UNIT 1 | ENGINEER DESIGN-IT
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.
4th-5th Grade

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

1. ______________________________________________________________
   ______________________________________________________________

2. ______________________________________________________________
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3. ______________________________________________________________
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4. ______________________________________________________________
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5. ______________________________________________________________
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6. ______________________________________________________________
   ______________________________________________________________
<table>
<thead>
<tr>
<th>Process Grid:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What is the Problem?</strong></td>
</tr>
<tr>
<td><strong>Brainstorm Ideas &amp; Solutions</strong></td>
</tr>
<tr>
<td><strong>Create a Model</strong></td>
</tr>
<tr>
<td><strong>Test Your Model</strong></td>
</tr>
<tr>
<td><strong>Improve Your Model &amp; Retest</strong></td>
</tr>
<tr>
<td><strong>Explain what You did and learned</strong></td>
</tr>
</tbody>
</table>
Balloon Blast Off! (Carrying a load)

Unit 1: Engineer Design It

Next Generation Science Standards (NGSS):

3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-3: 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:
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).

Objective(s):
Carry a small load across the room using balloons, straws, tape, and string.

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

Setting the Stage:
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 design a contraption to carry a small load across the room using balloons, straws, tape and string.

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, carrying a load (2 washers).
3. Set each group up with a chair and materials, and let them begin designing and experimenting.
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. Those who reach the wall can then extend their chairs out farther and try again!
6. 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

#### 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.

#### 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

#### Prep:

None

#### 2-3

30 Minutes

#### 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.

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.

3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-3: 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.
**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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**K-5**

**30 Minutes**

**Prep:** Read lesson and gather materials

**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.

**Objective(s):**

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

**Instructor Notes:**

**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.
WEEK 4
Boats Afloat

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.
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.
3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-3: 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

Prep:
Read lesson and gather materials

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

Instructor Notes:

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.

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.
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.
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.
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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 have to 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.

**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:**

**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.
**Paper Cup Walk 2.0**

**WEEK 6**

**Unit 1: Engineer Design It**

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

3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-3: 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:**

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**

- Variety of cups (small paper, large plastic, styrofoam, etc.)
- 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. Have them test out the different types of cups. Which cups are the strongest? Which cups are the weakest? Make sure they are recording their results on their Process Grid.
5. At the end of the lesson, discuss the results as whole group. How many cups did it take? Is there a kind of cup that can hold your weight with just one? What is it about the different sizes and materials of the different types of cups that makes some stronger than others? Have them record what they learned on their Process Grid.
# Unit 1: Engineer Design It

## ROCKING & ROLLING

### WEEK 7

**Rock-No-Roll**

## 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.
- **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.
- **3-5-ETS1-1**: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- **3-5-ETS1-3**: 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.

## 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.

## 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.

## 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 Grids.
# Unit 1: Engineer Design It

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

3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-3: 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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### 4-5

**Prep:**

Read lesson and gather materials

**Materials:**

- 2 Sheets of Newspaper per group
- Process Grid

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### 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 as high as possible without it falling down, using only 2 sheets of newspaper.

**Brainstorm** ideas of how they might fold/cut/stack the newspaper to make the tallest structure possible. Have them add their ideas to their Process Grid.

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### Activity Instructions:

1. Divide students into group of 2-3 and let them experiment and design their towers. Instructor circulates and measures the different structures. Encourage them to keep trying to make their tower taller.

2. Remind students to be careful which way they breathe or sneeze!

3. At the end of the lesson, have students share how tall their building was. How did they design it? What worked and what didn’t work? How did they redesign their tower to make it taller? Write what they learned on their Process Grid.

**Hint for adults only:** A quite simple design utilizes triangles. If you look at the structure of a building you will notice that many of the support beams are triangular.
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.

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.

3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-3: 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.

WEEK 9
Straw Bridge

2-5 30 Minutes

Prep:
Read lesson and gather materials

Objective(s):
Students will build a bridge using straws and tape that can support a toy car.

