Before you begin the activity, please hand out the pre-test to each student. The pre-test has two different grade levels, make sure to use the correct one for your age group. The pre-test will help us evaluate how effective this unit is on teaching kids about the engineering method. At the end of the quarter the same test will be administered again to see how much knowledge students have gained.
Pre/Post Test for Unit 1: Engineer Design-It

2nd-3rd Grade

Write and/or explain the 6 steps in the engineering process.

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- **Problem Grid:**
  - What is the Problem?
  - Constraints
  - Criteria

- **Process Grid:**
  - Explain what You did and learned
  - Improve Your Model & Retest
  - Brainstorm Ideas & Solutions
  - Create a Model
  - Test Your Model
  - Explain what You did and learned

- **Diagram:**
  - Illustrations for each step
  - Visual representation of the process grid

- **Keywords:**
  - Process Grid
  - Explain what You did and learned
  - Improve Your Model & Retest
  - Brainstorm Ideas & Solutions
  - Create a Model
  - Test Your Model
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**Unit 1: Engineer Design It**

### Next Generation Science Standards (NGSS):

- **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.
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- **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.

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### Prep:
Cut 15 feet of string beforehand for each group of 3-4 students. (15 feet allows extra for those who figure out quickly how to get the balloon across 10 feet and you can then extend it for an extra challenge).

### Materials:
- Balloons
- String
- Straws
- Process Grid
- Tape

### Setting the Stage: 5 Minutes

**Talk** to students about the new unit. Tell them that they will be designing and redesigning lots of different contraptions. The idea is to make a plan, try it, think about how to improve it (redesign it) and try again.

**Explain** the objective for the lesson: students will hit a target across the room using balloons, straws, tape & string.

### Objective(s):
Hit a target across the room using balloons, straws, tape & string.

### Instructor Notes:

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### Activity Instructions:

1. Put students in groups of 3-4. Have a chair for each group that stands 10 ft. away from a wall.
2. Let them know, their goal is to use the tape, string, straw and balloons to get the balloon(s) from the chair to the wall.
3. Brainstorm ideas and have them chart their ideas on the Process Grid.
4. For those who need help getting started, show them how the string can go through the straw. Then ask how they could use that with the balloon to get to the wall.
5. Instructor may need to help students attach the string to the wall and/or the chair.
6. Those who reach the wall can then extend their chairs out farther and try again!
7. At the end of the lesson, discuss the results. What worked and what didn’t? How did they redesign their contraptions to make them work better?
Balloon Brain

Unit 1: Engineer Design It

Next Generation Science Standards (NGSS):
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WEEK 2

2-3

Prep:
Read lesson and gather materials

Materials:
- Water Balloons
- Tape
- Soft & Protective Materials (newspaper, cotton balls, bubble wrap, Easter grass, etc.)
- Drop/Throw space such as into a large bucket, an outside sidewalk, or a concrete wall that kids can throw balloons at
- Process Grid

Setting the Stage:

Ask students what sort of engineering goes into helmets (What are helmets made of? How are they shaped? Why?), and discuss why head protection is so important.

Explain the objective of the day: To create a protective covering for a water balloon (like a helmet for your brain) using soft & protective materials.

Brainstorm some ideas they have for protecting the balloon to keep it from popping. Have them record their ideas on their Process Grid.

Objective(s):
To create a protective covering for a water balloon (like a helmet for your brain) using soft & protective materials

Instructor Notes:

Activity Instructions:

1. In groups of 2-3, have students work on covering their balloons, being careful to NOT pop them! If they pop it prematurely, they have to sit and watch others try. They can use any materials available in any way they’d like to.

2. Once their protective covering is complete, let them test it out by dropping them into a large bucket, or onto a concrete surface outside. Start from only a foot above, then go higher if it resists. Have each group record on their Process Grid how high they were able to drop their balloon before it burst.

3. After the end of the lesson, discuss as a group which materials were the best at protecting the balloons? Which were the worst? What combination of materials worked best? What is it about these materials that made them better or worse than others? Record what they learned on their Process Grid.
Deliver A Message

Objective (s):

Students will deliver a message from one end of a table to the other (or between 2 desks).

Materials:

- Pencil & Paper for writing a message
- Stuff to build a message delivery system: string, scissors, straws, water bottles, masking tape, rubber bands, etc.
- Process Grid

Setting the Stage:

Ask students: When you’re stranded on a deserted island, you can’t use a telephone or e-mail to communicate to others across the island. So how would you get a message to a friend on the other side of your island?

Explain the objective of the day: students will build a way to deliver a message from one side of the table (island) to the other. (Without throwing it or using their own feet to deliver it!)

Brainstorm ideas of what a delivery system might look like. Have them add their ideas to their Process Grid.

Activity Instructions:

1. Have students in teams of three. Each team can write a secret message to another team.
2. After they write their message, have them begin working on their delivery system. As they work, ask them questions about their plan. If something doesn’t work, ask them what they could do to redesign it. You may have to give a few suggestions to get them started. It could be as simple as rolling the message in a bottle across the table or folding it into an airplane to fly through the air, or a catapult. (Don’t give any hints unless there are some students really struggling and frustrated.)
3. If students succeed quickly, place “obstacles” in the way for more of a challenge.
4. At the end of the lesson, discuss what worked and what didn’t work. Add their results and what they learned to their Process Grid.
Next Generation Science Standards (NGSS):
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.
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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.

Materials:
- Aluminum foil (1 sq. foot for each pair of students, extra foil to redesign
- 100 pennies
- Bucket or tub of water
- Process Grid

Setting the Stage:
Ask students to think about different boats that they have seen. What shape did they have? What were they made out of?

Explain objective for the day: students will design a boat and test the number of pennies it can hold before it sinks.

Brainstorm ideas for building a boat, and have students add their ideas to their Process Grid.

Objective (s):
Students will construct a boat out of aluminum foil that can hold the most pennies.

Instructor Notes:

Activity Instructions:
1. Give students each one square foot sheet of aluminum foil. They can cut it, fold it, staple it, do whatever they want to design their boat.
2. When students have built their boat, let them test it and see how many pennies they can place in it without it sinking. Have them record their results on their Process Grid. When they know how many pennies their boat can hold, have them go back and redesign their boat to make it hold more pennies.
3. Re-test boats, and record the new results.
4. As a whole group, reflect on the results. How many pennies could the boat hold? How did they re-design their boat? Did the re-design work? Why or why not? Have students add what they learned to their Process Grids.
BUOYANCY

WEEK 5
Flinker

Next Generation Science Standards (NGSS):
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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.

Prep: Read lesson and gather materials

Materials:
- 8 Corks
- Pipe Cleaners
- 12 Inches of string per group
- Rubber Bands
- Washers or Pennies
- Large clear plastic cups filled with water
- Tape

Setting the Stage:

Review what they have learned about objects that float. What kinds of things float? What kinds of things sink?
Explain the objective of the day: Build a flinker.
Explain what a flinker is: something that likes to hang out in the middle of water- it doesn’t float on the top nor sink to the bottom of the water - it ‘flinks’ for at least 10 seconds.
Brainstorm ideas for how they might create their flinker. Add their ideas to their Process Grids.

Activity Instructions:
1. Have students work in pairs to create their own flinker using the materials available. They will need to test a multitude of times to see how much it floats or sinks as they add materials, and adjust accordingly. So it is best to have a clear plastic cup with water for every pair to use for testing.
2. When students think their object will “flink” for 10 seconds, have them test it out in their cup. If it doesn’t work, tell them to re-design. Prompt them to change one thing at a time in their design to make their flinker work better. What can you change to make it flink? Could you attach washers or pennies to your cork with string? Or, could you change the shape of the cork? Or use something else that floats?
3. Have students test how long their object will flink, and record their results on their Process Grid.
4. As a whole group, discuss the results. How did the pairs make their flinker? Did it work? How did they change it to make it work? Have them record what they learned on their Process Grid.

Objective(s):
Build something that likes to hang out in the middle of the water - it doesn’t have to float on the top nor sink to the bottom of the water - it ‘flinks’ for at least 10 seconds.

Instructor Notes:
PLATFOMS

WEEK 6
Paper Cup Walk

Unit 1: Engineer Design It

Next Generation Science Standards (NGSS):

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2-3

Prep:
Make a strong platform by gluing two pieces of cardboard together so that the lines in the cardboard are going in the opposite directions. Each group of 3 students will need a platform.

Materials: Per Group of 3
- 50 Small Paper Drinking Cups
- Cardboard Square 24" x 24"

Setting the Stage:
Ask students: can you stand on paper cups without crushing them? How could it be possible?
Explain the objective: use platforms to stand on cups without crushing them.
Brainstorm ideas for how they might use only cardboard and cups to accomplish the objective. If necessary, give them a hint using the information for teacher below. Have them record their ideas on their Process Grid.

Here’s why it works (info. for teachers). If you try to stand on just one cup, it will crush. That’s because all of your weight is pushing, or compressing, the cup. But if you arrange the cups, and put a piece of cardboard on top, then the cardboard spreads out your weight. So, each cup supports less weight. That means that there isn’t too much weight on any one cup.

Objective(s):
Use platforms to stand on cups without crushing them.

Instructor Notes:

Activity Instructions:
1. Divide students into groups of three and hand out materials.
2. Let students experiment with their cups and cardboard platform. Eventually, they will want to line up a bunch of cups in a square on the ground and put the cardboard on top.
3. When they think they have used enough cups, have them test their cups by standing on the cardboard on top of the cups. Make sure they have a partner to spot them! If it holds them without crushing, have them try using fewer cups. What is the fewest number of cups they can use to support themselves?
4. At the end of the lesson, discuss the results as whole group. How many cups did it take? Have them record what they learned on their Process Grid.
Unit 1: Engineer Design It

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2-5

Prep:
Read lesson and gather materials

Materials:
- 15 Straws
- 20 Sheets Cardstock
- Tape
- Scissors

Setting the Stage:

Explain the objective: build a structure that’s not attached to the table that will rock back and forth without rolling away. (Tell them to think of a rocking chair if they are struggling to understand what you mean).

Brainstorm ideas of how they can create a contraption that will rock back and forth when blown on by someone, but will NOT be able to roll. What kinds of shapes might help something rock back and forth? Have them add their ideas to their Process Grid.

Objective (s):
Using straws and tape, build a structure that is not attached to the table that will rock back and forth without rolling away when you blow on it through a straw.

