottom of the vial. The sticks will be parallel.
c. Position the vial two notches in from the end of the parallel skill sticks, so that the vial and skill sticks form a lopsided letter "H."
d. Wrap the normal size 16 rubber band around the skill sticks and vial to keep the vial in place (see top photo on next page).
e. If students are able, have them wrap the rubber band around the still sticks and vial a second time (you may need to help with this, or it's OK to leave the rubber band wrapped only once).
f. Slip the outer loops of the size 16 rubber band onto the free ends of the skill sticks (one loop goes around each skill stick on the end farthest from the vial).

4. Ask students: ***For the rubber band to power the boat, it needs something to push the water under it. Do you think you can make something that will push against the water?***

5. Have students insert the wooden ice cream spoon into the center gap in the knotted size 16 rubber band (see photo at left).
6. Put students in four groups and assign each group to one of the planter boxes.
7. If you decide to stay indoors, put down newspaper or paper towels, then give each group a planter box that's three-quarters full of water (from prep). If you go outdoors, you'll need to bring the planter boxes of water with you. You can fill them partway indoors, then have a student carry a full pitcher of water to bring the water level in the boxes up to three-quarters full before you begin the activity.
8. Ask students: ***Now that you have your boat, how can you store energy in it so it will move forward when you put it in water? Remember, rubber bands can store potential energy when they're stretched or twisted, then convert it back to kinetic energy!***

6. Wind up the ice cream spoon by taking the side of the spoon farthest from the vial, pushing it upward (toward the vial), then circling it down and back up again. Repeat 10-15 times to wind up the rubber band. Make sure students hold the spoon in place after turning it to store that potential energy!

   Discussion Prompt:
   - ***What do you think will happen when you place your boat in the water?***

7. Have students take turns placing their boat in the water (at one end of the planter box, *with the vial in the back of the boat*) and

releasing the spoon. It helps to make sure the spoon is fully immersed in the water before letting it go to minimize splashing. (The boat should travel at least one length of the box. Students may need to adjust how close the vial is to the end of the skill sticks if the boat isn't traveling that far.)

Discussion Prompts:

- ***What happened to your boat?*** *(It moved across the water!)*
- ***Which part of the boat had potential energy that was released to make the boat move?*** *(The twisted rubber band).*
- ***Could you change which direction the boat moves?*** *(Yes, by twisting the rubber band the opposite way.)*
- ***How is the paddle on a paddleboat like a wheel? How is it different?***

Activity Three – Straw Rockets **Time: 10 Minutes**

Supplies	#
Straws (bendy tip, striped, full size)	16
Straws (colorful, full size)	16

Goal: To demonstrate that every action has an equal and opposite reaction by blowing a bent straw out of a straight straw.

Source: https://www.stevespanglerscience.com

Straw Rockets. The bendy straw sticks out from inside the colorful straw. Blow on the open end of the colorful straw to shoot the bendy straw forward.

Procedures:

1. Tell students: ***In the last activity, you stored up potential energy in a twisted rubber band and released it to make your boat move. Let's launch a mini rocket using a different source of energy—air power!***

2. Give each student a colorful straw and a bendy tip straw.
3. Have students insert the long, straight part of the bendy straw into the colorful straw. Don't bend the bendy straw yet.
4. Ask students: ***What will happen if you blow into the open end of the colorful straw? Try it!***

WARNING: Tell students they should never point their straw rocket at anyone. Make sure students have plenty of space between them.

5. Have students blow gently on the open end of the colorful straw to try to shoot the bendy straw out the other end (see top photo at left).

Discussion Prompts:

- ***What happened?*** *(The bendy straw flew out of the colorful straw.)*


Straw Rockets. Bend the bendy straw and repeat. The bendy straw flies farther because the air has something to push against.

- ***How could you change the design to make the bendy straw fly out even farther?***

6. Have students:
   a. Bend the tip of the bendy straw so the bend forms a right angle (or goes slightly past a right angle).
   b. Reinsert the long, straight part of the bendy straw into the colorful straw.
   c. Try gently blowing again on the open end of the colorful straw (see bottom photo at left).

