# STEM Curriculum for the Boys & Girls Club of Worcester

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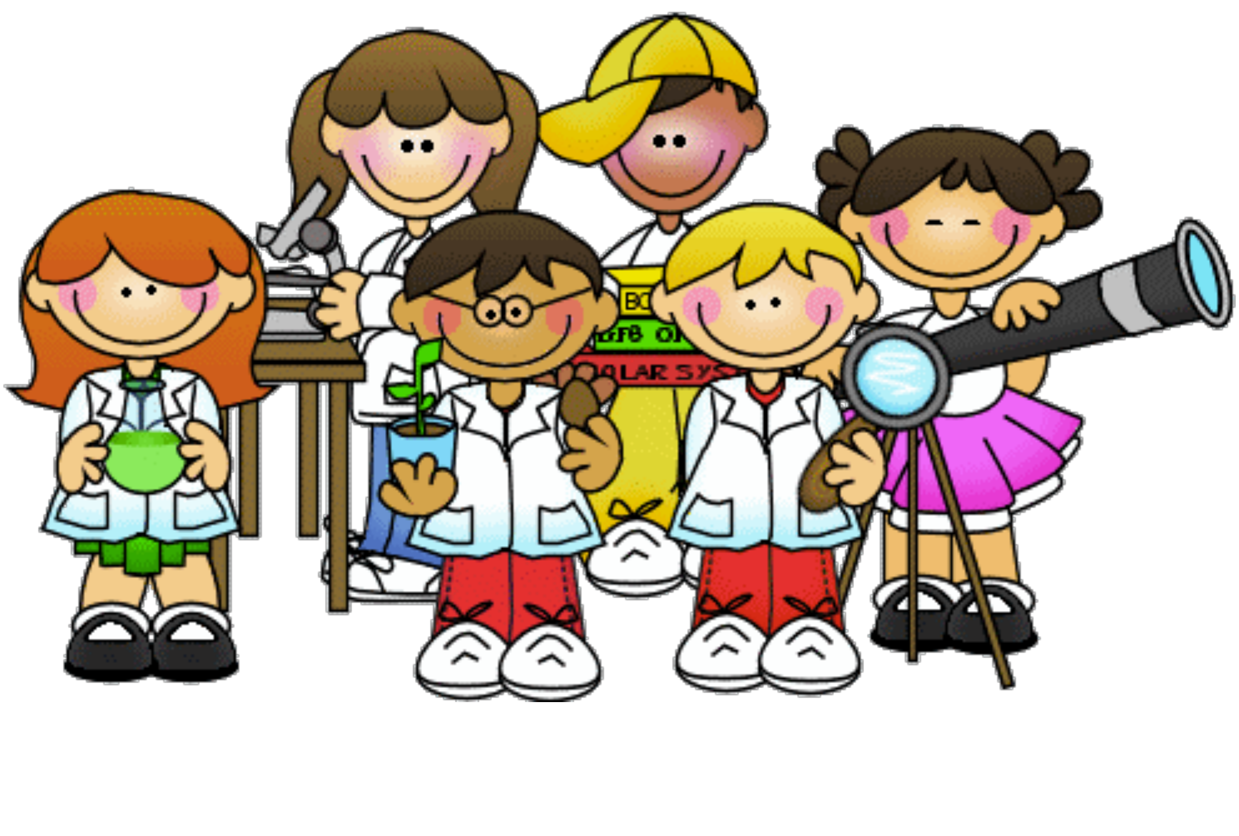
## **Introduction**

**"How to Use" STEM Curriculum:**

We created a curriculum that consists of seven core units. Each unit contains activities that are relevant to that week's topic and that coincide with Massachusetts Common Core and the Next Generation Science Standard, which were taken from the organization sites. Also, within each unit is a manual guide, including a detailed curriculum lesson plan and any necessary teacher/student quick sheets for the respective lessons. We designed teacher quick sheets for each activity that contain necessary and succinct information about the activity that the instructor can quickly review. Dependent on the lesson, we included a student reference sheet if it is necessary for them to receive additional information to help them perform the activity, beyond the teacher's instructions. The curriculum topics are placed in an order such that discussions can be built from week to week. However, we built the curriculum to be flexible to meet the needs of the classroom and the instructor, allowing the instructor to execute the curriculum in an order that best complements the classroom. Additionally, to permit flexibility, we provided back-up lessons and incorporated activity extensions in each lesson to be completed at the end of the session (if time permitted), or as a follow-up activity for the upcoming session.

# Unit 1: STEM Intro and Basics



**<u>Unit 1: Materials List</u>**

## Lesson 1: Skewer Through a Balloon

Materials:
- Latex balloons
- Bamboo cooking skewer
- Cooking oil
- Sharpie pen/marker

## Lesson 2: Several Layers Density Column

Materials:
- Light Karo Syrup
- Water
- Vegetable Oil
- Dawn dish soap (blue)
- Rubbing alcohol
- Lamp oil
- Honey
- Graduated cylinder (per group/student)
- Food coloring or True Color Coloring Tablets
- Food baster
- 9 oz. portion cups

## Lesson 3 (optional): Pop Rocks Experiment

Materials:
- Pop Rocks
- Soda in 2 liter bottles (get a variety--diet works best)
- Balloons
- Funnels
- Chip clips
- Small cups

## STEM Introduction Unit: "How does that happen?"

The purpose of these activities is to introduce the wonder behind STEM (Science, Technology, Engineering, and Mathematics) disciplines. The purpose of this unit is to ignite the interest and fascination behind STEM by including all encompassing lesson plans and discussions.

## Lesson 1: Skewer Through a Balloon

**(***Physical Science)*

Time: 20-25 minutes
Group Size: Individual

Introduction:

In this lesson we are going to do our best to get this skewer through our balloons! I want all of us to blow up our balloons and attempt to get a wooden skewer completely through the balloon. This may seem a little crazy, but we will have to test out the experiment ourselves! Before we begin we need to make our first scientific hypothesis so, do you think the balloon will pop? Or is it possible to push the skewer through and through?

Materials:

- Latex balloons (2 per student)
- Wooden cooking skewer (2 per student)
- Cooking oil (1 container per class)
- Sharpie pen/marker (1 per student)

Procedure:

1. The first step is to inflate the balloon until it's almost nearly full size and then let out about ⅓ of the air. Tie a knot at the end of the balloon. The balloon should be smaller than the length of the skewers.
2. Examine the balloon and try to find an area where you can push the skewer through
3. You can try to dip the wooden skewer into the cooking oil, which can act as a sealant.
4. Be careful not to prick yourself or the balloon with the skewer!

For the Teacher:

1. If students are unable to do the task it is likely because they are putting the skewer in the wrong way. Give students a new balloon and a marker. Have the following discussion before showing the correct way. This will assess understanding of the stress placed on the balloon.
2. Tell students to blow up the new balloon, and use the Sharpie pen/marker to draw about 10-15 dots on the balloon. The dots should be about the size of the tip of a match. Be sure to draw them at both ends and in the middle of the balloon.
3. Inflate the balloon halfway and tie at the end. Observe the various sizes of the dots all over the balloon.
    a. Where are the dots on the latex molecules stretched out the most?
    b. Where are they stretched out the least?

    c. Dip the wooden skewer in the vegetable oil and use your fingers to coat the skewer with oil.
4. Dip the wooden skewer in the vegetable oil and use your fingers to coat the skewer with oil.
5. Use the observations that you made previously about the dots on the balloon to decide the best spot to put the balloon with the skewer.
6. Have the students place the sharpened tip of the skewer on the thick end of the balloon and push the skewer into the balloon. Just use gentle pressure (and maybe a little twisting motion) to puncture the balloon.
7. Push the skewer all the way through the balloon until the tip of the skewer touches the opposite end of the balloon (other thick portion). Keep pushing until the skewer penetrates the rubber.
8. Gently remove the skewer from the balloon when you are done!

For the Student (*Can be printed or discussed):

1. Take your first balloon and blow it up as much as you can (without popping it), and release a little bit of air so that you can tie it
2. Tie the balloon at its ends
3. Take your skewer and choose a spot on the balloon to push it all the way through!
4. It's ok if you pop your first try! You will have more chances.
5. Take your second balloon from your teacher, and a marker
6. Put small marker dots all over the balloon (like the size of a tic tac)
7. Follow the teacher's instructions!

Conclusion:

There is a little secret behind being able to put the skewer through the balloon. The secret is in finding the part of the balloon where the molecules are under the least amount of stress or strain. After you all drew on the balloon with the marker, you should have been able to see where the dots were smaller and larger. The small parts were your areas of less stress, and those were found on the ends of the balloon. When the point of the skewer is positioned at the ends of the balloon, the solid object passes through the inflated balloon without popping it.

If you could see the rubber that makes up a balloon under a microscope, you would see many long strands or chains of molecules. These long strands of molecules are called *polymers*, and the polymer chains are so elastic that it allows the rubber to stretch. Even before drawing the dots on the balloon, you probably noticed that the middle of the balloon stretches more than either end. Therefore, to get it through you have to pierce the balloon at a point where the molecules are the least stretched out! However, the molecules around the holes you made that stretched around the skewer, were so tight that they were able to keep the air inside the balloon instead of rushing out.

For engineers, this a way for them to understand the stress and tension placed on certain objects. Before the begin construction, designing, or building, engineers must understand the stress of their materials to make sure they can withstand the pressure!

Objectives/Outcomes:

- Students are able to begin developing hypotheses based on previous knowledge, and test their hypotheses

- Students are able to explain to their peers the phenomena and the discussion behind it
- The discussions of polymers and tension coincide with the common core expectancies of science courses in grades 6 through 8.
- Students are encouraged to test this out at home and have their parent's perform a taste test as well.

Common Core:

- Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real world phenomena, examples, or events. (Grades 6-8)

Next Generation Science Standards:

- Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS2-2) (MS-PS2-4)

*Inspired by:* Steve Spangler Science Experiments
(http://www.stevespanglerscience.com/lab/experiments/skewer-through-balloon/)

## Lesson 2: Seven Layer Density Column

*(Chemistry and Physical Science)*

Time: 30 Minutes
Group Size: Individual (if materials permit- if not in groups of 2 students)

Introduction:
In this activity students will layer varying liquids in a column to see the varying densities.