Instructor Notes:

Activity Instructions:
1. In groups of 2-3, let students begin building their structures. Remind them to constantly test if it will rock but not roll over.
2. If they think they have a structure that worked, have them prove it to you by demonstrating how it works. If students succeed quickly, ask them if they can come up with different design that does the same thing. Record results on their Process Grid.
3. At the end of the lesson, discuss what designs worked. What designs didn’t work? Which designs continue rocking for the longest time? Have them record what they learned on their Process Grid.
# TOWERS

## WEEK 8

### Golf Ball Tower

### Unit 1: Engineer Design It

#### Next Generation Science Standards (NGSS):

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### Objective(s):

Build a tower that can hold a golf ball at the top, out of 10 pieces of newspaper and 50 centimeters of tape.

### Instructor Notes:

- **Activity Instructions:**
  1. Let students experiment in pairs to build their tower. Have them test their tower to see if it will hold the golf ball. If it does, have them try to make their tower even taller.
  2. Remind students if one design doesn’t work, to think about why it doesn’t and then change the design in some way that fixes what they think doesn’t work. Instructor circulates and measure towers that hold the golf ball. Make sure students are recording their results on their Process Grid.
  3. At the end of the lesson, have students share what worked/didn’t work. Why did or didn’t their design work? How did they change their design to make it work? Have them record what they learned on their Process Grid.

### Materials:

- 10 sheets of Newspaper per pair of students
- Tape
- 4 Golf Balls

### Setting the Stage:

**Ask** students if they have ever seen a really high tower. What did it look like? What did the base look like? What kept it strong?

**Explain** today’s objective: build a tower that can hold a golf ball at the top, out of 10 pieces of newspaper and 50 centimeters of tape.

**Brainstorm** ideas and have them add their ideas to their Process Grid. Let them know they won’t be able to tape the tower to the table to help it stand. It has to stand on its own!
Unit 1: Engineer Design It

Next Generation Science Standards (NGSS):
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Materials:
- Straws
- Masking Tape
- Scissors
- Toy Cars

Setting the Stage:
Ask students what they know about bridges. What makes a strong bridge? What different types of bridges are there?

Explain today's objective: To make a bridge using straws and tape that will support a toy car.

Brainstorm ways they can use the materials to make a bridge strong enough to support a toy car. What do bridges look like? Have students record their ideas on their Process Grid.

Activity Instructions:
1. Divide students into groups and give each group a handful of straws and 2 feet of masking tape. This is all they can use on their entire project!
2. When a group finishes building their bridge, place the car or shoe on top. Can the bridge hold it? If it doesn't hold the car, tell them to re-design. If it does hold the car, tell them to design a bridge that can hold a shoe.
3. Once they have a bridge that can support a show, if there is time, let them test which parts are needed and which parts aren't needed. To test this out, use the scissors to carefully snip away at the bridge.
4. They might also choose to see which bridge can support the most weight. They can add more shoes on top, or use a cup with washers from a previous lesson to add more weight until the bridge gives out.
5. At the end of the lesson, discuss the results. What worked and what didn't? What did the strongest bridges look like? Which parts were necessary and which parts weren't? Have them record what they learned on their Process Grid.
UNIT 2 | INVISIBLE FORCES
Before you begin the activity, please hand out the pre-test to each student. The pre-test has two different grade levels, make sure to use the correct one for your age group. The pre-test will help us evaluate how effective this unit is on teaching kids about the engineering method. At the end of the quarter the same test will be administered again to see how much knowledge students have gained.
Pre/Post Test for Unit 2: Invisible Forces

2nd-3rd Grade

Write and/or explain the 6 steps in the engineering process.

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</table>
ELECTRICAL EQUIPMENT

1. WIRE
   - bell wire (20 gauge)
   - or aluminum foil strips, backed or covered with masking tape

2. BULB
   - flashlight bulbs
   - or miniature Christmas lights (replace bulb and holder)
   - cut lights apart

3. BULB HOLDER
   - or clamp foil strip clamped next to the side of the bulb
   - or tape wire to side of bulb
   - or tape wire to end of bulb

4. SWITCH
   - or 2 brass paper fasteners
   - and 1 piece of tagboard
   - and 1 large paper clip
Unit 2: Invisible Forces

Next Generation Science Standards (NGSS):

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.

4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

**STATICALLY CHARGED OBJECTS**

**WEEK 1**

*Statically Charged Objects*

**Materials:**
- Class set of Investigation Worksheet
- 1 sheet of Paper Towel
- 2 Paper Clips
- 1 piece of Thread
- 1 Piece of String
- 1 Pinch of Salt
- 1 small piece of Styrofoam Cup
- 1 small piece of Aluminum Foil
- 1 Pencil

**Setting the Stage:**

**Explain** to students about the new unit “Invisible Forces”. Tell them that they will be experimenting with forces that we can’t see. They will be using static electricity (Have you ever seen someone hair standing up due to something in the air?) and magnets.

**Ask** students: Have you ever zapped /shocked someone on accident? Have you ever used this kind of plastic wrap? Have you noticed how things magically stick to it? Does everything stick to it? This invisible force that makes things stick to the plastic wrap is called “static electricity’. We’re going to experiment with “static electricity” today!

**Show** students how to “statically charge” their plastic wrap. Lay the plastic wrap flat on the table. Rub it with a paper towel. Students can then lift the plastic wrap from the desk by one corner and observe what happens. Then have them charge it again (by rubbing it with the paper towel) and pick up by the midpoints of two opposite sides. What happens? Explain that this is “static electricity” that is causing it to do what they observed.

**Explain** the objective of the day. They will be testing different objects to see which objects are affected by the statically charged plastic wrap and which objects aren’t.

**Demonstrate** with the first object how to use the student worksheet to keep track of their data. They can use backside of worksheet to write in objects that they want to investigate.

**Brainstorm** what they think will happen with a partner. Have students add their ideas to their Process Grid.

**Objective (s):**

Which objects does the statically charges plastic wrap affect? Why?

**Instructor Notes:**

**Activity Instructions:**

1. Students investigate the different objects. Ask questions to help students think about why some objects are affected by statically charged plastic wrap and why others aren’t.
2. Have students reflect in whole group about the objects that were and weren’t affected and their conclusions. (The static charge can affect light objects, but not heavy objects.) Have them add their conclusions to Process Grid.
## Investigation Worksheet: Statically Charged Objects

Name: ________________________________

<table>
<thead>
<tr>
<th>Object</th>
<th>Affects</th>
<th>Doesn’t Affect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thread</td>
<td></td>
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<tr>
<td>Paper clips</td>
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<tr>
<td>Styrofoam</td>
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<tr>
<td>Aluminum foil</td>
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<td>Book</td>
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<tr>
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<td>Pencil</td>
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Next Generation Science Standards (NGSS):

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.

4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

Objective(s):
Discover how balloons with like and unlike charges interact with each other and with other materials

Supporting Materials:
Static Electricity Handout (2-5)
Read lesson and gather materials

Materials:
- 2 Balloons (inflated prior to lesson) tied to two 30 cm. pieces of thread
- Small bits of Paper
- 1 Book
- 1 Pencil and Pencil Shavings
- Plastic Ruler
- Piece of Plastic Wrap
- Tape
- Cheerio tied to a string
- Piece of Nylon Fabric
- Optional: Bubbles

Setting the Stage:
Review what happened last week when statically charged plastic wrap got close to certain objects. Use the Static Electricity handout and introduce them to the idea that like charges repel, and unlike charges attract. Rub a balloon with a paper towel (or a clean, dry head- no hair gel!) and touch the balloon to a wall. Discuss what happens and why. It should cling to the wall because it has become negatively charged and induces a positive charge near the surface of the wall. Since opposite charges attract, it sticks to the wall.

Ask students what they think will happen if they have 2 balloons, 1 with a positive charge, and the other with a negative charge.

Make predictions about what they think will happen to some objects when both balloons have the same charge. Then make predictions about what they think will happen when each has a different charge. Will it be the same? When will objects be attracted to the balloons? When will they be repelled? When will there be no difference? Have them write their predictions on their Process Grid.

Activity Instructions:
1. Tape the end of the string to the edge of a table so the balloons hang down and there is a 5 cm space between the balloons.
2. Show them how to charge 1 balloon by rubbing it with a piece of plastic wrap (giving it a positive charge) and the other by rubbing it with a piece of nylon (giving it a negative charge.) Have them observe and discuss what happens. (They should attract each other- stick together- due to different charges.)
3. Then, have them charge both balloons with a piece of nylon (giving them both a negative charge). Have them observe the effects of like charges on the 2 balloons and discuss. (They should repel- push away from each other- due to having similar charges.)
4. Have them charge the balloons again with the nylon. Then have them hold their hands between the two balloons and observe what happens. Then have them place other objects between the balloons: pencil shavings, cheerio tied to string brought close to balloon, pencil, book, plastic wrap, ruler, small pits of paper and/or thread.
5. Observe and discuss what happens.
6. Share results with whole group, and have them write their results on their Process Grid.
7. Those who finish more quickly can try accompanying an adult to the bathroom and observe the effects the charged balloon has on a thin stream of water. You can also try blowing some bubbles and seeing what happens. Another extension is to put a piece of paper on the wall and rub it with nylon or plastic wrap, and see which makes it stick to the wall the longest.
Static Electricity

Have you ever rubbed a balloon on your hair and then stuck the balloon to the wall? Static electricity was at work!

All matter is made up of tiny particles called atoms. Each atom contains 3 basic parts:
- protons which have a positive electrical charge (+)
- electrons which have a negative electrical charge (-)
- neutrons which have no electrical charge

Protons and neutrons are in the nucleus or central core of an atom, while the electrons orbit around the nucleus.

Most objects, such as a balloon, normally have about the same number of electrons and protons, making them electrically balanced.

Sometimes objects gain or lose electrons through friction (rubbing 2 things together). When this happens the object becomes electrically charged. If an object gains electrons when it is rubbed, it becomes negatively charged because it has more electrons (-) than protons (+). If an object loses electrons when it is rubbed, it becomes positively charged because it has more protons (+) than electrons (-).
# Unit 2: Invisible Forces

## Supporting Materials:
Lighting an LED With Playdough Guide (Instructor guide, not a handout for students!)

### Materials: Per Pair
- 9 volt battery with a snap connector
- 2 LED lights (1.9-2.4 V)
- Safety Goggles
- Playdough

### Setting the Stage:
**Ask** students: How can you make a LED light up using only playdough, a battery, and two wires?  
**Explain** the objective: they are to use only the materials provided to make the bulb light up. Let them know they need to make a circuit—they should think of a circle as they connect things. (Make sure the you have read the guide on page 16 and are familiar with the procedure. But don’t show the students the guide!).  
**Brainstorm** what they will try first. Show them the materials and ask how they might make a circle with them. Have them add their ideas to their Process Grid.