Instructor Notes:

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.
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.
4th-5th Grade

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

1. __________________________________________________________________________
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   __________________________________________________________________________

2. __________________________________________________________________________
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Statically Charged Objects

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.

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.

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.
<table>
<thead>
<tr>
<th>Object</th>
<th>Affects</th>
<th>Doesn’t Affect</th>
</tr>
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<td>Paper clips</td>
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</table>
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.

Objectives (s):

Discover how balloons with like and unlike charges interact with each other and with other materials.

Instructor Notes:

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.

Supporting Materials:

- Static Electricity Handout (2-5)
- Read lesson and gather materials
- 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.
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**

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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**Light That Bulb!**

- **Supporting Materials:** Lighting an LED With Playdough Guide (Instructor guide, not a hand out 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.

- **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 bulb? (They should get dimmer). Why did that happen?

---

**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.

---

**Instructor Notes:**

**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).**
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.

![Diagram of LED with playdough connections](image-url)
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.

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.

Objective(s):
Students will build simple switches to control the flow of electricity in a circuit.

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

WEEK 5
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:
Activity Instructions:
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)
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: __________________________________________

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

## Dough Creations

### Supporting Materials:

- Example Creations

### Materials: Per Pair

- Playdough
- Insulation Dough
- LEDs
- 9 Volt Battery with Snap Connector
- Safety Goggles
- Various materials from last week
- Photocopies of Example Creations sheet

### 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.

### Instructor Notes:

- **MAGNET CHALLENGE**

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

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**WEEK 7**

**Building a Long Circuit**

**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?
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

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.

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.

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 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: _________________________________
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-PS3-4: 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: 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

Objective(s):
Students will show what they’ve learned by creating their own parallel circuit that incorporates a switch.

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. 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.
4th-5th Grade
Write and/or explain the 6 steps in the engineering process.

1. ____________________________________________________________________________
______________________________________________________________________________

2. ____________________________________________________________________________
______________________________________________________________________________

3. ____________________________________________________________________________
______________________________________________________________________________

4. ____________________________________________________________________________
______________________________________________________________________________

5. ____________________________________________________________________________
______________________________________________________________________________

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

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**INTRO/ PAPER CUPS**

**WEEK 1**

*Paper Cups*

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**K-5**

**30 Minutes**

**Prep:**
- Pre Tests
- Read lesson and gather materials

**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?

**Objective(s):**

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

**Instructor Notes:**

**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.
Supporting Materials & Prep:
Read lesson and gather materials

Materials:
• Process Grid
• Small Paper Cups
• Box Fan

Setting the Stage:

Review Last week’s process and results. Use Process Grids from last week.

Explain the objective for the day, and that they will try to improve upon their cups from last week.

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

Activity Instructions:
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.
2. Do experiment again (same as previous week) Continue to have students add ideas and results to Process Grid.
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.
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 the 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 attache 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

Objective(s):
Students will order their pop bottles from lowest to highest sounds (pitch).

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. 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.
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.

**K-5**

**30 Minutes**

**Supporting Materials & Prep:**
Cardboard Boat from previous week
Read lesson and gather materials

**Materials:**
Same as previous week:
- Fan
- Fishing Wire
- Straws
- Tape
- Cardboard Boat
- Wax Paper
- Regular Tape
- Craft Sticks
- Cardstock

**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.
**Unit 3: Wind**

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

3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

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

### Supporting Materials & Prep:

**Cardboard Boats from previous weeks**

**Read lesson and gather materials**

**Materials:**

- 2 liter Pop Bottles partially filled with pebbles to weight down (1 for each group)
- Foam Balls (1 for each group)
- Wooden Skewers (1 per group)
- Big Note Cards (20 per group)
- Craft Sticks
- Paper Cups (1 per group)
- Tape
- Twine
- Approximately 30 Metal Washers
- 1 Fan
- Scissors

**Setting the Stage:**

**Explain** the objective of the day.

**Understand** that wind (a form of energy) does work (lifts objects). They will do this by using process to create the windmill that lifts the most washers. Through this process, they will increase their understanding of wind energy.