Environmental engineers rely on their understandings of the chemical and physical properties of materials. For example, they might measure the pH level (level of acid), which is one important chemical property, especially for environmental engineers who focus on water quality. *Did you know that engineers work specifically with the water that we drink? How do they help us keep our water clean?* Then, these engineers will have to find a way to calculate the densities. To calculate density, we must measure the mass of an object and its volume. Then we divide the mass by the volume. This gives us the density of that object. We are going to use small cylinders to test out density.

I want each of you to think that you are an environmental engineer and you must test the quality of water in Indian Lake in Worcester! We have all of the contents that you can find in the lake (gross!), but we need to figure out which contents are more dense than the others!

Opening Questions:

1. *What is Density? Mass? Volume?*
2. What are some important physical properties that environmental engineers might also be concerned about? (Listen to student ideas. Possible answers: Weight, mass, area, volume, density.) We are going to focus on mass and density in today's activity.
3. How do you think we can test density of liquids? (So you can't just put it on a normal scale)
    a. *Mass/volume*

Materials:

- Light Karo Syrup
- Water
- Vegetable Oil
- Dawn dish soap (blue)
- Rubbing alcohol
- Lamp oil
- Honey
- Graduated cylinder
- Food coloring or True Color Coloring Tablets
- Food baster
- 9 oz. portion cups

For the Teacher:

- Review the procedure before the class session

- (Optional) Write out values on a whiteboard or poster so that children are able to see the density chart
- Remind the students of the exact amount (8 ounces)

Procedure:

1. Measure 8 ounces of each fluid with the food baster into individual 9 ounce cups and label each cup.
2. Color each of the liquid differently (some may already have color)
   a. May not be able to color the vegetable oil or honey
3. Start your column (in the graduate cylinder) by pouring in the honey
4. Now you will pour each liquid in slowly into the container, ONE AT A TIME
   a. IN THIS ORDER:
      i. Honey
      ii. Karo syrup
      iii. Dish soap
      iv. Water
      v. Vegetable oil
      vi. Rubbing alcohol
      vii. Lamp oil
5. Try to make sure the liquids do not touch the sides of the cylinder when you are pouring them in. (It's ok if the fluids mix a little bit, they will even themselves out)

Conclusion:

*The Science Behind it:* Even if you have the same amount (volume) of two liquids, they will likely have different weights because they have different masses. The liquids that weigh more (have a higher density) will sink below other liquids that have a lower density.

Density is basically how much "stuff" is smashed into a particular area, but you can also look at it as an object's mass and volume. Remember the all-important equation: Density = Mass divided by Volume. *Did any of you know this equation before? Why might we use this equation?* Based on this equation, if the weight (or mass) of something increases but the volume stays the same, the density has to go up. Likewise, if the mass decreases but the volume stays the same, the density has to go down. Lighter liquids (like water or rubbing alcohol) are less dense than heavy liquids (like honey or Karo syrup) and so float on top of the more dense layers.

1. *What does density mean?*
2. *Had you learned about density as Mass divided by Volume in school?*
3. *What kind of STEM professionals would have to test density?*
4. *What are objects we would test the density for?*
5. *Why do you think it is that the colors do not mix?*

Objectives/Outcome:

- Student should be able to explain the difference and relationship between mass and density.
- Students are able to take accurate measurements of mass and volume, and apply the respective values to comparison
- Relate hydrophobicity and miscibility to density (Can discuss the solubility of the solutions, and why they do not ultimately mix)

Common Core:

- Describing the nature of the attribute under investigation, including how it was measured and its units of measurement. (Grades 6 - 8)
- Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered. (Grades 6 - 8)
- Relating the choice of measures of center and variability to the shape of the data distribution and the context in which the data were gathered. (Grades 6 - 8)
- Knowledge gained from other fields of study has a direct effect on the development of technological products and systems. (Grades 6 - 8)

Next Generation Science Standards:

- Properties of Matter: Differentiate between volume and mass. Students can define density. (5-PS1-3.2.9)
- Make observations and measurements to identify materials based on their properties (5-PS1-3.)

Activity Extension:

Show or write out the following table of density values and allow the advanced students identify the densities of their materials used. Ask questions about the densities involved:

- What makes a substance 'more dense'?
- Compare substances: what is more dense, honey or vegetable oil?
- Why do the substances not mix?
  - *The substances are not soluble with each other (they don't mix)*

| Material | Density |
|---|---|
| Rubbing Alcohol | .79 |
| Lamp Oil | .80 |
| Baby Oil | .83 |
| Vegetable Oil | .92 |
| Ice Cube | .92 |
| Water | 1.00 |
| Milk | 1.03 |
| Dawn Dish Soap | 1.06 |
| Light Corn Syrup | 1.33 |
| Maple Syrup | 1.37 |
| Honey | 1.42 |

You can set up a scale and measure each of the liquids you poured into your column. Make sure that you measure the weights of equal portions of the liquid. Make your own chart!

- This will allow students to understand that density and weight are closely related, but are independent of volume.
- The densities of the liquids above are all based on manufacturer results...your chart should look different since each company uses different densities in their products (measured in g/cm3 or g/mL)
- Density= (how much stuff is in one area) compares something's mass and volume (Density=Mass/Volume)

This means that if the weight or mass of something increases (but the volume stays the same) the density will increase-- if mass decreases but volume stays the same, density will decrease

*Inspired by:* Steve Spangler Science Experiments (http://www.stevespanglerscience.com/lab/experiments/seven-layer-density-column/)

## (Optional: Expensive Unit) Lesson 3: Pop Rocks Experiment
**(***Chemistry)*

Time: 20 minutes
Group Size: Groups of 2

Introduction:

How many of you guys have had pop rocks before?! Well if you have, can you tell me what they do? THEY POP INSIDE YOUR MOUTH. In today's lesson we are going to try to understand the science behind these carbonated candies, and do an experiment involving carbon dioxide!

1. Can anyone tell me what carbonated means?
2. What is carbon dioxide? Where else might we see it?
3. Did you know there was this much science behind candy?!

Materials:

- Pop Rocks
- Soda in 2 liter bottles (get a variety--diet works best)
- Balloons
- Funnels
- Chip clips
- Small cups

Procedure:

1. Use the funnel to pour a packet of pop rocks into each balloon


2. Use the chip clip to keep the pop rocks contained in the bottom of the balloon
3. Before you put the balloon on top of the soda, ask yourself the following questions:
    a. What is going to happen to the soda?
    b. What is going to happen to the balloon?
4. Take the cap off of the soda, and carefully put the balloon around the mouth of the bottle.
5. When you are ready, release the chip clip!
    a. Shake the bottle to make the reaction happen quicker!
6. Take note of what is happening!

Conclusion:

*The Science behind it:* In each little pop rock there is a packed in amount of pressurized carbon dioxide gas. The gas is the bubbles which make the popping sound, when they burst free from their candy shells! Take a large pop rock and use a spoon to break it against a table, you should be able to hear the rock 'POP', like on your tongue.

So what causes the balloon to inflate? The CO2 (carbon dioxide) in the candy is not enough gas to cause the balloon to inflate so what is doing it? The soda you are mixing it with also contains pressurized carbon dioxide gas (that's why it is called carbonated soda). When the candy and the soda mix, the carbon dioxide wants to escape from mixing with the high fructose corn syrup in the soda and can only travel up--to the balloon!

Common Core:

- Knowledge gained from other fields of study has a direct effect on the development of technological products and systems. (Grades 6 - 8)

Next Generation Science Standards:

- A system of objects may also contain stored (potential) energy, depending on their relative positions. (MS-PS3-2)
- Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems. (MS-PS3-2)

*Inspired by:* Steve Spangler Science Experiments

# Seven Layer Density Column Teacher Quick Sheet

Opening Discussion:

In this activity students will layer varying liquids in a column to see the varying densities.

Environmental engineers rely on their understandings of chemical and physical properties of materials. For example, they might measure the pH level (level of acid), which is one important chemical property, especially for environmental engineers who focus on water quality. *Did you know that engineers work specifically with the water that we drink? How do they help us keep our water clean?* Then, these engineers will have to find a way to calculate the densities. To calculate density, we must measure the mass of an object and its volume. Then we divide the mass by the volume. This gives us the density of that object. We are going to use small cylinders to test out density.

I want each of you to think that you are an environmental engineering and you must test the quality of water in Indian Lake in Worcester! We have all of the contents that you can find in the lake (gross!), but we need to figure out which contents are more dense than the others!

Procedure (To be explain to students):

1. Measure 8 ounces of each fluid with the food baster into individual 9 ounce cups and label each cup.
2. Color each of the liquid differently (some may already have color)
   a. May not be able to color the vegetable oil or honey
3. Start your column (in the graduate cylinder) by pouring in the honey
4. Now you will pour each liquid in slowly into the container, ONE AT A TIME
   a. IN THIS ORDER *(*Write the order of the fluids on the board):*
      i. Honey
      ii. Karo syrup
      iii. Dish soap
      iv. Water
      v. Vegetable oil
      vi. Rubbing alcohol
      vii. Lamp oil
5. Try to make sure the liquids do not touch the sides of the cylinder when you are pouring them in
   a. It's ok if the fluids mix a little bit, they will even themselves out

Materials:

- Light Karo Syrup
- Water
- Vegetable Oil
- Dawn dish soap (blue)
- Rubbing alcohol
- Lamp oil
- Honey
- Graduated cylinder
- Food coloring or True Color Coloring Tablets
- Food baster (to dispense fluids)
- 9 oz. portion cups

Closing Discussion/Questions:

1. What does density mean?
2. Had you learned about density as Mass divided by Volume in school?

3. What kind of STEM professionals would have to test density?
4. What are objects we would test the density for?
5. Why do you think it is that the colors do not mix?