**Tell students NOT to touch the wires directly to the legs on the LEDs. Explain that the dough must always be between the wires and the LED. (If the wires and the LED touch, there is a small chance the LED can shatter. Make sure students are wearing their safety goggles for this experiment).**

### Objective(s):  
Using Playdough and a battery, students will make an LED light up.

If students are unfamiliar with LEDs, you can tell them that they are bright, energy efficient light sources. Ask them if they can see any differences between the LEDs and a normal light bulb.

### Activity Instructions:
1. Make sure students are wearing their safety goggles. Make sure the instructor is modeling the behavior by also wearing the goggles.
2. Put students into pairs and show them how to connect the snap connector to the end of the battery. Demonstrate how the wires go into different pieces of dough.
3. From there, let students experiment to see if they can figure out how to light the LED. If they get stuck, suggest that they try sticking the legs of the LED light into the dough as well. (Refer to the guide on page 16 for procedure, but don’t show the kids the guide! Let them try to figure it out).
4. Once they have managed to light the bulb, challenge them to light up two bulbs at the same time. Let them experiment and play with the materials.
5. As a whole group, discuss why it works. (The salt in playdough makes it conductive, meaning that the energy from the battery can flow through the wires, into the playdough, and into the LED). Did the LED light up only one way? Why? What happened if you lit two bulbs? (They should get dimmer). Why did that happen?
Lighting an LED with Playdough

(Procedure taken from SciGirls “Get Tech” Activity Guide)

**This sheet is to inform instructors on the procedure. Do not hand this out to students! Let them explore and figure it out.

The salt in playdough makes it a conductor, meaning that energy can pass through it. This makes playdough a safe and fun way to explore electricity. Below are the steps for using playdough to light a small LED.

**You will need:**
- 9 volt battery with snap connector
- 2 LEDs (1.9-2.4 V)
- playdough (playdough is conductive)

**Steps:**
1. Connect the snap connector onto the end of the 9 volt battery.
2. Form two “logs” of playdough and line them up next to each other.
3. Insert the black wire from the battery connector into one playdough log, and the red wire into the other log (the red wire is the positive one, the black is negative).
4. Spread the legs of the LED light and notice that one end is longer (the longer end is the positive side). Insert the long leg into the same playdough log as the red wire, and the short leg into the playdough with the black wire. The LED will light up!
   - If the legs are switched, the LED will not light up. The long positive leg needs to match up with the positive red wire.
   - If the playdough logs are touching, the LED will not light up. (This is a short circuit—the energy is traveling between the playdough instead of to the LED).

**Important!** Never touch the legs of the LED directly to the wires. If they touch, there is a small chance the LED can shatter. You will want to make sure your playdough logs are long enough so that the wire and the LED leg can be inserted without touching each other.
**Unit 2: Invisible Forces**

**Next Generation Science Standards (NGSS):**

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.

4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

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**Prep & Supporting Materials:**

**Make a Switch Handout (2-5)**

Read lesson and gather materials

**Materials: Per Group:**

- 9 Volt Battery with a Snap Connector
- Playdough
- 1 LED Light
- 1 Paper Clip
- Photocopies of Make a Switch Handout
- Safety Goggles

**Setting the Stage:**

**Review** how they made the LED light up in the last lesson. What is a circuit?

**Explain** the term current - the flow of electricity. Electricity flows through the circuit in order to light up the LED.

**Explain** today’s objective.

**Ask** students: How can you turn the current on and off in an electrical circuit? Remind students not to let the legs of the LED touch the wires.

**Activity Instructions:**

1. Make sure students are wearing their safety goggles. Make sure the instructor is modeling the behavior by also wearing goggles.
2. Put students into groups and pass out one "Make a Switch" handout to each group. Have groups build the circuit and switch pictured. Let them try to build the circuit on their own, and offer pointers if they get stuck.
3. The paper clip is the switch. What happens when the paper clip is touching both pieces of playdough? (The LED will light up). What happens when they lift the paper clip so it is only touching one piece of playdough? (The LED goes off). Have them record their results on their handout.
4. Discuss the results as a whole group. Why does the LED go off if they move the paper clip? (The circuit is only a complete circle when the paper clip is touching both pieces of dough. The circuit is broken when the paper clip is moved).
5. Ask them: How is this like the light switches at home or school? How would they have to change their circuit to turn off a light that was across the room?
Make A Switch

You will Need:
• 9 volt battery with snap connector
• playdough
• 1 paper clip
• 1 LED light

Make 3 log-shaped pieces of playdough and line them up next to each other. Then connect the snap connector to the battery.

Look at the picture, and connect the wires and LED light as shown.

Touch the paper clip to the two pieces of playdough on the left, as shown. What happens to the LED light? _______________

Move one end of the paper clip up so it is only touching one piece of dough. What happened to the LED light? _______________
## Conductor or Insulator?

### Supporting Materials:
- Circuit Testing Diagram (2-5)
- Investigation Worksheet: Conductor or Insulator? (2-5)

### Materials: Per Pair
- 9 Volt Battery with Snap Connector
- 2 LEDs (1.9-2.4 V)
- Wooden Ruler
- Safety Goggles
- Playdough
- Paper Clip
- Penny
- Pieces of Copper Wire
- Nails
- Piece of Styrofoam Cup
- Piece of Fabric
- Other materials on hand (book, shoe, etc.)

### Setting the Stage:

**Ask** students: Remember how the battery power passed through the wires and playdough last week? What are some other materials you think electricity can pass through?

**Show** students how to build a circuit to test the conductivity of materials. Build the same circuit you made last week to build a switch. Remind the students that when the paper clip is connecting the two pieces of dough on the left, it is completing the circuit and making the LED light up.

**Explain** that they can replace the paper clip with other items to test whether they conduct electricity or not. Explain that when the light stays ON, the material is conducting electricity, but when the light goes OFF, the material is **not** conducting electricity. If the test object is conducting electricity, the circuit will be complete and the LED will light up. If the test object is not conducting electricity, the circuit will not be complete and the LED won't light up.

**Brainstorm** what materials/objects they think will conduct electricity and which objects they think won’t. (Introduce here the word “insulate” or “insulators” - those objects that don’t conduct electricity/don’t allow electric current to pass through.) Write down a few predictions on their Process Grids.

### Objective(s):
Students will determine which of the available objects conduct electricity, which insulate (don’t conduct) and which objects do both.

### Instructor Notes:

1. Make sure students are wearing their safety goggles. Make sure the instructor is modeling the behavior by also wearing goggles.
2. Have students work in pairs. Pass out handouts and materials and have students test the conductivity of the objects. Students record results on their Investigation Worksheet as they work. They can choose a few more objects available to test if they have time.
3. Discuss the results as a group. How are all the conductors alike? How are all the insulators alike? What makes a conductor different from an insulator? What other things do you think might be conductors/insulators? Why are many wires coated with plastic or some other material? (Getting them to think about real-world applications)
Circuit Testing Diagram

If the LED light is ON, the test object is conducting electricity (conductor)

If the LED light is OFF, the test object is not conducting electricity (insulator)
# Investigation Worksheet: Conductor of Insulator?

Name: ________________________________

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<tr>
<th>Object</th>
<th>Passes through</th>
<th>Doesn’t pass through</th>
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<tr>
<td>Wooden ruler</td>
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<tr>
<td>Piece of copper wire</td>
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<tr>
<td>Aluminum foil</td>
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<tr>
<td>Fabric</td>
<td></td>
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<td>Paper clip</td>
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<tr>
<td>Shoe</td>
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<tr>
<td>Book</td>
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<td></td>
</tr>
<tr>
<td>Penny</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Styrofoam cup</td>
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<tr>
<td>Nail</td>
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</tbody>
</table>
Unit 2: Invisible Forces

Next Generation Science Standards (NGSS):

3-PS2-3: Ask questions to determine cause and affect 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.

4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

Setting the Stage:
Review conductors and insulators from last week. Which materials were conductors and which were insulators? What does an insulator do? What does a conductor do?

Show them the insulating dough. Explain that, like many of the objects from last week, the dough does not conduct electricity. Build a circuit (with only 2 playdough logs) and show them how when you put the insulating dough between the playdough logs, the light stays on. Show them that if you put regular playdough between the logs, the light will go out. (This is because when the regular playdough is touching each other, the circuit is short circuiting and the energy is not making it to the light).

Explain the objective of the day. Tell them they will be creating a creature (or other object) out of the regular playdough and insulating dough, and incorporating an LED into their creation somewhere (as eyes, nose, etc.).

Objective (s):
Students will use knowledge of insulators and conductors to build a creation that will light an LED bulb.

Make sure to have pre-made the insulating dough!

Activity Instructions:

1. Make sure students are wearing their safety goggles. Make sure the instructor is modeling the behavior by also wearing goggles.

2. Show the students an example creation that the instructor has made, where they used their playdough, battery, LED, and insulating dough to make an object. Hand out the Example Creations sheet so they can get ideas.

3. Put students in pairs and pass out materials, and let them start creating. They may also use insulating materials from last week in their creations, if they would like.

4. At the end, have students share their creations with the group.

Materials: Per Pair
- Playdough
- Insulation Dough
- LEDs
- 9 Volt Battery with Snap Connector

Supporting Materials: Example Creations

Prep: Prior to the activity, make a batch of insulating playdough.

Materials: Per Pair
- Playdough
- Insulation Dough
- LEDs
- 9 Volt Battery with Snap Connector

Supporting Materials: Example Creations

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Materials: Per Pair
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Supporting Materials: Example Creations

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Materials: Per Pair
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- Insulation Dough
- LEDs
- 9 Volt Battery with Snap Connector

Supporting Materials: Example Creations

Prep: Prior to the activity, make a batch of insulating playdough.
**Instructions for Making Insulating Dough** (from Sci Girls “Get Tech” Activity Guide)

Ingredients:
- 3 cups of flour
- 1 cup sugar
- 6 tablespoons vegetable oil
- 1 cup deionized or distilled water

Mix the oil and solid ingredients (setting aside ½ cup of flour) in a bowl. Mix in 2 tablespoon deionized water and stir. Continue to add deionized water 1 tablespoon at a time until the mixture becomes moist and dough-like. Remove it from the bowl and slowly knead in flour until the desired consistency is reached.