### Activity Instructions:

1. In groups of 4s, students will create a windmill. Take them through directions below, but don’t show them how to design the blades.
2. Have students set up the windmill and talk about how they might create the blades with their group. Each group will submit a note card with their blade design idea.
3. Let them experiment with what sort of blade can lift the most washers.
4. Collect windmills and keep for next lesson.

### How to Build a Windmill:

1. Use a skewer/scissors to poke a hole through the pop bottle about 2/3 of the way up
2. Place the dowel through the holes and fit the foam ball on the end.
3. Use the string to tie the cup onto the other end of the dowel
4. Design the windmill blades, cut them out and tape each blade to a craft stick.
5. Insert the craft sticks into the foam ball.
6. Test it out with a fan or outside in the wind.
Next Generation Science Standards (NGSS):

3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

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

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

Supporting Materials & Prep:
Pre-make pinwheel frames for K-1 students: 2 straws attached in an “x” to a pencil with a thumbtack through the eraser.

Objectives:
Students will design a windmill that can use wind energy to lift weights.

Instructor Notes:

Activity Instructions:
1. Have students continue designing blades for their windmills in their groups.
2. When a group is ready, they bring it up to test in front of fan. Count how many washers their windmill can lift. Have students mark how many washers their windmill was able to lift on their Process Grid.
3. If time, group tries to redesign to be able to lift more washers
4. At the end of lesson, have students discuss what has been worked to lift the washers and what hasn’t. Have them record their progress on their Process Grid.
5. Collect windmills and save for next lesson.
PINWHEELS/ WINDMILLS

WEEK 8
Windmills

Next Generation Science Standards (NGSS):

3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
3-5-ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

4-5 Minutes

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

Materials:
- Pinwheels from previous week
- Big Note Cards (20 per group)
- Craft Sticks (Popsicle)
- Tape
- Approximately 30 Metal Washers
- 1 Fan
- Twine
- Scissors

Setting the Stage:
Review objective and Process Grid from previous weeks.

Brainstorm new ideas for blade designs. Have them record ideas on their Process Grid.

Objective (s):
Students will design a windmill that can use wind energy to lift weights.

Instructor Notes:

Activity Instructions:
1. Have students continue designing new blades and testing which blades carry the most washers. 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 windmills 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.

Objectives(s):

Reflect what they’ve learned from the wind unit and how they might use what they’ve learned to test other wind experiments.

Materials:

- Process Grid
- Journal Paper

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.
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.
4th-5th Grade

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

1. __________________________________________________________________________
   __________________________________________________________________________

2. __________________________________________________________________________
   __________________________________________________________________________

3. __________________________________________________________________________
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4. __________________________________________________________________________
   __________________________________________________________________________

5. __________________________________________________________________________
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6. __________________________________________________________________________
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<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>
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<td>?</td>
<td>Innovation</td>
<td>Assembly</td>
<td>Failure</td>
<td>Modifications</td>
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INTRODUCTION TO SOUND

WEEK 1

Sound Contraptions

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.

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.

Objective(s):

Students will be able to explain how sound is produced.

Get kids moving by asking them a question but involving movement. For example, “If you like apples, stand up.”

Instructor Notes:

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>Sound Vocabulary</th>
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<tbody>
<tr>
<td><strong>Echo</strong></td>
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<td><strong>Frequency</strong></td>
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<td><strong>Pitch</strong></td>
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<td><strong>Sound Energy</strong></td>
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<td><strong>Vibration</strong></td>
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<td><strong>Volume</strong></td>
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<td><strong>Wave</strong></td>
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Sound Background Information

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 lightning 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.

**Objective(s):**
Students will choose 1 variable to change about the connection on their telephone that will answer a question they have about how sound travels.

**Supporting Materials:**
- Sound Vocabulary
- Sound Background Information

**Materials:**
- Plastic Cups
- Paper Clips
- Fishing Line
- String
- Push Pins for poking holes
- Wire
- Yarn

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

**Activity Instructions:**
1. Students choose a variable they want to change with their partner and make a prediction. Share variable and prediction whole group.
2. In partners or groups of 3 students 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?
3. Add results to process grid.
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.
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.