   Discussion Prompts:
   - ***Did the bendy straw fly farther?*** *(Yes.)*
   - ***What made a difference this time?*** *(Instead of the air flowing mostly around and through the bendy straw, it hit the "wall" of the bent part of the straw. The bend gave the air something to push against.)*
   - ***Do you think how hard you blow affects how far the bendy straw flies? Let's find out!***

7. Allow students to experiment with how hard they blow, making sure they don't hit anyone with their flying straw.

   Discussion Prompts:
   - ***What did you notice?*** *(Blowing harder caused the straw to fly farther.)*
   - ***Why?*** *(The harder you blew, the more force you provided to push against the bent part of the straw and send the straw rocket flying.)*

8. Have students throw their straws away.

Activity Four – Balloon Rockets Time: 20 Minutes

Supplies	#	Supplies	#
Balloons (9in)	16	Straws (clear, full size)	2
Fishing line (ft)	32	Tape (rolls, painter's)	1
Scissors (site provides)	1		

Goal: To observe an action/reaction sequence by making a balloon-and-straw "rocket" travel along a piece of fishing line.

Source: *Physics for Every Kid* by Janice Van Cleave

Background:

The balloon rockets work because of Newton's Third Law. As you may have guessed, the action and the reaction in this activity are similar to the balloon racer. The only difference is that this time, the balloon zooms forward on a line instead of pushing a car on wheels.

Which balloon vehicle seemed more powerful to you? If the rocket seemed more powerful, then it's most likely because of 2 factors: 1) the rocket straw moving against the fishing line encountered less friction than the racer wheels moving against the desk or floor, and 2) the rocket had less weight to move than the racer (just the straw versus the wheels and axles on the popsicle stick).

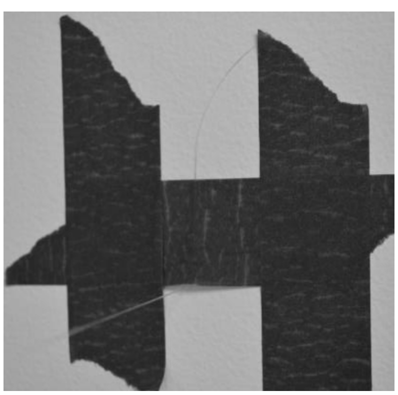
Did you know that octopuses move like balloons? Since an octopus lives in the ocean, it uses jet propulsion—taking in water then shooting it backwards—to move itself forward, just like you did with your balloons! Other animals that use jet propulsion are squid, cuttlefish, and even dragonfly nymphs! (http://bit.ly/3HNfX7x, http://bit.ly/3Ic4BeM)

<u>Procedure</u>:

<u>Tell students:</u> ***In the previous activity, you built a mini rocket that was powered by air from your lungs. It worked because every action causes an equal and opposite reaction. Can we use that same idea to make a different type of air-powered rocket? Let's try!***

Steps 1-3 below are <u>suggested as prep</u> for the Class Leader to prepare the fishing line:

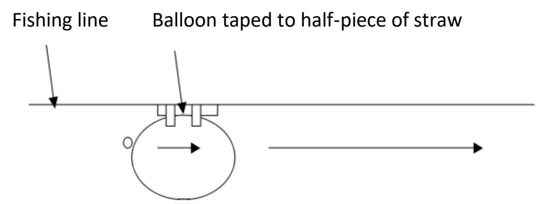
1. Unravel the 32ft fishing line gently (so it doesn't get knotted).
2. Cut the fishing line so you can string several pieces taut across your space, parallel to the ground. You can make four 8ft pieces *or* two 16ft pieces. *(Note: the longer the fishing line, the harder it will be to keep taut.)*
3. <u>For each line</u>:
   a. Thread a half-straw piece onto the line.
   b. Tape the ends of the line to vertical surfaces so the line is fairly taut.
      - Smooth, unpainted surfaces are ideal. In a pinch, you can string the line between desks, have two students hold the line stretched between them, or tape one end and hold the other.)
      - To secure each end, place a piece of painter's tape perpendicular to the length of the line, then add two pieces of tape parallel to the line on both sides of the first piece of tape (see top photo).
   c. Place two pieces of painter's tape onto each half-straw piece. The pieces of tape should be perpendicular to the straw, with the sticky side facing down and the ends of the tape hanging loose off the piece of straw. These will stay on the straw for repeated uses (see bottom photo at left).