Store dough in an airtight container for up to three weeks.
Examples of Playdough Creations
(From SciGirls “Get Tech” Activity Guide)
Building a Long Circuit

**WEEK 7**

**Building a Long Circuit**

Next Generation Science Standards (NGSS):

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.

4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

**2-5**

**30 Minutes**

**Prep:**
Read lesson and gather materials

**Materials:**
- 9 Volt Battery with Snap Connector
- 2-3 LED Bulbs
- Playdough (normal kind)
- Safety Goggles
- Various conducting materials from 2 weeks ago: Paper Clips, Pennies, etc.

**Setting the Stage:**

**Review** what they explored in the last two weeks about conductive and insulating materials. Which materials were conductors?

**Explain** the objective. They will be using the provided materials to create a working circuit, using at least 3 different materials. Remind them that the LED legs cannot touch the wires (or other conducting materials) directly.

**Brainstorm** ideas for building a long circuit. Help students develop ideas about how they can connect their circuit without letting the LED legs touch the conductors. One idea is to make lots of logs of playdough and connect them all with paper clips.

**Objective (s):**

Students will use knowledge about conductive materials to build a circuit using at least 3 different materials.

**Instructor Notes:**

**Activity Instructions:**

1. Make sure students are wearing their safety goggles. Make sure the instructor is modeling the behavior by also wearing goggles.
2. Divide students into groups and give them their supplies. Let them experiment with building a circuit. Ask questions as they work to make sure they understand that the circuit must be a complete circle for the LED to light up.
3. If they complete a circuit, challenge them to make an even longer circuit. How long can they make it? How many bulbs can they light up?
4. At the end of the lesson, have students share their circuits with the class and discuss what worked for them, and what didn’t. What have they learned about building circuits?
## Series & Parallel Circuits

### Unit 2: Invisible Forces

Next Generation Science Standards (NGSS):

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.

4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

### 2-5 Minutes

#### Supporting Materials:
- Series and Parallel Circuits Handout
- Read lesson and gather materials

#### Materials:
- 9 Volt Battery with Snap Connector
- Playdough (conductive)
- 2-3 LED Lights
- Safety Goggles
- 2 Paper Clips or pieces of Copper Wire

#### Setting the Stage:

**Review** what a circuit is. What parts do you need to make a complete circuit?

**Ask** students: Is there only one kind of circuit? What happens if you add more bulbs, or more pieces of playdough?

**Explain** today’s objective: they will be investigating the difference between two different kinds of circuits.

#### Instructor Notes:

**Objective (s):**
Students will build and observe series circuits and parallel circuits. They will observe how the flow or electricity differs between the two types of circuits.

#### Activity Instructions:

1. Make sure students are wearing their safety goggles. Make sure the instructor is modeling the behavior by also wearing goggles.
2. Divide students into pairs and hand out the Parallel and Series Circuit Handout. Have them look at the diagrams of the two circuits and predict what they think will happen if they remove a bulb in each of the circuits. Have them record their predictions on their group handout.
3. Have students pick either a series or parallel circuit to build first. Tell them to build the circuit according to the diagram on the handout. Ask them questions as they build, and make sure both bulbs in the circuit light up.
4. **Note:** For the parallel circuit, students will create two pairs of playdough logs, and connect them with either paper clips or pieces of copper wire (a conductive material) See the diagram on the next page.
5. Once students have one circuit complete, have them remove one bulb from the circuit and observe what happens. Record their observations on their handout.
6. Repeat the experiment with the other type of circuit.
7. At the end of the activity, discuss the results as a class. What happened when they removed a bulb? Was it the same for both circuits? Why is it not the same? (Removing a bulb from the series circuit breaks the “complete circle” of the circuit. Removing a bulb from the parallel circuit does not break the circle).
Series and Parallel Circuits

1. Build a series circuit like this:

2. What happens when you remove one bulb?
   Prediction: ________________________________
   ________________________________________
   ________________________________________
   ________________________________________
   Results: ________________________________
   ________________________________________
   ________________________________________

3. Build a parallel circuit like this:

4. What happens when you remove a bulb?
   Prediction: ________________________________
   ________________________________________
   ________________________________________
   ________________________________________
   Results: ________________________________
Parallel Circuit with a Switch

WEEK 9

Next Generation Science Standards (NGSS):

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.

4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

Materials: Per Pair

- 9 Volt Battery with Snap Connector
- 2-3 LED lights
- Playdough
- Safety Goggles
- Various conductive materials from previous weeks: Copper Wire, Paper Clips, Nails, etc.

Setting the Stage:

Review parallel and series circuits from last week. Ask students if they remember the difference between the two types (parallel circuits still work when a bulb is removed).

Explain today’s objective: today they will try to create a parallel circuit that incorporates a switch, so that the circuit can be turned off and on.

Brainstorm ways that they might be able to create their circuit. Add ideas to their Process Grids

Activity Instructions:

1. Make sure students are wearing their safety goggles. Make sure the instructor is modeling the behavior by also wearing goggles.

2. Put students into pairs and hand out materials. Let them experiment and try to build their circuits. Have them show you when they can make their bulbs light up and then switch off. Those who finish quickly can try and adjust their circuits.

3. Discuss the results as a whole group. How did they make their switches? What worked and what didn’t? What could be a real-world application of their circuit?
Before you begin the activity, please hand out the pre-test to each student. The pre-test has two different grade levels, make sure to use the correct one for your age group. The pre-test will help us evaluate how effective this unit is on teaching kids about the engineering method. At the end of the quarter the same test will be administered again to see how much knowledge students have gained.
Write and/or explain the 6 steps in the engineering process.

1. __________________________________________________________________________
   __________________________________________________________________________

2. __________________________________________________________________________
   __________________________________________________________________________

3. __________________________________________________________________________
   __________________________________________________________________________

4. __________________________________________________________________________
   __________________________________________________________________________

5. __________________________________________________________________________
   __________________________________________________________________________

6. __________________________________________________________________________
   __________________________________________________________________________
## Process Grid:

<table>
<thead>
<tr>
<th>What is the Problem?</th>
<th>Brainstorm Ideas &amp; Solutions</th>
<th>Create a Model</th>
<th>Test Your Model</th>
<th>Improve Your Model &amp; Retest</th>
<th>Explain what You did and learned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Constraints</td>
<td>Innovation</td>
<td>Assembly</td>
<td>Failure</td>
<td>Modifications</td>
<td>Explain</td>
</tr>
<tr>
<td>Criteria</td>
<td>Invention</td>
<td>Component</td>
<td>Data</td>
<td>Operational Optimization</td>
<td>Justify</td>
</tr>
<tr>
<td></td>
<td>Solution</td>
<td>Design</td>
<td>Testing</td>
<td>Optimization</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trade-Off</td>
<td>Model</td>
<td>Instrumentation</td>
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<td></td>
<td></td>
<td>Prototype</td>
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<td>System</td>
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<tr>
<td></td>
<td></td>
<td>Technology</td>
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</tr>
</tbody>
</table>
INTRO/ PAPER CUPS

WEEK 1

Paper Cups

Unit 3: Wind

Next Generation Science Standards (NGSS):

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.

Objective(s):

Students will create a cup that floats by using the wind’s force.

Materials:

• Process Grid
• Small Paper Cups
• Scissors
• Box Fan

Setting the Stage:

Ask students: “What have you seen the wind do?”

Explain the objective for the day.

Place a non-cut cup above the fan (turned on) and time it.

Ask students if they can cut the cup to make it stay in the air longer?

Activity Instructions:

1. Give students one cup today to try out. Have students fill in their Process Grid with what they are trying, under the “Create a Model” section.

2. When students have designed their cup, have them test it and time it. Have them add their results to Process Grid. Ex: 1 cup fell to the ground and didn’t work; floated for 10 seconds.

3. Have them reflect on their cup and the changes that they might make to it next week. Have a couple of students share their ideas for improving their cup for next week and prompt them to write their ideas on their Process Grid under “Improve your Model”.

4. Have students write their name on their cup and teacher collects for next week.

Prep:

Pre Tests
Read lesson and gather materials

Instructor Notes:

30 Minutes

K-5
**Unit 3: Wind**

**Next Generation Science Standards (NGSS):**

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.

<table>
<thead>
<tr>
<th>K-5</th>
<th>30 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supporting Materials &amp; Prep:</strong></td>
<td>Read lesson and gather materials</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Materials:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Process Grid</td>
</tr>
<tr>
<td>• Small Paper Cups</td>
</tr>
<tr>
<td>• Box Fan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Setting the Stage:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Review</strong> Last week’s process and results. Use Process Grids from last week.</td>
</tr>
<tr>
<td><strong>Explain</strong> the objective for the day, and that they will try to improve upon their cups from last week.</td>
</tr>
<tr>
<td><strong>Ask</strong> students if they can cut the cup to make it stay in the air longer?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Objective(s):</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will modify a cup that floats by using the wind’s force.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Activity Instructions:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ask students to look at their cup from last week and discuss with a partner how well it worked, what they might want to do to change it and why. Have them fill in their ideas on their Process Grid, and then share a couple of ideas whole group.</td>
</tr>
<tr>
<td>2. Do experiment again (same as previous week) Continue to have students add ideas and results to Process Grid.</td>
</tr>
<tr>
<td>3. At the end of the lesson, look at 1-2 examples of cups that worked really well and ask students what they learned about “wind energy” from this engineering project. (Why did they work well?) Have them add what they learned to their Process Grid.</td>
</tr>
</tbody>
</table>
Next Generation Science Standards (NGSS):

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.

K-LS1-1: Use observations to describe patterns of what plants and animals (including humans) need to survive.

Objective (s):

Students will use what they learned about the cup to design their own “seed” that will travel the farthest.

Instructor Notes:

Activity Instructions:

1. Students are given materials to design a seed that will travel. Let them experiment and try different approaches to creating their seed.

2. As students finish, they will bring their seed up, stand by fan and drop it. Then they will measure how far it traveled until it came to a complete stop (rolling counts!). Student will mark on their Process Grid how far their seed went. Then student goes back and tries to redesign their seed to make it go farther.

3. At the end of the lesson, look at 1-2 examples of seeds that worked really well and ask students what they learned about “wind energy” from this engineering project. (Why did they work well?) Have them add what they learned to their Process Grid.
Supporting Materials & Prep:
Prior to the lesson, Instructor must create 2 cardboard boats for students to attach their sail to, in order to race their sails.

Materials:
- Fan
- Fishing Wire
- Straws
- Tape
- Cardboard Boats
- Craft Sticks (Popsicle)
- Cardstock
- Wax Paper
- Regular Paper

Setting the Stage:

Explain the objective of the day.