*The Science Behind it:* Even if you have the same amount (volume) of two liquids, they will likely have different weights because they have different masses. The liquids that weigh more (have a higher density) will sink below other liquids that have a lower density.

Density = Mass divided by Volume. *Did any of you know this equation before? Why might we use this equation?* Based on this equation, if the weight (or mass) of something increases but the volume stays the same, the density has to go up. If the mass decreases but the volume stays the same, the density has to go down. Lighter liquids (like water or rubbing alcohol) are less dense than heavy liquids (like honey or Karo syrup) and so float on top of the more dense layers.

# (Optional) Pop Rocks Experiment Teacher Quick Sheet

<u>Introduction Discussion:</u>
How many of you guys have had pop rocks before?! Well if you have, can you tell me what they do? THEY POP INSIDE YOUR MOUTH. In today's lesson we are going to try to understand the science behind these carbonated candies, and do an experiment involving carbon dioxide!

1. Can anyone tell me what carbonated means?
2. What is carbon dioxide? Where else might we see it?
3. Did you know there was this much science behind candy?!

<u>Materials</u>:

- Pop Rocks
- Soda in 2 liter bottles (get a variety--diet works best)
- Balloons
- Funnels
- Chip clips
- Small cups

<u>Procedure:</u>

1. Use the funnel to pour a packet of pop rocks into each balloon

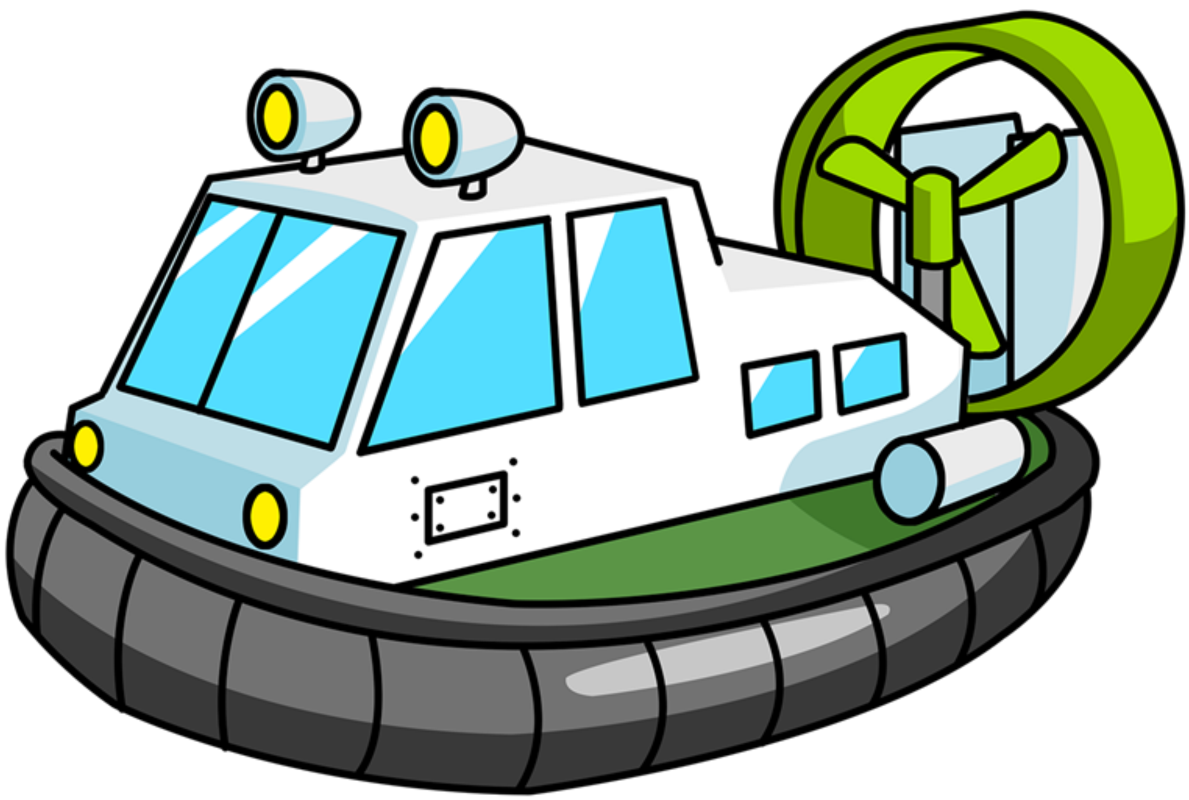

2. Use the chip clip to keep the pop rocks contained in the bottom of the balloon
3. Take the cap off of the soda, and carefully put the balloon around the mouth of the bottle.
4. When you are ready, release the chip clip! (Shake the bottle to make the reaction happen quicker!

<u>Concluding Discussion/Questions:</u>

1. Why did the balloon inflate?
2. What would happen if we used less pop rocks?
3. What if we used a smaller container of soda?

*Begin a class discussion and allow students to compare ideas on $CO_2$ and the carbonation within soda
*The Science behind it:* In each little pop rock there is a packed in amount of pressurized carbon dioxide gas. The gas is the bubbles which make the popping sound, when they burst free from their candy shells! Take a large pop rock and use a spoon to break it against a table, you should be able to hear the rock 'POP', like on your tongue. So what causes the balloon to inflate? The CO2 (carbon dioxide) in the candy is not enough gas to cause the balloon to inflate so what is doing it? The soda you are mixing it with also contains pressurized carbon dioxide gas (that's why it is called carbonated soda). When the candy and the soda mix, the carbon dioxide wants to escape from mixing with the high fructose corn syrup in the soda and can only travel up--to the balloon!

# Unit 2: Activities in Motion



**Unit 2: Materials List**

## Lesson 1: Hovercraft Racers

Materials:

- 1 CD (per student/group)
- 1 regular soda/water bottle cap (per student/group)
- 1 soda/water bottle cap with closeable nipple (per student/group)
- 1 large balloon (per student/group)
- Drill (to put holes in the caps)
- Hot-glue gun
- Meter stick(s)
- Stopwatch

## Lesson 2: Balloon Launcher

Materials:

- Plastic straws
- Plastic bags (grocery bags)
- Paper Streamers
- 25 ft. of thick fishing line (per group/student)
- Long, tube-shaped balloons
- Tape measure or meter stick

## Lesson 1: Hovercraft Racer

*(Physical sciences and engineering)*

Students will learn through a hands-on activity how friction impacts motion. They will do so through the creation of hovercrafts that use air to levitate a CD. Students will learn from this how the air underneath an object reduces friction while it is in motion.

Time: 45 Minutes
Group Size: Individual

Introduction:

"*Friction"* is a force that happens when things rub against each other. Friction is also something that can slow things down. Different objects have different amount of friction when they rub together; however, when surfaces do not rub against each other, there is no friction between them. So, to reduce friction, objects can't touch! For example, boat engineers and builders know that friction between a boat and water is something that slows the boat down. Over the years, they have been figuring out ways to design boats so that they do not touch water very much, but still float. In 1877, an engineer named Sir. John Thornycroft came up with a method to design boats to ride on a cushion of air. Basically, he used a large fan and motor to force air underneath of the craft! Eventually, the air pressure was large enough to lift the vehicle off the surface.

Engineers starting designing "flying boats" and other airplanes that can lift off of a water surface. In 1955, another engineer named Christopher Cockerell tested out a new vehicle called the hovercraft. This would be a vehicle that can travel on practically any surface. Even Ford Motor Company tried to make a "hovercar" called the Glideair in 1959. Now, hovercrafts are used for rescue work on rapidly moving rivers and thin ice, cargo transport and ferrying work), and by the military to transport troops and equipment from boats to the shore.

In this activity, we need your help! We have been stranded on a small island on Lake Quinsigamond. We must find a way to get our note across the large body of water. We are going to build our own model hovercraft to learn why suspending something on a cushion of air might help it slide over certain surfaces. Then, we will be able to test our idea to see how far we would make it!

Opening Discussion Questions:

1. How do objects move together without having friction?
   a. *If they are not touching*
2. Why does the hovercraft move differently on different surfaces? (test on all surfaces)
   a. *On the carpet there isn't enough resistance to hold up the CDs, it moves better with smoother surfaces*
3. Why did we put different amounts of holes? How many holes did yours have?
   a. *With more holes, air escapes faster so the CD glides better*
   b. *With one hole the air escapes slower making the racer last longer…to win races!*

Materials: (highly recommended to buy additional material)

- 1 CD for each student/group
- 1 regular soda/water bottle cap for each student/group
- 1 soda/water bottle cap with closeable nipple for each student/group

- 1 large balloon for each student/group
- Drill (to put holes in the caps)
- Hot-glue gun
- Meter stick(s)
- Stopwatch

For the Teacher (Before Prep):

1. Gather supplies, but ask students to bring in their own CDs
2. Prepare the materials—use a saw to cut the tops of the bottles at the neck. Save the top and cap. Drill 1-3 holes in each bottle cap with a different number in each cap. This is so that students can compare with other students who had different holes. (Suggestion: Take the bottle caps off before sawing off the caps)
3. **With students:** discuss friction. Ask them about forms of transportation they know about that deal with friction.

Procedure:

1. Have the students grab one bottle cap with 1-3 holes drilled. Be sure some students have one with one hole, some have a bottle cap with two holes, and some have a bottle cap with three holes.
2. Have the students carefully use the hot glue gun to attach the caps to each side of the CDs, with the holes in the caps centered over the holes in the middle of the CDs as shown below. Be sure to completely seal the space between the cap and CD.
3. Let the glue cool for a few minutes. Have students blow up their balloons, then pinch the neck so that air doesn't escape while attaching the balloon to the bottle cap so it looks like the picture below. Make sure the nipple is closed before releasing the balloon.
4. Place the hovercraft racer on a smooth, flat surface (i.e. floor) and open the nipple. Tap the sides of the racer, and see how it glides over the surface.
5. Have the students tap their hovercrafts down the length of a meter stick and use a stopwatch make note of the time it takes to travel a certain distance.
6. Calculate the velocity to see which student's hovercraft went the fastest.