Balloon Rocket. Place one piece of painter's tape perpendicular to the fishing line. Place two pieces of tape parallel to the line (one on each side of the line).

Balloon Rocket. Attach the balloon to the half-straw piece on the fishing line with two pieces of painter's tape. Pinch the balloon neck shut until you're ready to let the balloon rocket fly along the fishing line.

4. Give each student a balloon.
5. Have students blow up the balloon and DON'T TIE IT. Instead, twist the neck and pinch it shut to make sure the air can't escape.



6. For each piece of fishing line, make sure the half-straw piece with tape is near one of the ends of the line.
7. Have the first student(s) tape the body of their inflated balloon to the underside of the straw on the line (you may want to be in charge of this step). The balloon should be parallel to the line, with its neck pointed toward the closest endpoint.
8. Have students let go of the balloon (see diagram above and bottom photo at left).
9. Allow students to repeat the experiment until every student gets a turn (the length of time will depend on number of lines set up). You can also allow students to turn their balloons around and see if they work in the opposite direction.

Discussion Prompt:

- ***So what was the action, and what was the equal and opposite reaction?*** *(Action: when we released the neck of the balloon, the sides of the balloon pushed the air out of the balloon. Reaction: the air inside the balloon also pushed back against the balloon, with equal force in the opposite direction, which made the balloon move.)*

Activity Five – Wrap-Up! Time: 5 Minutes

Clean up: Make sure students help clean the room before they leave.

What goes home:

ALMOST* EVERYTHING!

***Never send students home with items that they can't be expected to use safely while unsupervised.** For this particular unit, **don't** send home metal nuts with *any* students. *See the special note about magnets below.* Other than that, please use your judgment about whether to send other extra supplies home with students.

- **Please only send magnets home with students for whom the Site Coordinator has confirmed that a signed permission slip is**

on file. *(Review safety guidelines with students: magnets should not be handled roughly because they can chip or break; they should be kept away from small children, computers, cell phones, credit cards & people with pacemakers; magnets are a particular risk around small children, because in addition to being a choking hazard, swallowed pieces of magnets can pinch the digestive tract and cause serious medical problems)*

- If some students have permission to take home magnets—but other students don't—feel free to send home other extra items from the kit with the students who aren't taking magnets (so they don't feel left out).

- From Class 8, you can send each student home with their homemade boat and (if desired) the balloon from their balloon rocket. Please <u>don't</u> send the straw rockets home (just throw them away).
(Review safety guidelines with students: small items—including balloons—should always be kept away from children ages 3 and younger to avoid the risk of choking)

- **For leftover supplies that aren't possible to send home with students:**
  - Please ask if the site has a use for them. If so, the site can keep them!
  - If there are some supplies that the site can't use, we're happy to put them back in our inventory! You're welcome to bring the leftover supplies to the next Class Leader training, drop them at our office, etc.

Questions? Contact Kathryn Sechrist at ksechrist@impactnw.org
Thanks for your help – and thanks for teaching AKA Science!

AKA Science is funded by our generous community partners.

NGSS - Next Generation Science Standards Aligned in this Curriculum

- **K-PS2-1**
  - Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.
- **K-PS2-2**
  - Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.
- **K-2-ETS1-1**
  - Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.
- **K-2-ETS1-2**
  - Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
- **K-2-ETS1-3**
  - Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.
- **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.
- **2-PS1-3**
  - Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.
- **3-PS2-1**
  - Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.
- **3-PS2-2**
  - Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.
- **3-PS2-3**
  - Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.
- **3-PS2-4**
  - Define a simple design problem that can be solved by applying scientific ideas about magnets.
- **3-5-ETS1-1**
  - Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- **3-5-ETS1-2**
  - Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- **3-5-ETS1-3**
  - Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
- **4-PS3-1**
  - Use evidence to construct an explanation relating the speed of an object to the energy of that object.
- **4-PS3-2**
  - Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
- **4-PS3-3**
  - Ask questions and predict outcomes about the changes in energy that occur when objects collide.
- **4-PS3-4**
  - Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
- **5-PS2-1**
  - Support an argument that the gravitational force exerted by Earth on objects is directed down.