Show them the pre-made cardboard boats and explain they will be creating sails to attach to the boats.

Brainstorm ideas about what makes a boat go fast.

Activity Instructions:

1. Students can create their own sail, or they can collaborate and work in small groups to create a single sail. Let them experiment with the materials.

2. When 2 students have their sails ready, they bring them up to race. Race boats by setting them on the floor in front of the fan, and seeing which boat travels further. Have students write their results on their Process Grid. Ex: The triangular one went faster. Mine didn’t win because it was too small. Students can draw the shape that they tried on a sticky note and put under a fast or slow column the teacher has created on the wall.

3. The “winning” sail will stay in the boat and the students go back to redesign.

4. Someone else that has a sail ready challenges the “fastest” sail.

5. NOTE! For this week, have students focus on material when redesigning, but remember other factors (shape, size, etc.) for upcoming weeks.

6. At the end of the lesson, look at 1-2 examples of sails that worked really well and ask students what they learned about “wind energy” from this engineering project. (Why did they work well?) Have students add what they learned to their Process Grid.
### Change Shape of Sail

**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.  
**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.

**K-5 30 Minutes**  
**Supporting Materials & Prep:** Cardboard Boat from previous week  
**Read lesson and gather materials**

**Materials:**  
<table>
<thead>
<tr>
<th>K-3</th>
<th>K-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same as previous week:</td>
<td>Cardboard Boat</td>
</tr>
<tr>
<td>• Fan</td>
<td>Wax Paper</td>
</tr>
<tr>
<td>• Fishing Wire</td>
<td>Regular Tape</td>
</tr>
<tr>
<td>• Straws</td>
<td>Craft Sticks</td>
</tr>
<tr>
<td>• Tape</td>
<td>Cardstock</td>
</tr>
</tbody>
</table>

**Setting the Stage:**  
**Review** sailboats and ideas from previous week.  
**Brainstorm** ways they can change the size or shape of their sail to make it go faster.

**Objective (s):**  
Students will manipulate factors to create the fastest sailboat and understand wind energy.

**Instructor Notes:**

**Activity Instructions:**

1. Students can create their own sail, or they can collaborate and work in small groups to create a single sail. Last week they experimented with different materials, this week have them focus changing the shape and/or size of their sail. Have them record their ideas on their Process Grid.

2. **NOTE!** For this week, have K-3 students focus ONLY on changing the shape of their sail when redesigning (they will do size next week), and have 4-5 students focus on changing the size AND shape of their sails.

3. When 2 students have their sails ready, they bring them up to race. Race boats by setting them on the floor in front of the fan, and seeing which boat travels further. Have students write their results on their Process Grid. Ex: The triangular one went faster. Mine didn’t win because it was too small. Students can draw the shape that they tried on a sticky note and put under a fast or slow column the teacher has created on the wall.

4. The “winning” sail will stay in the boat and the students go back to redesign.

5. Someone else that has a sail ready challenges the “fastest” sail.

6. At the end of the lesson, look at 1-2 examples of sails that worked really well and ask students what they learned about “wind energy” from this engineering project. (Why did they work well?) Have students add what they learned to their Process Grid.
Change Size of Sail

Next Generation Science Standards (NGSS):

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.

Supporting Materials & Prep:
Cardboard Boats from previous weeks
Read lesson and gather materials

Materials:
Same as previous week:
• Fan
• Fishing Wire
• Straws

• Tape
• Cardboard Boat
• Wax Paper
• Regular Paper

• Craft Sticks
• Cardstock

Setting the Stage:
Review sailboats and ideas from previous weeks.

Brainstorm ways they can change the size of their sail to make the boat go faster.

Objective (s):
Students will manipulate factors to create the fastest sailboat and understand wind energy.

Instructor Notes:

Activity Instructions:

1. Students can create their own sail, or they can collaborate and work in small groups to create a single sail. Last week they experimented with different materials, this week have them focus changing the shape and/or size of their sail. Have them record their ideas on their Process Grid.

2. NOTE! For this week, have students focus on changing the size of their sail when redesigning.

3. When 2 students have their sails ready, they bring them up to race. Race boats by setting them on the floor in front of the fan, and seeing which boat travels further. Have students write their results on their Process Grid. Ex: The triangular one went faster. Mine didn’t win because it was too small. Students can draw the shape that they tried on a sticky note and put under a fast or slow column the teacher has created on the wall.

4. The “winning” sail will stay in the boat and the students go back to redesign.

5. Someone else that has a sail ready challenges the “fastest” sail.

6. Challenge students to design a sail that uses the best material, the best size, AND the best shape.

7. At the end of the lesson, look at 1-2 examples of sails that worked really well and ask students what they learned about “wind energy” from this engineering project. (Why did they work well?) Have students add what they learned to their Process Grid.
**Pinwheels**

**WEEK 7**

*Pinwheels*

**Unit 3: Wind**

**Next Generation Science Standards (NGSS):**

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.

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.

**Supporting Materials & Prep:**

Pre-make pinwheel frames for students: 2 straws attached in an "x" to a pencil with a thumbtack through the eraser.

**Materials:**

- Tape
- Cardstock
- Construction Paper
- New Pencil with Full Eraser (1 per pair)
- Straws (4 per pair)
- Thumbtacks (1 per pair)

**Objective (s):**

Students will design pinwheel blades that will go as fast as possible.

**Instructor Notes:**

**Activity Instructions:**

1. Pairs of students are given materials to design their pinwheel. K-1 students will be given the frame pre-made: 2 straws attached to pencil with thumbtack.

2. Let students experiment with designing blades for their pinwheel and taping them to the straws.

3. As students finish, they will bring their pinwheel, stand by fan and try to count rotations. (Draw an X on one of the blades for counting.) Students will mark on their Process Grid with how fast their pinwheel went. Student will know they have a very fast pinwheel when they can no longer count the rotations. Then student goes back and tries to redesign their pinwheel to make it go faster.

4. At the end of lesson, discuss with students which types of blades seemed to work best. Have them record their progress on their Process Grid.

5. Collect pinwheels and save for next lesson.
Unit 3: Wind

Next Generation Science Standards (NGSS):
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.

K-3

30 Minutes

Supporting Materials & Prep:
Pinwheels from previous week
Read lesson and gather materials

Materials:
- Pinwheels from previous week
- Tape
- Cardstock
- Scissors
- Construction Paper

Setting the Stage:
Review objective and process grid from previous week.

Brainstorm new ideas for making faster blades. Have students record ideas on their Process Grid.

Objective(s):
Students will design pinwheel blades that will go as fast as possible.

Instructor Notes:

Activity Instructions:
1. Have students continue designing new blades and testing which blades go the fastest. Ask them to record the results in the Process Grid. Prompt them with ideas for shape and size changes if they are stuck.

2. Look at 1-2 examples of pinwheels that worked really well and ask students what they learned about “wind energy” from this engineering project. (Why did they work well?) Have them record what they learned on their Process Grid.
Next Generation Science Standards (NGSS):

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.

**Unit 3: Wind**

**Supporting Materials:**
- Post Tests
- Read lesson and gather materials

**Objective(s):**
Reflect what they’ve learned from the wind unit and how they might use what they’ve learned to test other wind experiments.

**Instructor Notes:**

**Setting the Stage:**
**Explain** today’s objective.

**Activity Instructions:**

1. Review the Process Grid with students. Ask them to think about all the projects they have done in this unit. Then ask them what worked best to make the wind work and what didn’t work. (Write ideas on their paper).

2. Use what you’ve learned. Have students draw a picture of a kite that would fly the best in the wind. What would it look like?

3. Discuss the kites, and why students think they would work. Students can take their reflection home to share what they have learned.

4. In the last 10 minutes, have students take the Post-Test. Make sure to give the correct test to the correct grade level.
UNIT 4 | SOUND 4
Before you begin the activity, please hand out the **pre-test** to each student. The pre-test has two different grade levels, make sure to use the correct one for your age group. The pre-test will help us evaluate how effective this unit is on teaching kids about the engineering method. At the end of the quarter the same test will be administered again to see how much knowledge students have gained.
Write and/or explain the 6 steps in the engineering process.

1. __________________________________________________________________________ 
   __________________________________________________________________________

2. __________________________________________________________________________ 
   __________________________________________________________________________

3. __________________________________________________________________________ 
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4. __________________________________________________________________________ 
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5. __________________________________________________________________________ 
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<table>
<thead>
<tr>
<th>Process Grid:</th>
<th>Explain what You did and learned</th>
<th>Explain Justify</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve Your Model &amp; Retest</td>
<td>Modifications</td>
<td>Operational Optimization</td>
</tr>
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<td>Test Your Model</td>
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</tr>
<tr>
<td>Create a Model</td>
<td>Assembly</td>
<td>Component Design</td>
</tr>
<tr>
<td>Brainstorm Ideas &amp; Solutions</td>
<td>Innovation</td>
<td>Invention Solution Trade-Off</td>
</tr>
<tr>
<td>What is the Problem?</td>
<td>Problem Constraints Criteria</td>
<td>?</td>
</tr>
</tbody>
</table>
Unit 4: Sound

Next Generation Science Standards (NGSS):
1-PS4-1: Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.

INTRODUCTION TO SOUND

WEEK 1
Sound Contraptions

K-5

20-30 Minutes

Supporting Materials:
- Pre and Post Tests
- Sound Vocabulary
- Sound Background Information

Materials:
- Process Grid
- 2 Slinkys
- 4 Metal Spoons or Forks
- 4 Metal Hangers
- 4 Wooden Rulers
- Set of Tuning Forks
- Small Plastic Cups
- Different sizes of Rubber Bands
- String

* Instructor needs to create a sound contraption before class and keep in kit.

Setting the Stage: 5 Minutes

Ask students:
- What do you know about sound?
- How is it made?
- How can you change sound?
- What are some different words to describe sound?

Explain the objective for the lesson:
- You will be able to figure out what makes sound by exploring the “sound contraptions”.

Show the students the Slinkys, the silverware, the hangers the rulers, and the tuning forks. Hold one of each up to your ear.

Investigation:
- Say: “Hmmm… I don’t hear anything. What should I do to make the sound?”
- Have students brainstorm ideas as a group.
- Send them off to explore the objects. Remind them to think about what happens to make the object produce sound.

Activity Instructions:

1. As students are exploring, ask them questions to extend their thinking on sound. Write on the process grid what you hear them saying. For example: Why do they sound different? What do you think caused___________? How__________?