Conclusion Discussion Topics:

1. Have the students brainstorm and discuss in their groups—encourage all ideas to be heard and creative.
2. Ask them if they can think of ways (no matter how crazy) to improve their design? If not, what are ways to keep the air flowing since a balloon ends so quickly.
3. What changes would you make if you needed to have a hovercraft carry heavy cargo?
    a. *(If they don't answer) How much would the balloons hold? How would you carry cargo?*

Outcome/Objectives:

1. Students gain an understanding of friction and how it slows objects down and acts as a way of controlling motion.
2. Understand how and why a hovercraft floats
3. Students are able to predict and hypothesize surfaces that may influence friction based on problem solving techniques.

4. Students recognize that friction is understood by engineers and is used to understand how to control the motion of certain objects.

Common Core Standards:

- Brainstorming as a group problem solving design is a way for each student to express their ideas (Grades 6-8)
- Transportation vehicles are made of subsystems such as structural propulsion, suspension, guidance, control, and support, that must function together as a system to work effectively (Grades 6-8)
- Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields (Grades 9-12)
- Designs are continually checked and critiqued, and the ideas of the design are refined and improved (Grades 9-12)

Next Generation Science Standards:

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
- Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success (MS-ETS1-3)
- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). (MS-PS2-1)
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2)
- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (MS-PS2-2)

Activity Extension:

For students that have moved forward with their construction, encourage them to begin racing each other. Lay out pieces of tape so that children may race from one end of the room to the other. By comparing the number of holes, students may want to transform their hovercraft to become the optimal racer. Encourage students to use materials around the room to boost their hovercraft design!

*Inspired by:* eGFI Teacher Resources (http://teachers.egfi-k12.org/hovercraft-racers/)

## Lesson 2: Balloon Launcher

*(Aerodynamics and Newton's Three Laws of Motion)*

Time duration of lesson: 1 hour
Group Size: 2 students per group

Introduction:

So just like the hovercraft activity, we are going to move on to another activity that involves motion. We are going to test just how much pressure we can get from the air being pushed out of the balloon.

Engineers of all disciplines use their understanding of Newton's laws of motion to quantify the "invisible" forces acting on all objects. *Have any of you heard of Newton's Laws? Who can tell me what gravity is?* Many of you have hear about satellites, and many even how sometimes they are pulled out of orbit when the forces become too weak. To keep them something in orbit, engineers look at Newton's second law! They have created inventions such as thrusters that burn fuel and boost the rocket forward! So, this means they create extra boosters to push the shuttle farther when it is falling out of orbit!

(*For the Teacher): Give a demonstration: if you can, get a skateboard or something on wheels you can stand on. Grab a basketball and try to throw it to someone else. Have the students see what happens? This will show the students that when you roll backwards you are really being propelled from forces in the opposite direction. This activity demonstrates all three of Newton's laws of motion. The air pushing out of the balloon cause an equal reaction and force, causing movement. The more air initially in the balloon, the further the balloon travels along the string because the action force is greater. Similarly, if there is only a small amount of air initially in the balloon, the balloon travels a shorter distance.

We are going to test out the most creative ways we could pass information (attached to our balloons) from one point to another! Your friend is in the room next to you and you need to get them some information—write the message on your balloon when you are ready, and let it fly!

**Law #1: Objects at rest will stay at rest, and objects in motion will stay in motion in a straight line unless they are acted upon by an unbalanced force. (law of inertia)**

**Law #2: Force is equal to mass multiplied by acceleration. (F = ma)**

***Law #3: For every action, there is always an opposite and equal reaction.**

Opening Discussion Points/ Questions (if necessary):

- Have any of you heard about Newton's Laws?
- What are some of the objects/transportation devices NASA has sent into space?
- Why would we have to worry about gravity?
- What is the purpose of the thrusters?

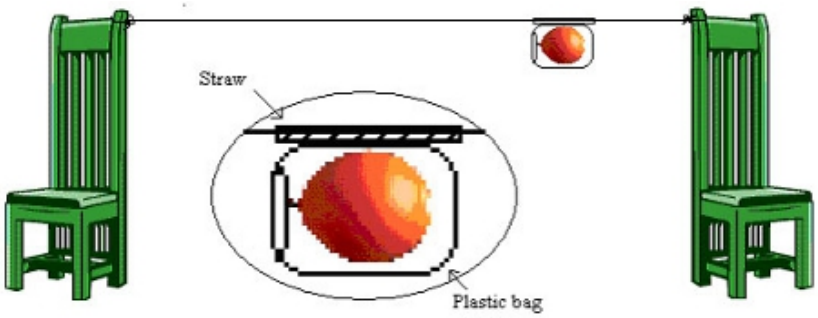
Materials:

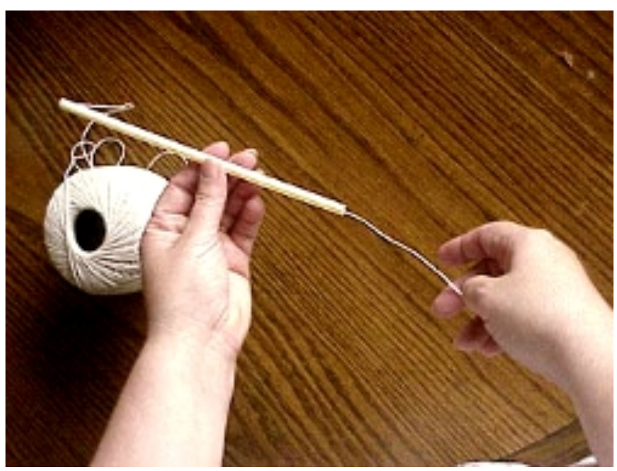
- Plastic straws
- Plastic bags (grocery bags)

- Paper Streamers
- 25 ft. of thick fishing line
- Long, tube-shaped balloons
- Tape measure or meter stick

For the Teacher Procedure:

- This will be the set-up of the activity so make sure there are enough chairs or locations where the string may be tied
- Have students vote on which of Newton's three laws of motion applies to the flight of rockets. Tabulate votes on the board. (Answer: Trick question! All three laws apply.)
- Once completed: Have students measure the distance their balloon rocket traveled on the string and complete the worksheet if necessary.
- Allow students to discuss with each other and race their balloons as an extension



Procedure (For the Student):

1. Tape a drinking straw along the side of a plastic bag (see diagram) *can also just tape balloon to straw*
2. Tape streamers along the open edge of the plastic bag.
3. Thread the string through the straw.
4. Tie each end of the string to a chair, and pull the chairs apart so that the string is tight (see diagram).
5. Position the bag at one end of the string, with the open end of the bag facing toward the chair.
6. Blow up a balloon and put it into the bag, holding the balloon closed.

7. Countdown to zero, and let go of the balloon!
8. Continue testing this with balloons blown up the different sizes (small-large)

Conclusion/ Closing Discussion Points:

- What did we learn about forces and gravity?
- Who can tell me one of Newton's Laws that we experimented today?
- Wrap up the lesson with insight on the applied STEM topics and pull out any topics or interest the students encountered.

Rockets and rocket-propelled flight has been in use for more than 2,000 years. People in ancient China used gunpowder to make fireworks and rockets; anything that would act as a booster! Now, aerospace engineers have gained enough knowledge to make rockets fly farther, faster, higher and more accurately. To understand how rockets work with gravity we look at Sir Isaac Newton's three laws of motion. It is important for engineers to understand Newton's laws because they not only describe how rockets work, they explain how everything that moves or stays still works!

Activity Extension:

- Tape pennies to the outside of the rocket to increase the mass. How does increased mass affect the flight of the rocket? (Answer: Because of Newton's second law, the same force exerted upon a larger mass will result in a lower acceleration – the rocket will not go as far!)
- See possible worksheet below

Objectives/Outcomes:

- Understand practical applications of Newton's Laws of Motion
- Students can use the model of the balloon to understand the different forces that may be applied to space travel
- Students can collect data from their experimental trials

Common Core:

- Science as Inquiry: Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation. (Grades 6-8)
- Science and Technology Standard: Collect data about the performance of a proposed object, tool, process, or system under a range of conditions. (Grades 6-8)

Next Generation Science Standards:

- Motions and Forces (4-8) For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). (MS-PS2-1)
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2)

- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (MSPS2-2)

*Inspired by:* eGFI Teacher Resources (http://teachers.egfi-k12.org/balloonautics/)

Activity Extension Worksheet:

*Team Name:* ________________________________________ *Date:* ____________________

*Worksheet Action-Reaction!*

1. What is Newton's first law of motion and give an example from the experiment?

2. What is Newton's second law of motion and give an example from the experiment?

3. What is Newton's third law of motion and give an example from the experiment?

4. Draw a picture of your "Rocket." Label the where there are forces!

# Hovercraft Teacher Quick Sheet

Objective: Objective: Students will be building small hovercrafts, and gain understanding on the impact of friction as well as recognition of problem-solving techniques used in the engineering disciplines.

Materials:

- 1 CD for each student
- 1 water/soda bottle cap with a nipple for each student
- 1 water/soda bottle cap without a nipple for each student
- 1 large balloon for each student
- Hot glue gun
- Meter stick(s)

Preparation:

Before the activity, drill one, two, or three holes into each bottle cap. Be sure some bottle caps have one hole, some have two, and some have three. When passing out the caps to the students, make sure there are an even number distributed. (Suggestion: Take the bottle caps off before sawing off the caps)

Opening Discussion:

1. How do objects move together without having friction?
    a. *If they are not touching*
2. Why does the hovercraft move differently on different surfaces? (test on all surfaces)
    a. *On the carpet there isn't enough resistance to hold up the CDs, it moves better with smoother surfaces*
3. Why did we put different amounts of holes? How many holes did yours have?
    a. *With more holes, air escapes faster so the CD glides better*
    b. *With one hole the air escapes slower making the racer last longer…to win races!*

Procedure:

1. Have each student grab a bottle cap, varying who gets bottle caps with 1, 2, or 3 holes.
2. Assist the students as they glue the bottle caps to THE SHINEY SIDE OF THE CD.
3. Have the students blow up their balloons and pinch the bottoms as they attach the balloons to the caps
4. Release the pinched fingers and tap around the hovercraft to observe how it moves.
5. Have the students tap their hovercrafts down the length of a meter stick and use the stopwatch to note the time it took to travel a certain distance.
6. Have each student calculate the velocity of their hovercraft to see who's went the fastest.