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.

TELEPHONES PART 2

WEEK 3

Telephones: The Best Sound & Speaking Piece

4-5 30 Minutes

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

Materials:
- Best cords from last week
- Paper Clips
- Plastic Cups in assorted sizes
- Push Pins for poking holes
- Styrofoam Cups

Setting the Stage: 2-5 Minutes

Ask students: Which connection helped us produce the highest volume last week?

Explain the objective for the day: Today you will investigate which container produces the highest volume.

Show students how to make a ‘control’ telephone (see lesson plans from last week or sound unit chart).

Use the connection (string/wire/cord) that they decided worked best last week. It is important that all students start with the same design, so they learn to only change 1 variable at a time.

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 change only one variable.)

Students choose a variable they want to change with their partner and make a prediction. Share whole group. Add to the process chart.

Objective (s):

Students will choose 1 variable to change on their telephones about the listening or speaking part that will answer a question they have about sound.

Instructor Notes:

Activity Instructions:

1. Students make a phone, changing the variable they chose and test it out. Students share results with the whole group. Were their predictions close? Which container seems to work the best? Why do you think it worked that way?

2. Add results 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.

Supporting Materials & Prep:

Read lesson and gather materials

Materials:

- 4 Pop Bottles for each group
- One Metal Spoon for each group
- Water
- Food Coloring
- Tuning Forks
- Xylophone/keyboard/piano (borrow from music teach 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

WEEK 5
Pitch: High & Low Buzzing Cards

Supporting Materials:
- Sounds Contraptions from Week 1
- Read lesson and gather materials

Objective (s):
Students will create a device to investigate how string length and speed affect pitch.

Materials:
- Index Cards (3x5) and Wide Rubber Band
- 2 Pencil Cap Erasers and Cradt Stick (Popsicle)
- Scissors and Stapler & Staples

Setting the Stage: 2-5 Minutes

Ask students: What do you remember about pitch vs. volume from last week? What did we learn about pitch?

Explain the objective for the day: Today we will be investigating how to change the pitch on a noisemaker that we make in groups of 2-3.

Activity Instructions:
1. Fold the index card in half (hamburger style).
2. Place the craft stick in the fold and center the index card so that equal amounts of the craft stick are poking out on either end.
3. Staple the index card to the craft stick.
4. Place the pencil cap erasers on the ends of the craft stick.
5. Use the scissors to cut a length of string or yarn 1 meter in length. Tie one end of the string to one end of the craft stick (make the tie between the eraser and the index card).
6. Stretch the rubber band over the craft stick and the pencil cap erasers, ensuring the rubber band is not twisted.
7. Twirl the Buzzing Noise Maker overhead.
8. Observations- put student answers on process grid
   - How does the pitch change when you shorten or lengthen the string?
   - What happens when you change the twirling speed of the Buzzing Noise Maker?
   - Can you twirl the Buzzing Noise Maker backwards? Why or why not?
9. If there is time to experiment further:
   - What else do you think will affect the noise that comes from the Buzzing Noise Maker? Try using different sizes of craft sticks, rubber bands, or even index cards. Is the shape we made with the index card the best shape for this experiment? Try using different shapes that you think might work better.

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.

How Does it Work: For Instructor background info only
The buzzing noise produced by your Buzzing Noise Maker is produced by the rubber band vibrating against the craft stick. The vibrations are caused by air movement around the rubber band and are maximized when the Buzzing Noise Maker is moving parallel to your twirling motion. The apparatus itself is designed so that aerodynamic drag will keep the Buzzing Noise Maker parallel to air flow. You may have noticed that the speed of your twirl directly affects the pitch of the noise made by your Buzzing Noise Maker. The faster you spin your Buzzing Noise Maker, the higher the pitch produced by the vibrating rubber band will be.
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.