2. Have them reflect on the sound contraptions. What caused each of them to produce sound? (If the word ‘vibration’ doesn’t come up, this is the time to introduce it.) What else did they notice about the sound contraptions? (Pitch-High/Low sounds, volume-soft/loud)
<table>
<thead>
<tr>
<th><strong>Sound Vocabulary</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Echo</strong></td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
</tr>
<tr>
<td><strong>Pitch</strong></td>
</tr>
<tr>
<td><strong>Sound Energy</strong></td>
</tr>
<tr>
<td><strong>Vibration</strong></td>
</tr>
<tr>
<td><strong>Volume</strong></td>
</tr>
<tr>
<td><strong>Wave</strong></td>
</tr>
</tbody>
</table>
Invite children to close their eyes and listen. What do they hear? How do they hear it? In this unit, they will explore sound, a kind of energy we can hear. Remind children that light and heat are other types of energy that are important to our daily lives. Sound is made when something vibrates and pushes molecules in the air to create waves. The waves travel to our ears and vibrate our eardrums, which helps us hear. Unlike light, sound waves require a medium (matter) to travel through, and they can move through solids, liquids, and gases. Sound travels faster through solids than through liquids, and more slowly still through gases. Sounds can differ in volume or pitch and they can also be absorbed or blocked by objects. An echo occurs when a sound bounces off of something and returns to its source. Remind children that sound travels slower than light, which is why they'll usually see a flash of lightening before they hear the crack of thunder; both happen at the same time, but light reaches us before the sound does. We recommend doing plenty of hands-on activities and experiments with children to help them explore, understand, and have fun with sound.

Have children place their hands on the sides of their throats and make different sounds like humming, talking, or whispering. What do they feel? Sound is made when something vibrates, or moves back and forth. Air from the lungs pass through the vocal cords and cause them to vibrate. This helps us speak. If possible, pluck a guitar string or a rubber band to show how it vibrates. When something vibrates, it pushes particles of matter and causes them to compress. That compression then creates another next to it, and these compressions travel through matter as a wave of energy. These are sound waves. The sound waves travel through the air and to our ears and cause our eardrums to vibrate, helping us hear. Have children imagine throwing a rock in the middle of a pool or pond. Small waves move away from the rock along the surface of the water. These waves are similar to how sound waves travel through the air.

Volume describes how soft or loud a sound is. Students should know that volume, or loudness, is measured in units called decibels, with rustling leaves having a decibel level of 10, while a loud concert can have a level of 120 dB or above. If possible, use a stereo to demonstrate different volumes. The waves of loud sounds have a lot of energy and can travel far. This is why you can hear a fire truck siren or a school bell without being near it. Their sound waves can travel greater distances than softer sounds. The waves of softer sounds, such as a squeaking mouse or a whisper, do not have as much energy. You have to be pretty close to the source in order to hear them.

Pitch describes how low or high a sound is. If possible, use a stringed instrument or sing to demonstrate low notes and high notes. When you play a high note on a guitar, the string vibrates quickly and the sound waves move at a fast rate. When you play a low note, the string vibrates slower and the sound waves move at a slower rate. Remind children that just because something vibrates slower, it does not mean it's softer. You can use a bass drum or a tuba to play low notes very loudly. The rate of vibration affects the pitch, but the amplitude, or height, of the sound wave determines the volume.
Sound waves need matter to move through, which means they cannot travel through a vacuum. Most of the sounds we hear travel through the air, but sounds can also travel through solids. Have children put their ear to a table and knock on the other side. They can hear the sound, and they will be also able to feel the vibration of the sound waves travelling through the wood. Sounds can also be blocked or absorbed by certain objects. Have children notice the difference in sound when a door or window is opened or closed. The door or window blocks out some of the sound waves and keeps them from reaching your ears. Earplugs are made to absorb some sound waves so they don’t reach your ears. People who work in loud environments, such as construction workers or ambulance drivers may use earplugs to protect their ears and hearing.

Sound waves can also bounce off things. An echo occurs when a sound bounces off something and returns to the source, or where it came from. Have children share experiences when they have heard echoes. Where were they? What did they say or hear? Some animals such as bats and dolphins use echoes to help them navigate and hunt. Bats emit a sound and use the echo to help find their way and look for food. Dolphins make a clicking noise that creates sound waves that bounce against surrounding objects; when the sound is reflected back, the dolphin can use it to visualize an image. This is known as echolocation.
Next Generation Science Standards (NGSS):

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

1-PS4-4: Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.

**Materials:**
- Plastic Cups
- Paper Clips
- String
- Push Pins for poking holes

**Setting the Stage:**

**Ask** students: When you talk on the phone, how does your voice travel?

**Explain** the objective for the day: Today we will be investigating how we can make sound travel through an object.

**Ask:** How can we get sound to travel from one person to another using these materials and without shouting? Students brainstorm ideas then share whole group.

**Objective (s):**
Students will determine how to make sound travel from one person to another using the materials provided.

**Activity Instructions:**
1. Let them experiment. Remind them the goal is to create something that will help sound travel from one person’s mouth to another person’s ear at a distance of over 3 feet. Help them as they work with a partner to brainstorm solutions to problems that arise. Help them test it out and encourage them to ask questions.

2. Share as a whole group what they created and how well it works. Which ones work best? Why?
Instructions on how to create a basic telephone: *(For teacher reference- not to read aloud to kids. Let them try and discover how!)*

- With the push pin, carefully poke a small hole in the bottom of each plastic cup.
- Tie the paper clip to one end of the string.
- Thread the other end of the string through the hole in the bottom of one of the cups. Be sure to thread it from the inside of the cup. The paperclip will keep the string from going all the way through the hole.
- Then thread the string through the hole in the second cup, but this time, do it from the outside of the cup.
- Tie the second paper clip to the other end of the string. The paper clip should be inside the cup, just like the first paper clip.
- Then, pull the cups so that the string is tight and have one person talk into the cup while the other person holds the cup to their ear.
Next Generation Science Standards (NGSS):

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

1-PS4-4: Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.

4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

Supporting Materials & Prep:

Phones from previous week
Read lesson and gather materials

Materials:

- Ready-Made ‘Control’ phone using instructions below as the phone design, they will all start with
- Best Cords from last week
- Paper Clips
- Plastic Cups in assorted sizes
- Styrofoam Cups
- Push Pins for poking holes

Setting the Stage: 2-5 Minutes

Ask students: Do you remember which creation helped us produce the highest volume last week? What could we see the string/wire doing as people talked? (vibrating)

Explain the objective for the day: Today we will be creating phones that are the same except for 1 thing. You will investigate which container produces the highest volume. (Show them the different containers.) Ask them to brainstorm questions they want answered about the cups. Some examples might be: Does Styrofoam work better than plastic? Does the sound change if one cup is larger than the other? What if the cups are the same size but one is different material? (Remind students to choose only 1 variable to change.) Add ideas to process chart.

Students choose a variable they want to change with their partner and make a prediction. Share whole group. Add to process chart. Remind them of how they want to pull the cords tight to produce the best vibrations.

Activity Instructions:

1. Have students get into groups of 2-3 and make a phone like the ‘control’ phone, but change one thing—that’s the variable—and test it out. Students share results with the whole group. Were their predictions close? Why did it happen that way? Add results to process grid.

2. Have each group explain which container worked best (produced the loudest volume) and why they think it worked best.

3. Reflect on what worked the best and why.

Variations/ Alternatives:

1. Have each student make a phone to take home. (Use the best cord and container type).
**Unit 4: Sound**

**WEEK 4**

**Low vs. High**

**Next Generation Science Standards (NGSS):**

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

1-PS4-4: Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.

**Supporting Materials & Prep:**
Prepare bottles with water and food coloring beforehand. The bottles should progressively have more water in them. Add a different color food coloring to each bottle. (Make sure each group’s bottles match – i.e. the least amount of water is the same color for each group.)

**Materials:**
- 4 Pop Bottles for each group
- One Metal Spoon for each group
- Water
- Food Coloring
- Tuning Forks
- Xylophone/keyboard/piano (borrow from music teacher if possible)

**Setting the Stage: 2-5 Minutes**

Ask students if they can make a high sound with their voices. Can they make a low sound with their voices? (Some students will often think this means loud and soft.) Play a high note for them and then have them try to match their voices to that note. Then play a low note and have them match their voices. Brainstorm animals that have high-pitched voices and animals that have low pitched voices.

Explain objective for the day: They will put water in each bottle and then test the bottles to make sure that each bottle makes a different sound. Then they will determine which bottle has the lowest pitch sound and continue until they have the bottles in order. When they have them in order, food coloring can be added to show each sound.

As students are participating in the investigation, the teacher should go around and listen to their conversations. Push them to use the new vocabulary (pitch, high, low, vibrations).

**Objective (s):**
How can you make these pop bottles each make a different pitch just by using water and a metal piece of silverware? (Students will fill and order their pop bottles from lowest to highest sounds [pitch].)

**Instructor Notes:**

**Activity Instructions:**

1. Once groups have put their bottles in order from lowest to highest pitch, ask them to tap the different bottles and figure out which water vibrates faster. Is it the high pitch sounds or the low pitch sounds?

2. If 2 groups finish, can they put their bottles together and add water so that they have 8 different sounds? Can they play Mary Had a Little Lamb or Twinkle, Twinkle, Little Star by adding or taking away water?

3. Reflect and chart what students learned. To add to the discussion, put the tuning forks in order, lowest to highest. Play each one for the students. (You will need to walk close to students with tuning fork for them to hear it.) Have them watch and compare the vibrations of the low notes to the high notes. How are they vibrating differently? Add to reflections.
## Unit 4: Sound

### Ordering Objects from High to Low

#### Next Generation Science Standards (NGSS):

1. **1-PS4-1**: Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.
2. **1-PS4-4**: Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.

### 2-3 Minutes

### Supporting Materials & Prep:

- Sounds Contraptions from Week 1
- Read lesson and gather materials

### Materials:

- 2 different sized Hex Nuts per partner
- 2 different sized Balloons per partner
- Other objects to put in balloons such as: Marbles, Pennies, etc.

### Setting the Stage: 5-10 Minutes

**Ask** students: What is the connection between different pitches and vibrations? How can we investigate this using balloons? Students share thoughts.

**Explain** the objective for the day: Today we will be investigating pitch and its connection to vibrations.

**Show** students how to squeeze the hex nut through the mouth of the balloon (make sure that the hex nut goes all the way into the balloon so that there is no danger of it being sucked out while blowing up the balloon).

**Blow** up the balloon, but be careful not to overinflate the balloon, as it will easily burst. (It will also burst if the object inside is spun too fast so be careful!) Tie off the balloon and you’re ready to go.