Closer:

Discuss ways to improve the design. Have the students discuss: what difference the holes make? Talk about how this can be applied to the real world - are hovercrafts a viable mode of transportation for the future?

## Balloon Launcher Teacher Quick Sheet:

Objectives:

Students understand practical applications of Newton's Laws of Motion, and can use the model of the balloon to understand the different forces that may be applied to space travel, and collect information from their experiment.

Opening Discussion:

- Have any of you heard about Newton's Laws?
- What are some of the objects/transportation devices NASA has sent into space?
- Why would we have to worry about gravity?
- What is the purpose of the thrusters?

Materials:

- Plastic straws
- Plastic bags (grocery bags)
- Paper Streamers
- 25 ft. of thick fishing line
- Long, tube-shaped balloons
- Tape measure or meter stick

Preparation:

- This will be the set-up of the activity so make sure there are enough chairs or locations where the string may be tied
- Have students vote on which of Newton's three laws of motion applies to the flight of rockets. Tabulate votes on the board. (Answer: Trick question! All three laws apply.)
- Once completed: Have students measure the distance their balloon rocket traveled on the string and complete the worksheet if necessary. Allow students to discuss with each other and race their balloons as an extension

Procedure:

1. Tape a drinking straw along the side of a plastic bag (see diagram) *can also just tape balloon to straw*
2. Tape streamers along the open edge of the plastic bag.
3. Thread the string through the straw.
4. Tie each end of the string to a chair, and pull the chairs apart so that the string is tight (see diagram).
5. Position the bag at one end of the string, with the open end of the bag facing toward the chair
6. Blow up a balloon and put it into the bag, holding the balloon closed.
7. Countdown to zero, and let go of the balloon!
8. Continue testing this with balloons blown up the different sizes (small-large)

Closing Discussion Points:

- What did we learn about forces and gravity?
- Who can tell me one of Newton's Laws that we experimented today?
- Wrap up the lesson with insight on the applied STEM topics and pull out any topics or interest the students encountered.

# Unit 3: Activities in Engineering

## Unit 3: Materials List

### Lesson 1: Marshmallow Design Challenge

Materials:
- Scissors
- 20 pieces of uncooked spaghetti (regular, not angel hair, or thin)
- 3 ft. of string that can be easily cut/broken
- 1 fresh marshmallow (not stale, mini, or jumbo)
- 3 ft. of masking tape
- Paper bag (standard lunch size)

(*Note*: this is a list of materials per group)

### Lesson 2: Bridge Building

Materials:
- Safety scissors (for cutting stringers)
- Masking tape (optional, for attaching stringers to deck)
- Stapler with staples (optional, for attaching stringers to deck)
- 3-5 pound weights
- Two 15-foot pieces of rope (for cables)
- One 50-foot piece of string (for stringers/hangers)
- One 6-foot by 4-inch piece of cardboard (deck)
- 6 chairs (2 for each tower and 2 for anchors)

(*Note*: this is a list of materials per group)

## <u>Lesson 1: Marshmallow Design Challenge</u>

(*Engineering)*

<u>Time:</u> 30 minutes
<u>Groups</u>: 2 students per group (3 groups)

<u>Introduction:</u>

This is an exercise that involves simple lessons of collaboration, scientific assumptions, and creative engineering processes. Lessons will emerge especially once the students are able to compare as teams. Encourage students to talk with their teammates about techniques and design strategies.

Students will be timed during this activity to see who can build the tallest free-standing noodle structure that can support a marshmallow. This will teach students to learn as engineers through collaborating to design, test, and improve ideas as a team as well as examining the creative process of the final product. A project such as this could be related to the work of an architect or civil engineer. Both active subsets of the engineering profession that contribute to overall topic of STEM!

The city of Worcester has gotten the attention of the Boys & Girls Club and needs help from their members. Students will have 10 minutes to brainstorm and 18 minutes to construct a freestanding building. We want to petition for our building to be put in downtown Worcester, but only one design can be chosen! Let's see who can build the tallest freestanding structure with a teammate that can hold up the weight of a marshmallow.

<u>Materials</u>:

*All items should be placed in a paper bag so students cannot see before starting the brainstorm period

- Scissors
- 20 pieces of uncooked spaghetti (regular, not angel hair, or thin)
- 3 ft. of string that can be easily cut/broken
- 1 fresh marshmallow (not stale, mini, or jumbo)
- 3 ft. of masking tape
- Paper bags (standard lunch size)
- For the contest—measuring tape

<u>For the Teacher:</u>

1. Create a 'marshmallow challenge kit' that contains all of your materials in a paper lunch bag so students are unable to see materials until they begin.
2. Display the countdown clock somewhere for all students to see (i.e Computer)
3. Go through and carefully explain the rules numerous times and reinforce them by projecting them on a screen or somewhere students can see them.

<u>Rules:</u>

- Build the tallest *freestanding* structure—the winning team is the one that has the tallest structure (measured by measuring stick). It will be measured from tabletop surface to the top of the marshmallow

- The ENTIRE marshmallow must be on the top—this means you cannot cut or eat any of the marshmallow or your team will be disqualified
- Use as much or as little of the kit (this does not matter; you just cannot use the paper bag)
- Teams are free to break the spaghetti or cut up the tape and string
- The challenge is ONLY 18 minutes and will be forced to stop when the time is up

Contest Rules:
*Challenge—build the tallest freestanding structure in just 18 minutes using nothing more than 20 sticks of spaghetti, one yard of tape, one yard of string, and one marshmallow. The marshmallow must be on top and cannot be deformed to hold it in place. The structure has to stand firmly on its own; it cannot be propped up, held, or suspended from the ceiling.

Outcomes/Objectives:
1. Understanding the importance of teamwork as well as failure that is present in science and engineering
2. Understanding the strength of shapes as well as understanding weaker materials can be made strong with specific techniques involving mass distribution.
3. Further understanding that compression and tension affect the stability of a structure
4. Compare models with other students to understand why some models are stronger than other but that many ways work in the end.
5. Understanding why engineers have to consider tension, compression, and other forces when designing buildings and structures.

Common Core
- Make two-dimensional and three-dimensional representations of a designed solution model (Grades 6-8)
- Structures rest on a foundation (Grades 6-8)
- Communicate the process of technological design. Students should review their work and identify the stages of problem identification, solution design, implementation, and evaluation. (Grade 6-8)
- Evaluate completed technological designs or products (Grade 6-8)
- Student understands that technological designs have constraints (Grade 6-8)

Next Generation Science Standards:
- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (secondary to MS-PS3-3)

*Inspired by:* eGFI Teacher Resources (http://teachers.egfi-k12.org/marshmallow-design-challenge/)

## Lesson 2: Suspension Bridge Building

(*Engineering, Forces)*

Time: 1 hour
Groups: Two groups of 3 OR three groups of 2 (groups can be different or same as marshmallow challenge; at instructor's discretion)

Introduction:

Bridges are structures which carry people and vehicles across natural or man-made obstacles. There are many types of bridges. Based on the length of the barrier to be crossed, the amount and type of traffic as well as forces of nature (wind, tide, flood) different materials and shapes of bridges are used.

In this lesson, your team has been tasked with building a bridge across Lake Quinsigamond. For this task, you will be building the strongest of all the bridge structures - a suspension bridge. Since this bridge will be regularly used, it must withstand substantial weight. Once each group has completed their bridge, the integrity of the structure will be tested by placing weights on the bridge. Whose bridge will hold more weight?

Materials:

- Safety scissors
- Masking tape
- Stapler & staples
- 3-5 pound weights (or anything that estimates that weight)
- Two 15-foot pieces of rope
- One 50-foot piece of string (per team)
- One 6-foot by 4-inch piece of cardboard (this will be the deck for each team)
- 6 chairs (per team)

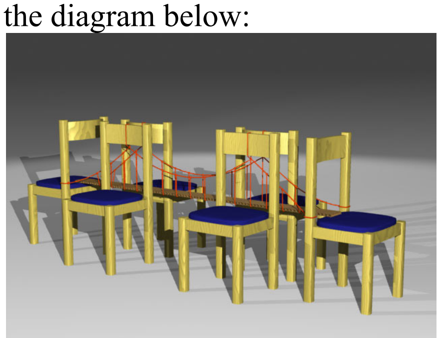
(*Note*: this is a list of materials per team)

For the teacher:

- To assist the students, practice constructing the bridge prior to the lesson

Procedure (For the Student):

- Arrange six chairs as in the diagram below:



- You and your teammates must figure out how to build the bridge. You are not allowed to anchor the deck, only the cables.

- Test your bridge by putting the weights in several different locations on the bridge. If your bridge supports the weight, congratulations!
- If you have extra time, put the weight in the middle of the bridge and start cutting the cables until the bridge collapses.

Conclusion/ Closing Discussion Points:

- What questions can we relate to the marshmallow design challenge?
- Would you make changes in your design process?

Objectives/Outcomes:

- Students build a model of a suspension bridge and test the amount of weight it will support.
- Students will learn materials can be positioned in specific patterns to form a stronger structure.

Common Core:

- Understanding that structures rest on a foundation (Grades 6-8)
- Communicate the process of technological design. Students should review their work and identify the stages of problem identification, solution design, implementation, and evaluation. (Grade 6-8)
- Evaluate completed technological designs or products (Grade 6-8)
- Student understands that technological designs have constraints (Grade 6-8)

Next Generation Science Standards:

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3), (MS-PS2- 5)
- Apply scientific ideas or principles to design an object, tool, process or system. (MS-PS2-1)
- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). (MS-PS2-1)

Activity Extension:

For students that complete the task early, have them use their craft sticks to construct more. Never let their ideas fade; encourage students who have completed their structures to change the design. This will allow them to continue constructing but consult other techniques.