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:
T-Chart
Read lesson and gather materials

Objective(s):
Students will use wind-up clock or toy and place it on different objects in order to find what material sound travels best through and what material sound doesn’t travel well through.

Instructor Notes:

Activity Instructions:
1. Hold a plastic bag of water against one of your ears. Cover your other ear with your hand. Have someone hold a ticking clock or kitchen timer against the bag of water. Listen. Keep the clock in the same place. Remove the bag of water. Listen
2. Place a block of wood between your ear and the clock. Listen. Remove the block. Listen. Do you hear the clock best through the air, the water or the wood?
3. After students discuss with partners, share whole group and chart on Process grid.
4. Place the clock 1 foot away from your ear and listen to the ticking. Have your partner hold the clock at the end of the wooden ruler. Place your ear at the other end and listen. Have your partner hold the clock at the 1 foot mark on the wall. Listen. Does sound move differently through some solids than it does through others?
5. Take the plastic cups (telephone) and hold your cup to your ear while your friend talks slowly and clearly into the other cup. Keep the string tight. How does it work? What is vibrating? How do the vibrations of your friend’s voice reach your ear? Can a third person talk and listen if another cup with a string is attached? Take the separate cup with the string and attach it to the first line. Keep all strings tight while one friend talks into one cup and the other two friends listen. Can you hear the message of the third party? How many lines could you attach? Does each addition weaken the vibrations?
6. Have groups discuss what they find. When all have done activities 1-4, and most have had a chance to experiment with different ways to connect telephones, have them share their findings, wonderings and thoughts with the whole group. Add to Process Grid.
| Sound travels well through these objects. | Sound does NOT travel well through these objects. |
### Talking Tape

#### 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.

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.

### 4-5

#### 30 Minutes

**Supporting Materials & Prep:**
Read lesson and gather materials

**Materials:**
- 16 oz Plastic Cups
- Push Pins
- Scissors
- Toothpicks
- Talking Tape
- Cardstock
- Construction Paper

**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 you voice (make it louder) just by using your hands? Have students experiment.

**Explain** objective for today: You will be making a cup with a string that talks. Your job is to amplify the sound of the string until it reaches the loudest volume possible.

**Objective (s):**
Partners will design a cup that amplifies sound to the greatest volume.

**Instructor Notes:**

**Activity Instructions:**

1. Here's how we make the talking cup: Take a 16 oz plastic cup (Solo cups in any color work great) and put a hole in the bottom with a push pins.
2. Attach Talking Tape to paperclip or toothpick like on the telephones (If Talking Tape comes with directions, use those directions to attach to the cup)
3. Follow directions about how to get the Talking Tape to talk.
4. Try making alterations to your apparatus to amplify its sound. What can you do to the cup to amplify the volume of the sound of the Talking Tape?
5. Walk around and ask students questions. (Add their ideas to process grid.) Push them to use the new vocabulary.
6. Reflection: Have students share their designs and decide which one amplifies the sound of the string the best. Why? (Add to process grid.)
**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.

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.

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**VIBRATING MUSICAL INSTRUMENTS**

**WEEK 8**

*Straw Oboe*

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**Supporting Materials & Prep:**

- Read lesson and gather materials

**Materials:**

- Large Diameter Straws (3-4 per student)
- Small Diameter Straws (1 per student)
- Scissors

**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 several straw oboes, some that make high sounds and some that make low sounds.

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**Objective(s):**

- Students will make several straw oboes, some that make high sounds and some that make low sounds.