**Grip** the balloon at the stem end as you would a bowling ball. The neck of the balloon will be in your palm and your fingers and thumb will extend down the sides of the balloon.

**Ask** them to make predictions about what might happen, based on what they have been learning about in the previous weeks. Then show them how to hold the balloon, palm down, and swirl it in a circular motion. The hex nut may bounce around at first, but it will soon begin to roll around the inside of the balloon. Show them how, but don’t let them listen for too long as you want them to figure out how to do it. Once the hex nut begins to spin, use your other hand to stabilize the balloon. The hex nut should continue to spin for 10 seconds or more.

**Let** them know they are going to do this with at least 3 different objects (1 per balloon) and try and put them in order from lowest pitch to highest.

### Objective (s):

Students will design their own sound contraption that has sounds in order from high to low.

### Instructor Notes:

1. Have students work in groups of 2-3 to follow steps above. (They may need adult help to get it going.)
2. Ask students to share what happened and why they think it happened that way. Add to the process chart.
3. Further investigation if time: What happens when you change the size of the balloon?
Clock in a Bag

WEEK 6

Next Generation Science Standards (NGSS):

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

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-PS4-1: Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.

Supporting Materials & Prep:

- Wind-up Toy or Ticking Clock/Timer
- Paper Bags
- Bucket/bowl of Water
- Metal Spoons
- Paper
- Extra Supplies from Box

Setting the Stage: 2-5 Minutes

Ask students: When you talk to someone, what might keep them from hearing what you say?

Explain the objective for the day: Today we will experiment and find what material sound travels through well, and what material sound doesn’t travel through well. We will be talking about solids, liquids and gases. What is a solid? Liquid? Gas? (Have students share examples of each quickly).

Ask the students to predict if sound can move through solids, liquids and gases. Add to process chart.

Objective(s):

Students will use a tuning fork and place it on different objects in order to find out through which material sound travels best, and through which material sound doesn’t travel well.

Instructor Notes:

Activity Instructions:

1. Have the students complete the following activities, which will lead them to experiment with traveling sound waves.

2. Can sound energy travel through solids? Students place their ears on a desk or table as they tap or scratch on the top. They compare that to the same sound made when their ear is not pressed to the table.

3. Can sound energy travel through liquids? Fill a large bowl or bucket (metal works best) with water. One student taps two spoons together under the water. Two other students observe and compare the tapping sound they hear, as heard through the air and as heard by placing an ear against the bowl.

4. Can sound energy traveling through gases (air)? The students feel their throats gently during each of these tasks: Hum with your mouth and nose open. Hum with your mouth open and nose closed. Hum with your mouth closed and nose open. Hum with your mouth and nose closed.

5. Discuss with the students what happened. Were their predictions correct? Can sound travel through air, water and solids? (Answer: Yes!) Sound needs molecules to move. Solids, liquids and gases are all made of molecules. The characteristics of the molecules (for example, the space between the molecules) determine whether the sound becomes muffled or changes in some way.

6. Now, they must use what they have learned, and the materials available (paper bags, extra materials in the box) to block or muffle as much as possible the sound of a ticking timer. Have them share ideas, then work in groups of 2-3 to create something, or try out different ways to ‘block’ a sound. (If there is only 1 timer, you can have them clank 2 metal spoons together and try to muffle that noise, or something similar.)

7. Share what they discovered, and why they think it happened that way. Chart student responses on process grid.
<table>
<thead>
<tr>
<th>Sound travels well through these objects.</th>
<th>Sound does NOT travel well through these objects.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Roaring Cups

Next Generation Science Standards (NGSS):
1-PS4-1: Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.

1-PS4-4: Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.

4-PS4-1: Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.

Supporting Materials & Prep:
Read lesson and gather materials

Materials:
- 16 oz. Plastic Cups
- Push Pins
- String
- Scissors
- Toothpick
- Water
- Paper Towels
- Construction Paper
- Cardstock

Setting the Stage: 2-5 Minutes

Engagement: What is it called when you make a sound louder? (If nobody knows, explain "amplification"). Ask: How could you amplify your voice (make it louder) just by using your hands? Have students experiment.

Explain objective for today: You will be making a cup that talks (using a string, not your voice!) Your job is to amplify the sound of the string until it reaches the loudest volume possible.

Activity Instructions:
1. Here’s how we make the talking cup: Take a 16 oz plastic cup and put a hole in the bottom with a push pin.
2. Use scissors to cut about 12” of string and thread it through the hole in the plastic cup.
3. Take the end of the string that is through the inside of the cup and tie it to a toothpick. Make sure that the toothpick is tied securely to the string or the cup won’t talk.
4. Pull the end of the string that is sticking out from the bottom of the cup until the toothpick catches on the cup. Give the string a couple of short, but firm, tugs to make sure everything is secure.
5. Now – to make the cup ‘talk’. Fold a paper towel into quarters and use water to wet the towel.
6. Pinch the string with the wet towel and slide the towel down the length of the string. What is that strange noise?
7. Ask students to brainstorm alterations they can make to the apparatus to amplify its sound. (What can you do to the cup to amplify the volume of the sound of the string?)
8. Add their ideas to process grid. Try out the ideas there is time for. Push them to use the new vocabulary.
9. Reflection: Have students share their designs and decide which one amplifies the sound of the string the best. Why? (Add to process grid.)
Next Generation Science Standards (NGSS):

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

1-PS4-4: Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.*

4-PS4-1: Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.

**Objective(s):**

Students will make an instrument and find ways to change its sound.

**Materials:**

- 2 Cardboard Pieces
- 3x11” for each student
- Masking Tape
- Clear Tape
- Extra Cardboard for students to make a second

**Setting the Stage: 2-5 Minutes**

Ask students if they have ever played an instrument before. See if they know that the notes go in order from lowest to highest or highest to lowest.

Explain today’s objective: They will make an instrument and find ways to change its sound.

**Activity Instructions:**

1. Use 2 pieces of cardboard that are about 3 X 1 inch. Make sure the 2 pieces are the same size.
2. Fold a piece of masking tape over the long sides of each piece of cardboard separately. (This keeps the cardboard from getting really soggy when you put it in your mouth.)
3. Take about a foot of masking tape and wrap it around (several times) one end of one of the cardboard pieces. It should wrap around 4 or 5 times.
4. Repeat Step 3 three more times until you have wrapped both ends of both pieces of cardboard separately. The tape will make the ends thicker than the middles.
5. Cut 2 pieces of clear tape just a little shorter than your piece of cardboard. Put the sticky sides of the tape together to make a strip of clear plastic.
6. Use masking tape to tape one end of the plastic strip to the end of one piece of cardboard. Stretch the strip tight, then tape the other end down. (Don’t stretch it so tight that the cardboard bends.)
7. Put the other piece of cardboard on top. Now you have a cardboard sandwich with a strip of plastic in the middle.
8. Play your Tingler like a harmonica. Hold the taped ends of the cardboard together tight, and blow through the middle. Don’t squeeze the middle part. If you get a whistle or a hum or buzz – that’s great. Wrap a piece of tape around each end of the cardboard to tape the sandwich together.
9. If you don’t get a good noise, un-tape the plastic strip and pull it a little tighter. Move it around until you like the sound it makes, then tape everything together.
10. Now play with your Tingler. What kind of sound do you get if you blow really hard? If you tighten your lips? If you wiggle the cardboard? If you bend it a little?
11. If time, have students make a second Tingler, but changing the size of the cardboard or the size of the tape to see if they can make a Tingler that makes a different sound. Add to the Process Grid.
**Design an Instrument**

**WEEK 9**  
*Design an Instrument*

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**Next Generation Science Standards (NGSS):**

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

1-PS4-4: Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.

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.

4-PS4-1: Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.

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.

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**Materials:**
- Paper Towel Tubes
- Toilet Paper Tubes
- Wax Paper
- Rubber Bands
- Straws
- String
- Fishing Wire
- Jewelry Wire
- Construction Paper
- Masking Tape
- Clear Tape
- Paper Clips
- Styrofoam Cups
- Plastic Cups
- Jewelry Wire
- Construction Paper
- Masking Tape
- Clear Tape
- Paper Clips
- Styrofoam Cups
- Plastic Cups
- Other Materials

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**Supporting Materials & Prep:**

Read lesson and gather materials

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**Objective (s):**

Students will create an instrument that has vibrating pieces, produces high and low sounds and has a way to amplify the volume.

**Instructor Notes:**

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**Setting the Stage: 2-5 Minutes**

**Brainstorm** different instruments that students have seen before. After looking at the materials, ask them what kinds of instruments they could create using these materials?

**Explain** the objective of the day: Students need to create an instrument that uses pieces that vibrate (by using their fingers, striking or blowing on them), produces high and low sounds and has a way to amplify the volume. They should be as creative as possible!

---

**Activity Instructions:**

1. As students are creating their instrument, listen for the vocabulary that they have learned throughout the unit. Push them to use the new vocabulary.

2. Have students share their instruments. Ask them to use the new vocabulary as they describe their instrument.

3. Reflection: Have students reflect on what they learned during the sound unit. What do they want to try at home?
UNIT 5 | MECHANICAL ENGINEERING
Before you begin the activity, please hand out the pre-test to each student. The pre-test has two different grade levels, make sure to use the correct one for your age group. The pre-test will help us evaluate how effective this unit is on teaching kids about the engineering method. At the end of the quarter the same test will be administered again to see how much knowledge students have gained.
2nd-3rd Grade

Write and/or explain the 6 steps in the engineering process.

1. ___________________________________________________________________________
   ___________________________________________________________________________

2. ___________________________________________________________________________
   ___________________________________________________________________________

3. ___________________________________________________________________________
   ___________________________________________________________________________

4. ___________________________________________________________________________
   ___________________________________________________________________________

5. ___________________________________________________________________________
   ___________________________________________________________________________

6. ___________________________________________________________________________
   ___________________________________________________________________________
<table>
<thead>
<tr>
<th>Process Grid:</th>
<th>Explain what You did and learned</th>
<th>Explain Justify</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve Your Model &amp; Retest</td>
<td>Modifications</td>
<td>Operational Optimization</td>
</tr>
<tr>
<td>Test Your Model</td>
<td>Failures</td>
<td>Data</td>
</tr>
<tr>
<td>Create a Model</td>
<td>Assembly</td>
<td>Component</td>
</tr>
<tr>
<td>Brainstorm Ideas &amp; Solutions</td>
<td>Innovation</td>
<td>Invention</td>
</tr>
<tr>
<td>What is the Problem?</td>
<td>Problem</td>
<td>Constraints</td>
</tr>
</tbody>
</table>
**Next Generation Science Standards (NGSS):**

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.