*Inspired by:* eGFI Teacher Resources (http://teachers.egfi-k12.org/lesson-bridge-swe/)

## Marshmallow Design Teacher Quick Sheet:

Introduction:

This is an exercise that involves simple lessons of collaboration, scientific assumptions, and creative engineering processes. Lessons will emerge once you have the students discuss their buildings. *Why did some stand freely while other fell? What techniques work best?*

Students will be timed during this activity to see who can build the tallest free-standing noodle structure that can support a marshmallow. This will teach students to learn as engineers through collaborating to design, test, and improve ideas as a team as well as examining the creative process of the final product. A project such as this could be related to the work of an architect or civil engineer. Both active subsets of the engineering profession that contribute to overall topic of STEM!

The city of Worcester has gotten the attention of the Boys & Girls Club and needs help from their members. Students will have 10 minutes to brainstorm and 18 minutes to construct a freestanding building. We want to petition for our building to be put in downtown Worcester, but only one design can be chosen! Let's see who can build the tallest freestanding structure with a teammate that can hold up the weight of a marshmallow.

Materials:

*All items should be placed in a paper bag so students cannot see before starting the brainstorm period

- Scissors
- 20 pieces of uncooked spaghetti (regular, not angel hair, or thin)
- 3 ft. of string that can be easily cut/broken
- 1 fresh marshmallow (not stale, mini, or jumbo)
- 3 ft. of masking tape
- Paper bags (standard lunch size)

For the Teacher:

- Create a 'marshmallow challenge kit' that contains all of your materials in a paper lunch bag so students are unable to see materials until they begin.
- Display the countdown clock somewhere for all students to see (i.e. Computer)
- Go through and carefully explain the rules numerous times and reinforce them by projecting them on a screen or somewhere students can see them.

Contest Rules:

*Challenge—build the tallest freestanding structure in just 18 minutes using nothing more than 20 sticks of spaghetti, one yard of tape, one yard of string, and one marshmallow. The marshmallow must be on top and cannot be deformed to hold it in place. The structure has to stand firmly on its own; it cannot be propped up, held, or suspended from the ceiling.

## Marshmallow Design Student Quick Sheet:

Contest Rules:
*Challenge—build the tallest freestanding structure in just 18 minutes using nothing more than 20 sticks of spaghetti, one yard of tape, one yard of string, and one marshmallow. The marshmallow must be on top and cannot be deformed to hold it in place. The structure has to stand firmly on its own; it cannot be propped up, held, or suspended from the ceiling.

Rules:

- Build the tallest *freestanding* structure—the winning team is the one that has the tallest structure (measured by measuring stick). It will be measured from tabletop surface to the top of the marshmallow
- The ENTIRE marshmallow must be on the top—this means you cannot cut or eat any of the marshmallow or your team will be disqualified
- Use as much or as little of the kit
- You ARE ALLOWED TO break the spaghetti and cut up the tape or string
- The challenge is ONLY 18 minutes and you will have to stop when the time is up

# Suspension Bridge Building Teacher Quick Sheet:

<u>Introduction:</u>

Bridges are structures which carry people and vehicles across natural or man-made obstacles. There are many types of bridges. Based on the length of the barrier to be crossed, the amount and type of traffic as well as forces of nature (wind, tide, flood) different materials and shapes of bridges are used.

In this lesson, your team has been tasked with building a bridge across Lake Quinsigamond. For this task, you will be building the strongest of all the bridge structures - a suspension bridge. Since this bridge will be regularly used, it must withstand substantial weight. Once each group has completed their bridge, the integrity of the structure will be tested by placing weights on the bridge. Whose bridge will hold more weight?

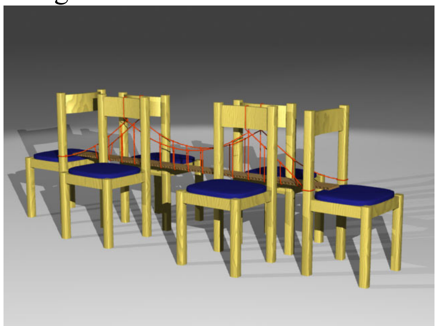
<u>Materials</u>:

- Safety scissors (for cutting stringers)
- Masking tape (optional, for attaching stringers to deck)
- Stapler with staples (optional, for attaching stringers to deck)
- 3-5 pound weights
- Two 15-foot pieces of rope (for cables)
- One 50-foot piece of string (for stringers/hangers)
- One 6-foot by 4-inch piece of cardboard (deck)
- 6 chairs (2 for each tower and 2 for anchors)

(*Note*: this is a list of materials per group)

<u>Procedure</u>:

- Arrange six chairs as in the diagram below:



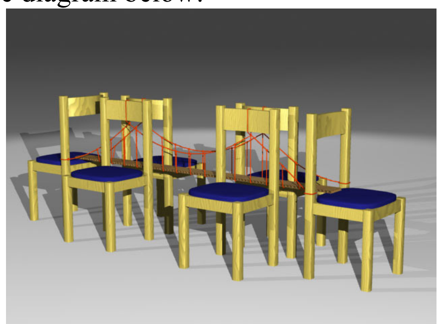
- You and your teammates must figure out how to build the bridge. You are not allowed to anchor the deck, only the cables.
- Test your bridge by putting the weights in several different locations on the bridge. If your bridge supports the weight, congratulations!
- If you have extra time, put the weight in the middle of the bridge and start cutting the cables until the bridge collapses.

## Suspension Bridge Building Student Quick Sheet:

Objective:
Students will build a model of a suspension bridge and test the amount of weight that it will support.

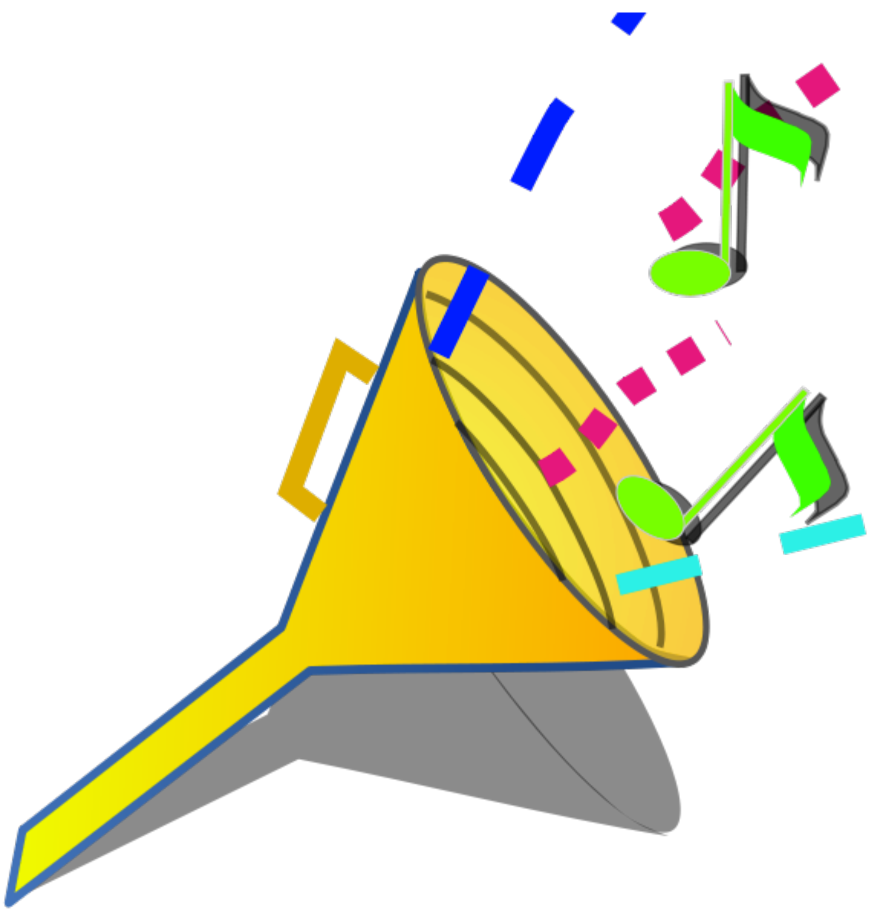
Procedure:

- Arrange six chairs as in the diagram below:



- You and your teammates must figure out how to build the bridge. You are not allowed to anchor the deck, only the cables.
- Test your bridge by putting the weights in several different locations on the bridge. If your bridge supports the weight, congratulations!
- If you have extra time, put the weight in the middle of the bridge and start cutting the cables until the bridge collapses.

# Unit 4: Activities in Sound



## Unit 4: Materials List

### Lesson 1: Introduction to Sounds and Pitches

Materials:
- Plastic and wooden rulers (1 per student)
- Stop watch (1 per student)
- Scissors
- Straws

### Lesson 2: Build a Band

Materials:
- Duct tape & Scotch tape
- Scissors & Staplers
- Pencils (at least 4 per student)
- Straws
- Craft sticks (4 per student)
- Rubber bands (2 mediums, 2 thin per student)
- Shoeboxes (1 per student)

## **Lesson 1: Introduction to Sounds and Pitches**

*(Physical Science, Energy, Waves)*

Time: 20-30 Minutes
Group Size: Individual

Introduction:

Sound energy is the energy produced when sound is created. Today we are going to talk mainly about two characteristics of sound energy, pitch and frequency. Everyone make a quick sound. Did you notice some were higher and some were lower? This characteristic of sound is called *pitch*. Does anyone know what *frequency* is? It's the number of *vibrations* for each sound pitch. High-pitched sounds have faster frequencies or more vibrations than low-pitched sounds with slow frequencies. This can be seen in wave formations.

*How do we use sound?* We use sound to communicate, or like listening to music! Engineers also listen to sounds and create machines that detect sounds that our ears cannot even hear! Our ears pick up a wide range of frequencies. However, some animals hear frequencies that are too high-pitched or low-pitched for human hearing. These frequencies are called ultrasounds and infrasonic sounds.