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**Instructor Notes:**

**Activity Instructions:**

1. With your fingers, flatten one end of the straw. If it's tough plastic, it won't stay flat easily. You can slide it between your front teeth to make a sharp crease in the plastic.
2. With the scissors, cut the flattened end of the straw.
3. Put the end that you cut into your mouth and blow. If you're lucky, you'll get a sound right away.
4. If you don't get a sound, try pinching the straw between your teeth as you blow. (Don't pinch so hard you close off the straw, just flatten it a little.) You can also use your fingers to squeeze the straw flat at your lips. If you still don't get a sound, try lowering a little harder or maybe a little softer.
5. Sometimes a straw oboe will work on your first try. Sometimes you have a start over with a new straw. It's tricky, but keep trying and sooner or later you'll get a buzzing, humming sound, like a musical duck call.
6. Once you've made a straw oboe, you can experiment to change the sound it makes. Try cutting off the end of the straw. Does the length of the oboe change the note it plays? Snip little holes in a long oboe. If you use your fingers to cover and uncover the holes as you play, you can make different notes.
7. Try putting a smaller straw inside a bigger straw and moving it like a trombone. What happens to the sound?
8. Students should try to make 3-4 different oboes that make high sounds, low sounds and high and low sounds.
9. Reflect: Ask students how they think their oboe works? What is vibrating to produce sound? What did they do to make a higher sound? Lower sound?
Design an Instrument

WEEK 9
Design an Instrument

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.

K-5
30 Minutes
Supporting Materials & Prep:
Read lesson and gather materials

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
- Other Materials

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!

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:

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

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2. ____________________________________________________________________________
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3. ____________________________________________________________________________
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4. ____________________________________________________________________________
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5. ____________________________________________________________________________
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6. ____________________________________________________________________________
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## 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>?</td>
<td>Innovation</td>
<td>Assembly</td>
<td>Failure</td>
<td>Modifications</td>
<td>Explain</td>
</tr>
<tr>
<td>Constraints</td>
<td>Invention</td>
<td>Component</td>
<td>Data</td>
<td>Operational</td>
<td>Justify</td>
</tr>
<tr>
<td>Criteria</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>Prototype</td>
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<td>System</td>
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<td>Technology</td>
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</tbody>
</table>

Explain what You did and learned

Problem Constraints

Criteria

Trade-Off

Innovation

Invention

Solution

Failure

Data

Testing

Instrumentation

Modifications

Operational

Optimization

Explain

Justify
INTRO & TOPS

WEEK 1

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.
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.

K-5

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:

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.
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.

Objective(s):
Design a top that spins the longest.

Instructor Notes:

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.

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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?
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.
WEEK 4
Catapults Part 2

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:
Read lesson and gather materials

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

Setting the Stage:

Review catapults from last week. Which catapults worked? Which ones didn’t? Why?

Explain the objective of the day.

Ask students: What did we learn that would help us improve our design this week? What will happen if we change the position of the throwing arm? What will happen if we change the length of the throwing arm? (Show them how to attach the spoon to a popsicle stick to make it longer.)

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’)

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

Instructor Notes:
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:**

**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 Balloons**

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

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:**

- 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.

**Instructor Notes:**

**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.
Self-Propelled Cars

WEEK 7
Cars that Move with Rubber Bands

Next Generation Science Standards (NGSS):

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.

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

Materials:
- Cars from previous week
- Rubber Bands
- String
- Tape

Setting the Stage:
Explain today's objective.

Show students a car model with a rubber band attached to make it move.

Brainstorm ideas about how they think they might attach their rubber band and how it will work. (Add to Process Grid.)

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

Instructor Notes:

Activity Instructions:
1. Have students begin experimenting with rubber bands to get their car to move.
2. When ready to test their rubber band powered car, have students come up to the testing site and test. (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 rubber band 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.
**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.

**Supporting Materials:**
Cars from previous weeks
Read lesson and gather materials

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

**Setting the Stage:**

**Explain** today’s objective.

**Brainstorm** ideas for making a “seat” that will protect the egg and keep it from breaking when the car goes down a ramp and has contact with a wall (Add ideas to Process Grid.)

**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.
**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.

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

**Supporting Materials:**

- Cars from previous weeks & Post Test
- Read lesson and gather materials

**Setting the Stage:**

**Explain** today’s objective.

**Objective (s):**

Students test their egg safety seat by letting it go down a ramp and contact the wall.

**Instructor Notes:**

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**Activity Instructions:**

1. Test all cars. Teacher puts egg in ‘safe seat’ before letting car roll down the ramp.
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?
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.
5. In the last 5 minutes, have students fill out Post-Test.