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.

4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

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.

**INTRO & TOPS**

**WEEK 1**

*Tops Engineering*

**Prep & Supporting Materials:**

- Pre Tests & Post (K-5)
- Read lesson and gather materials

**Materials:**

- Process Grid
- Clay
- Pencils
- Small Paper Plates
- Paper Clips
- Stop Watches

**Setting the Stage:**

**Ask** students: “What do you know about mechanical engineering?” Write their ideas, and show them pictures of vehicles, machines, etc., and have them guess what they have in common. Mechanical engineering involves making something that has motion - deals with tools and machinery.

**Explain** the objective of the day. Show them different tops to start the thinking process.

**Objective(s):**

Design a top that spins the longest.

**Instructor Notes:**

1. **Activity Instructions:**

1. Show the students the materials. Don’t give them any details on how to design their top. Have them brainstorm with a partner what they might do. Add some of their ideas to the process grid. (K-1 – You can tell them that they need to poke the pencil through the plate to make it spin, but don’t tell them where to poke the pencil. Let them experiment with putting the pencil in different places and talking about balance with them.)


3. When students are ready, have them go to the “testing area” and time how long their top spins. Record results on sticky notes. Have them go back and redesign to make it spin longer.

4. Have them reflect on the tops. What made them spin best? What could they change next week? Does the surface that they are spinning on matter? How could they make changes to the surface?

5. Keep their tops and results for the following week.
## Week 2

### Tops Engineering

### Unit 5: Mechanical Engineering

**Next Generation Science Standards (NGSS):**

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.

### Prep & Supporting Materials:

- **Materials:**
  - Process Grid
  - Clay
  - Pencils
  - Small Paper Plates
  - Paper Clips
  - Stop Watches
  - 4-5 Pennies

- **Read lesson and gather materials**

### Objective(s):

- Design a top that spins the longest.

### Instructor Notes:

- **Activity Instructions:**
  1. Show the students the materials. Don’t give them any details on how to design their top. Have them brainstorm with a partner what they might do. Add some of their ideas to the process grid. (K-1 – You can tell them that they need to poke the pencil through the plate to make it spin, but don’t tell them where to poke the pencil. Let them experiment with putting the pencil in different places and talking about balance with them.)
  3. When students are ready, have them go to the “testing area” and time how long their top spins. Record results on sticky notes. Have them go back and redesign to make it spin longer.
  4. Have them reflect on the tops. What made them spin best? What could they change next week? Does the surface that they are spinning on matter? How could they make changes to the surface?
  5. Keep their tops and results for the following week.
  6. For Week 2, challenge them to use pennies to balance their tops. How does it change the spinning of the top?
# CATAPULTS

## WEEK 3

### Catapults

### Unit 5: Mechanical Engineering

#### Next Generation Science Standards (NGSS):

- **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.

### Prep & Supporting Materials:

**How to Build a Mini-Catapult**

**Read lesson and gather materials**

### Materials: Per Group

- 15 Newspaper Sections
- Masking Tape
- 15 Plastic Spoons
- Rubber Bands
- Marshmallows

### Setting the Stage:

**Ask** the students: “Have you ever seen a catapult? What do they do? What is their purpose? How do you think they do this?”

**Explain** the objective of the day.

**Brainstorm** which ideas they might want to try first. Where might they attach the spoon to their base? Have them brainstorm and fill their ideas in on the Process Grid.

### Objective (s):

Students will create a catapult out of materials provided that will fling a marshmallow over the wall. (Use your supply tub as the wall, if needed).

### Instructor Notes:

#### Activity Instructions:

1. Have students work in pairs or groups of 3 to create their device. Remember to NOT tell them HOW to design it! (Teacher adds to Process Grid what students are attempting under the 'Create a Model' section.)
2. When students have designed their catapult, have them test it to see if their marshmallow goes over the wall. (Maybe have 2 groups testing at a time.) Teacher adds a couple of results to Process Grid. EX: 1 catapult fell over and didn’t work. 1 catapult projected the marshmallow straight up.
3. Have them reflect on their catapult and make changes. Then retest.
4. Reflect on what worked the best and why it worked.
How to build a mini-catapult:

1. Roll newspaper section like a log.
2. Secure the log with tape.
3. Stretch a rubber band, place log on top of it.
4. Loop the two ends of the rubber band to the top of the log. Pass one end of the rubber band through the other. Hold the surplus with your finger.
5. Stick the end of spoon through surplus rubber band.
6. Adjust spoon length and tape log down. Test catapult.
Next Generation Science Standards (NGSS):

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.

### Materials:
- Normal craft sticks (popsicle sticks)
- Ruler to measure distance
- Masking Tape
- Plastic Spoons
- Wooden Clothespins
- Rubber Bands
- Marshmallows
- Use same Bases from week 1

### Objective(s):
Students will create a catapult that will fling a marshmallow the furthest.

### Instructional Notes:

**Activity Instructions:**

1. Students work on their device in their partners or group of 3. If they come across a design ‘flaw’ or problem, DON’T tell them how to fix it. Instead, ask “How could you make it go farther instead of higher this time?”

2. When students have re-designed their catapult, have them test it and mark the distance with a sticky note. Have a line designated as the starting line. Only let 2-3 groups test at a time. (Teacher adds a couple of results to Process Grid.)

3. Have them reflect on their catapult and the changes that they made to it. Have a couple of students share changes they made to overcome a problem, or what seemed to work to make their catapult fling the marshmallow furthest. (Note down their responses on the Process Grid under ‘Explain What You Did and Learned’)
Next Generation Science Standards (NGSS):

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.

**Objective(s):**

Students will design a car that will roll straight and far down a ramp.

**Instructor Notes:**

**Setting the Stage:**

**Ask** students: How does a vehicle move? How do you make it go straight? How do you make it go far? Where does the car get its energy? (Mention axles, wheels, force to make it go; today it’s the ramp)

**Explain** the objective of the day.

**Show** students a model car and have them brainstorm how they might design their own.

**Activity Instructions:**

1. Give students materials to design their own car. Show K-1 the steps to make the car, but let 2-5 design it themselves. (K-1 will work on building their cars both this week and next).
2. When students are ready, have them test out their car using a ramp. Set up a ramp for testing with a line of masking tape coming straight out from the ramp. When students are ready, they test their car and mark where it stops with a sticky note. The car that stays closest to the line and the farthest out has the best design!
3. Reflect on the car and ramp height that worked the best. Discuss why they think that worked. ( Writes on Process Grid.)
4. Keep cars for next week.
WEEK 6
Cars that Move with Sails

Next Generation Science Standards (NGSS):
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.
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.
3-5-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.

2-3
Supporting Materials:
Cars from previous week
Read lesson and gather materials

Materials:
• Cars from previous week
• Tissue Paper
• Card Stock
• Cellophane Paper
• Popsicle Sticks (4 per student)
• Clay
• Fan

Setting the Stage:
Review with students which sails caught the most wind when they made the sails for the boats during the Wind Unit. Explain that they will be making their car move by capturing the power of the wind.

Explain the objective of the day.

Write down on Process Grid their ideas of what kind of sail they will make and where they will place it on their car base.

Show them that they will use a ball of clay to attach their sail to their car platform.

Objective(s):
Students will create a car that will go the furthest using the power of the wind.

Instructor Notes:

Activity Instructions:
1. Have students choose their materials and build their sails. When their sails are ready, have them attach them to their cars.
2. Have students bring their car to the fan site and test it. Mark how far it went with a sticky note. Then ask them questions about how they could make their sail better or move it so that it goes farther.
3. Reflect on which sail captured the wind the best and where it was placed. Discuss why they think that worked. (Write on Process Grid.)
4. Keep cars for next week.
Next Generation Science Standards (NGSS):

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.

4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

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.

Materials:
- Cars from previous week
- Balloons
- Tape

Setting the Stage:
Explain the objective of the day.

Brainstorm where they might place the balloon to make the car move. How will they attach it? Will they blow it up first or attach it first?

Objective (s):
Students will create a car that will go the furthest and straightest using the power of a balloon.

Activity Instructions:
1. Have students begin experimenting with balloons to get their car to move. Prompt them to consider different spots to attach the balloon.
2. When ready to test their balloon-powered car, have students come to the testing site and test their car. (Testing site will be a starting line with a line of tape going out about 8 feet.) Have them place a sticky note where their car ended. The “best balloon car” is the one that goes out the farthest and the closest to the line.
3. Reflect on which car went the farthest and the straightest. Discuss what they think worked the best, and what didn’t work (Write on Process Grid.)
4. Keep cars for next week.
Car that Safely Transport an Egg

### Supporting Materials:
- Cars from previous week
- Eggs
- Cotton Balls
- Tissue Paper
- String
- Tape
- Paper
- Clay
- Cups
- Any left over supplies from previous weeks

### Objective(s):
Students will create a car that can safely transport an egg when it comes in contact with a wall.

### Instructor Notes:

### Activity Instructions:

1. Have students design their “egg seat” with materials of their choice.
2. When ready to test, have students test their cars. Place a ramp close to the wall and let them test and redesign their egg seat. (You may want to use something other than a real egg for initial testing).
3. Reflect on different seat designs. Have students make predictions about which seat designs will best protect the eggs. Add predictions to Process Grid.
4. Keep cars for next week with seats.
# Unit 5: Mechanical Engineering

**Testing Egg-Seats**

**Week 9**

**Next Generation Science Standards (NGSS):**

- 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.

## K-5

**30 Minutes**

**Supporting Materials:**
- Cars from previous weeks & Post Test
- Read lesson and gather materials

**Materials:**
- Cars from previous weeks
- Eggs

**Setting the Stage:**

**Explain** today’s objective.

<table>
<thead>
<tr>
<th>Activity Instructions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Test all cars. Teacher puts egg in ‘safe seat’ before letting car roll down the ramp.</td>
</tr>
<tr>
<td>2. Chart results on Process Grid. What worked well? If the egg cracked, what can they do to make it ‘safer’ or to better protect the egg?</td>
</tr>
<tr>
<td>4. Have students write/draw a reflection on their favorite project from their unit on Mechanical Engineering, or what they learned from it when they’ve finished testing their ‘egg-safe seat’. If there’s time, they can share with another student</td>
</tr>
<tr>
<td>5. In the last 5 minutes, have students fill out Post-Test.</td>
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</tbody>
</table>