Engineers design other instruments that take pitch and frequency in consideration. Ultrasounds are used a lot in medical equipment, especially in devices that help us view what we cannot normally see. NASA engineers are even developing medical instruments that help people diagnose injuries in space. Today, we are going to look at sound energy and how changing the length of an object changes its pitch and frequency. Are you ready to make some noise?

Opening Discussion Points/ Questions (if necessary):

- What do we use sound for, and why would we measure it?
- What are ultrasounds used for?
    - o *It could also be to look at injuries (besides looking at a baby)*

Materials for Ruler Activity:

- Plastic and wooden rulers (1 per student)
- Stop watch (1 per student)

Materials for Straw Kazoo Activity:

- Scissors
- Straws

For the Teacher Procedure (Ruler activity):

- *Remind students that if they break their ruler on purpose they will not get another one*
- Create a discussion based on the difference between plastic and wood rulers. What would make the vibrations differ?
- Ask the students to fill out their chart

Procedure (For the Student):

1. Hold the ruler tightly to the table and hit the other end. Observe how the number of vibrations changes if you change how much the ruler extends past the table edge.

2. Continue doing this, and pull the ruler out more and more each time.
3. Fill out your chart with the number of vibrations. *What happens when you move the ruler out?*
4. What is the difference between the wooden and plastic rulers?

| **Distance of Ruler Beyond the Edge (in cm)** | **Number of Vibrations (How many sec. does the ruler vibrate?)** |
|---|---|
| | |
| | |
| | |
| | |
| | |

<u>For the Teacher Procedure (Straw Kazoo Activity):</u>

- Pass out straws and scissors to the children
- Ask students to cut one edge of the straw cutting one end to a point
- Tell them to blow through the straw and then cut a bit off the end to make it a little shorter
- Ask the students to observe the change in pitch as it is shortened
- Recall that *pitch* is the highness and lowness of a sound, and *frequency* is the rate of vibration in the pitch. So, slow vibrations = low pitch, high vibrations = high pitch.

<u>Conclusion/ Closing Discussion Points:</u>

- What happens to the frequency and pitch of the sound the ruler makes as you extend more of it off the table edge?
- What did cutting the straw do?
- How would you show a low pitch or low frequencies in waves?

<u>Objectives/Outcomes:</u>

- Students are able to define pitch and frequency.
- They can describe a sound with a high or low pitch and frequency.
- They can describe and show how to change the pitch of a sound.
- Students are able to give an example how engineers use pitch and frequency in the design of new products.

<u>Common Core:</u>

- Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. (Grade 4-8)
- Various relationships exist between technology and other fields of study. (Grades 3 - 6)

Next Generation Science Standards:

- A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS-PS4-1)
- A sound wave needs a medium through which it is transmitted. (MS-PS4-2)

*Inspired by*: PBS Designsquad Educator Resources (http://pbskids.org/designsquad/games/string_thing/)

## **Lesson 2: Build a Band**

***(****Physical Science, Energy, Waves)*

Time: 1 hour
Groups: Individual

Introduction (10 min):

Build this lesson off of the previous lesson. Continue the discussion of pitch and frequency, but ask how you would begin to change these. Have students touch the front of their throats and say something. You can begin a discussion with a talk about vibration, and ask the students how the vibrations play a role in the creation of sound.

Discuss the terms *tension, gauge, and length* to assess the understand the definition the students have for the words before the activity (the can be discussed again afterward as a form of evaluation)

Opening Discussion:

- How do your vocal chords feel as you change the pitch? (Make them go high to low)
  - *(Vocal cords tighten to produce higher-pitched sounds and relax to produce lower-pitched ones. They also vibrate at a higher frequency for higher pitches.)*
- Can you name me some stringed instruments?
  - *(Guitar; ukulele; violin; cello; bass; mandolin; banjo; harp; piano; zither; dulcimer, etc.*)
- What is tension? How does this play a role on the strings?
- How do you 'gauge' sound?
  - *Think about how you would tune a guitar's strings*

Tell them their challenge. They have one night to put together a band to play a show at Hanover Theater. It's for an improv show that requires all instruments to be hand made. All of you need to create your own instrument to be played at tonight's show, and we will compare at the end!

- What are some of the things you'll need to figure out as you make your instrument? *(What box to use; what side of the box to put the rubber bands on; how to make strings out of rubber bands; how to attach the strings; how to tune the strings; how to make the instrument loud)*

Materials:

- Duct tape
- Scotch tape
- Scissors
- Pencils (at least 4 per student)
- Straws
- Craft sticks (4 per student)
- Rubber bands (2 mediums, 2 thin per student)
- Shoeboxes (1 per student)

For the Teacher Procedure:

1. Gather materials together before students come in, and try to keep them covered so students cannot see them before the beginning of the activity.
2. Have the students begin a brainstorming process by gathering their materials and asking, "Can you make a stringed instrument that you can tune and play?"
3. Give them a blank sheet to brainstorm ideas with materials on the table
4. Only tell them that using the rubber bands will become the strings (but make sure to keep them free so they can be played on your instrument)
5. Have them brainstorm ways to keep the shoe box from interfering with the 'strings' of your instrument?
6. Now, have them brainstorm ways to make your instrument sound different by changing something…find ways to tune a rubber band.
7. At the end, tell them to pair up and play a tune together with peers

Concluding/Closing Discussion:

- What causes different pitches?
    - *(Things vibrating at different frequencies)*
- What can affect a string's pitch?
    - *(Its length, tension, and gauge)*
- How did the rubber band's thickness affect its pitch?
    - *(With tension and length equal, a thicker rubber band will produce lower pitch than a thinner one will.)*

Conclusion:

Music and sound are both extremely important in many of our lives! There will always be a need for people with a musical ear. Just like engineers use ultrasound and sound wave techniques to test the machines (to see if they're broken), artists and singers use the concepts of *pitch* and *frequency* to change the sound of their voices! STEM topics can be found in any of the things we do throughout our day, just like listening to music. So, the next time you go home, look around and see what you might have laying around that can be transformed into your next instrument!

Activity Extension:

- Since this is an individual activity, you can now have the students play their instruments together. This can be done in two ways:
    - Students can form groups and make bands (Optional: make names and perform for each other)
    - Students could each have a turn to play their instrument and compare
    - Have them try: *Happy Birthday, We Will Rock You, TV show theme songs, anything they may know*

Common Core:

- Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. (Grade 4-8)
- Various relationships exist between technology and other fields of study. (Grades 3 - 6)

Next Generation Science Standards:

- A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS-PS4-1)
- A sound wave needs a medium through which it is transmitted. (MS-PS4-2)
- Apply scientific ideas or principles to design an object, tool, process or system. (MS-PS2-1)

For the Teacher (troubleshooting):

**Hearing:**

- Try to keep the room as quiet as possible when students are testing out their instruments
- Remove anything that may interfere with the vibration of the strings such as excess tape

**Tuning:**

- To lower the pitch—stretch out the rubber band making it longer
- Raising or lowering the height of the bridge (pencils/straws) will change tension and increase or decrease pitch
- Tighten the rubber bands by re-adjusting the rubber band on the box

**Playing a song:**

- Remind the students that ‘fretting’ the string, pushing it down or pinching it, will change the pitch of the string
- Have them try: *Happy Birthday, We Will Rock You, TV show theme songs, anything they may know*

*Inspired by:* PBS Design Squad Educator Resources (http://pbskids.org/designsquad/games/string_thing)

# Sounds of STEM Introduction Teacher Quick Sheet

Objectives: Students are able to define pitch and frequency through a series of activities. Students are able to describe and exhibit change of sound through their own personal instruments in the later activity.

Introduction:

Today we are going to talk mainly about two characteristics of sound energy, pitch and frequency. Everyone make a quick sound. Sounds are higher and lower. This characteristic of sound is called *pitch*. Does anyone know what *frequency* is? It's the number of *vibrations* for each sound pitch. High-pitched sounds have faster frequencies or more vibrations than low-pitched sounds with slow frequencies. *How do we use sound?* We use sound to communicate, or like listening to music! Engineers also listen to sounds and create machines that detect sounds that our ears cannot even hear! Today, we are going to look at sound energy and how changing the length of an object changes its pitch and frequency. Are you ready to make some noise?

Opening Discussion Points/ Questions (if necessary):

- What do we use sound for, and why would we measure it?
- What are ultrasounds used for?
    - *It could also be to look at injuries (besides looking at a baby)*

Materials:

- Plastic and wooden rulers (1 per student)
- Stop watch (1 per student)
- Scissors
- Straws

For the Teacher Procedure (Ruler activity):

- *Remind students that if they break their ruler on purpose they will not get another one*
- Create a discussion based on the difference between plastic and wood rulers. What would make the vibrations differ?
- Ask the students to fill out their chart

For the Teacher Procedure (Straw Kazoo Activity):

- Pass out straws and scissors to the children
- Ask students to cut one edge of the straw cutting one end to a point
- Tell them to blow through the straw and then cut a bit off the end to make it a little shorter
- Ask the students to observe the change in pitch as it is shortened
- Recall that *pitch* is the highness and lowness of a sound, and *frequency* is the rate of vibration in the pitch. So, slow vibrations = low pitch, high vibrations = high pitch.

Conclusion/ Closing Discussion Points:

- What happens to the frequency and pitch of the sound the ruler makes as you extend more of it off the table edge?
- What did cutting the straw do?
- How would you show a low pitch or low frequencies in waves?

## Sounds of STEM Introduction Student Quick Sheet:

Procedure (For the Student):

1. Hold the ruler tightly to the table and hit the other end. Observe how the number of vibrations changes if you change how much the ruler extends past the table edge.
2. Continue doing this, and pull the ruler out more and more each time.
3. Fill out your chart with the number of vibrations. *What happens when you move the ruler out?*
4. What is the difference between the wooden and plastic rulers?

| **Distance of Ruler Beyond the Edge (in cm)** | **Number of Vibrations (How many sec. does the ruler vibrate?)** |
|---|---|
| | |
| | |
| | |
| | |
| | |

# Build a Band Teacher Quick Sheet

<u>Introduction (10 min):</u>

Build this lesson off of the previous lesson. Continue the discussion of pitch and frequency, but ask how you would begin to change these. Have students touch the front of their throats and say something.

<u>Opening Discussion:</u>

Tell them they have one night to put together a band to play a show at Hanover Theater. It's for an improv show that requires all instruments to be hand made. All of you need to create your own instrument to be played at tonight's show, and we will compare at the end!

- How do your vocal chords feel as you change the pitch? (Make them go high to low)
    - *(Vocal cords tighten to produce higher-pitched sounds and relax to produce lower-pitched ones. They also vibrate at a higher frequency for higher pitches.)*
- Can you name me some stringed instruments?
    - *(Guitar; ukulele; violin; cello; bass; mandolin; banjo; harp; piano; zither; dulcimer*)
- How do you 'gauge' sound? What is tension on the strings?
    - *Think about how you would tune a guitar's strings*
- What are some of the things you'll need to figure out as you make your instrument? *(What box to use; what side of the box to put the rubber bands on; how to make strings out of rubber bands; how to attach the strings; how to tune the strings; how to make the instrument loud)*

<u>Materials:</u>

- Duct tape & Scotch tape
- Scissors & Staplers
- Pencils (at least 4 per student)
- Straws
- Craft sticks (4 per student)
- Rubber bands (2 mediums, 2 thin per student)
- Shoeboxes (1 per student)

<u>For the Teacher Procedure:</u>

1. Gather materials together before students come in, and try to keep them covered so students cannot see them before the beginning of the activity.
2. Have the students begin a brainstorming stringed instrument and give them a blank sheet to brainstorm ideas telling them the materials (Only tell them that using the rubber bands will become the strings)
3. At the end, tell them to pair up and play a tune together with peers

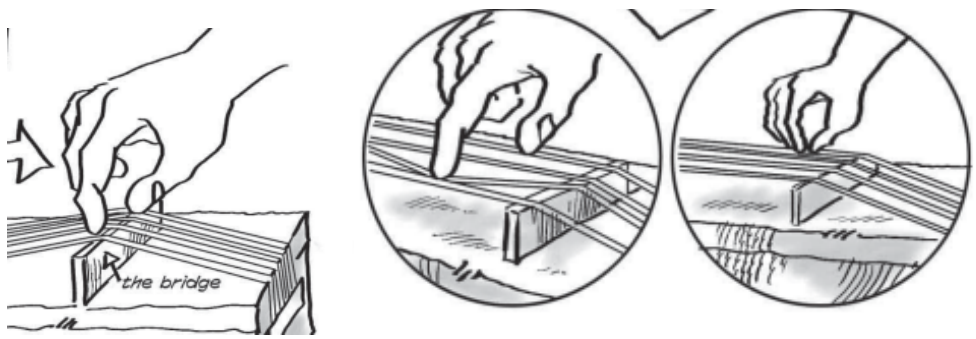
<u>Concluding/Closing Discussion:</u>

- What causes different pitches? *(Things vibrating at different frequencies)*
- What can affect a string's pitch? *(Its length, tension, and gauge)*
- How did the rubber band's thickness affect its pitch?
    - *(With tension and length equal, a thicker rubber band will produce a lower pitch than a thinner one will.)*

## Build a Band Student Quick Sheet

Things/Ideas to Keep in Mind:

- Rubber bands can be kept in loops, or could be cut into strips!
- Did you take the lid off of your shoe box?
    - Will the rubber bands go over a closed or open surface?
- The box OR lid could be your instrument!
- Pressing or pinching the string changes length! (Mark where it should be stretched to)
- Think about making a bridge to keep your strings off the box!
    - Vibrations go from the string to the box! (don't use too much tape)



# Unit 5: Gravity & Forces

## <u>**Unit 5: Materials List**</u>

### Lesson 1: Egg Drop

Materials:

- At least 8 Eggs (1 per student/group and 2 extra)
- Tape
- Hot glue
- Markers
- Trash bags or cheap table cloths - for covering the ground where the eggs will be dropped
- Recycled materials including:
  - Bubble wrap, plastic Easter eggs, parachute army men, paper towel/toilet paper rolls. saran/plastic wrap, plastic grocery bags, cardboard, printer/construction paper, latex balloons, craft sticks

(*Note:* Building supplies are necessary but any resources from our recommended list may be used, as well as any other recycled materials)

## **Lesson 1: The Egg Drop**

*(Engineering, Forces, Physics)*

Time duration of lesson: 1:30 (10 minutes for opening discussion, 50 minutes for construction, 20 minutes for egg drop competition)
Group Size: individual if resources permit, pairs otherwise

Introduction:

A force is a push or pull motion between two or more objects. One of the biggest forces we face every day is the force of gravity. What is gravity? Gravity is a pulling force which holds us on the ground. Also, if something is thrown into the air, it is gravity which pulls it down to the ground.

Our task is to safely drop food and First Aid supplies to an area which has been recently hit by a natural disaster. In this case, the egg will represent the supplies, and we must build a structure which will prevent the egg from breaking.

Opening Discussion Points/ Questions:

- What are forces?
- How does a bounce-house help you jump and stop you from hurting yourself when you fall?
- How do you keep something from breaking when it falls?
- What are some things that fall from the sky in our culture and how do we stop them from crashing? (Ex: Mars rovers, parachutes, airplanes)

Materials:

Note: Building supplies are necessary but any resources from our recommended list may be used, as well as any other recycled materials.

- At least 8 Eggs (1 per student/group and 2 extra)
- Tape
- Hot glue
- Markers
- Trash bags or cheap table cloths - for covering the ground where the eggs will be dropped
- Recycled materials including:
    - Bubble wrap, plastic Easter eggs, parachute army men, paper towel/toilet paper rolls. saran/plastic wrap, plastic grocery bags, cardboard, printer/construction paper, latex balloons, craft sticks

For the Teacher Procedure:

- The materials can be given to the students in two different ways:
    - Split the materials evenly and give each student their share - the requires the teacher to split all materials before the students enter the room, and is best done if there are more than enough supplies for all students.
    - Prepare a supply table, where students can walk up to the table and grab some supplies, a few at a time. Note, keep some scissors at this table for cutting off pieces.

- Determine where the egg structures will be dropped. We suggest this location would be at least 8 feet high, though the higher it is, the more challenging this activity will be. This location can be anywhere from on top a ladder, from a stairwell, or off of a balcony. However, wherever the egg structures will be dropped must be protected by either plastic bags or a plastic table cloth laid on the ground, to make the cleanup process easier. Additionally, this area should be "roped off" to keep people around the competition from standing in this area.
- Additionally, as an optional activity, each of the students may be given time (5-10 minutes) at the beginning of their build period to decorate their egg and make it their own.
- During the construction period: allow students to experiment with the different resources and assist them in the building of their structures. Ask particular questions about the resources they are using and why they are using those, not others. Encourage them to use resources that they may not think of working.
- For the competition period: one by one, drop each egg structure from the designated dropping point, cleaning up after each drop if necessary.

<u>Procedure (For the Student):</u>

- Build a structure using the given materials to prevent an uncooked egg from breaking when it is dropped from a given height.
- You may use any of the given materials but are not required to use any particular one.

<u>Conclusion/ Closing Discussion Points:</u>

- Have the students discuss what worked with their contraptions and what didn't.
- How did the things that worked well counter the force of gravity on your structures?
- If you had unlimited time and resources, how would you change your structure?
- Discuss any related careers of the topics that came up during the activity. Examples include aeronautical (space) engineering, civil engineering

<u>Objectives/Outcomes:</u>

- Describe and define material properties.
- Identify the forces of gravity, drag, and the term air resistance

<u>Common Core:</u>

- Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems. (Grade 6-8)
- Design involves a set of steps, which can be performed in different sequences and repeated as needed. (Grades 6 – 8)
- Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum. (Grades 6 -8)
- Identify appropriate problems for technological design. Students should develop their abilities by identifying a specified need, considering its various aspects, and talking to different potential users or beneficiaries. They should appreciate that for some needs, the cultural backgrounds and beliefs of different groups can affect the criteria for a suitable product. (Grades 5 - 8)

- Implement a proposed design. Students should organize materials and other resources, plan their work, make good use of group collaboration where appropriate, choose suitable tools and techniques, and work with appropriate measurement methods to ensure adequate accuracy. (Grades 5 - 8)

Next Generation Science Standards:

- *Physical Science, K-4, 5-8:* Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. (MS-PS2-4.)
- *Science and Technology, K-4, 5-8:* Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively). (MS-PS2-5)

*Inspired by:* Teach Engineering Teacher Resources (https://www.teachengineering.org/view_activity.php?url=collection/cla_/activities/cla_egg_drop_activity1/cla_egg_drop_activity1.xml)

# The Egg Drop Teacher Quick Sheet

Objectives: Have the students use engineering and problem solving to build a structure which will successfully prevent an uncooked egg from dropping from a designated height.

Materials:

- At least 8 Eggs (1 per student/group and 2 extra)
- Tape
- Hot glue
- Markers
- Trash bags or cheap table cloths - for covering the ground where the eggs will be dropped
- Recycled materials including:
    - Bubble wrap, plastic Easter eggs, parachute army men, paper towel/toilet paper rolls. saran/plastic wrap, plastic grocery bags, cardboard, printer/construction paper, latex balloons, craft sticks

Preparation:

Determine the location from which the eggs will be dropped. We recommend dropping from a height that is at least 8 feet tall, though higher works better. A ladder, balcony, or stairs may work.

Determine whether the students will be given individual packages with the given materials, or a materials table can be utilized. Then prepare either the packages or the table.

Opening Discussion:

What are forces? And how do they affect our daily lives? What happens to forces when something is dropped on the ground? How do we prevent dropped things from breaking?

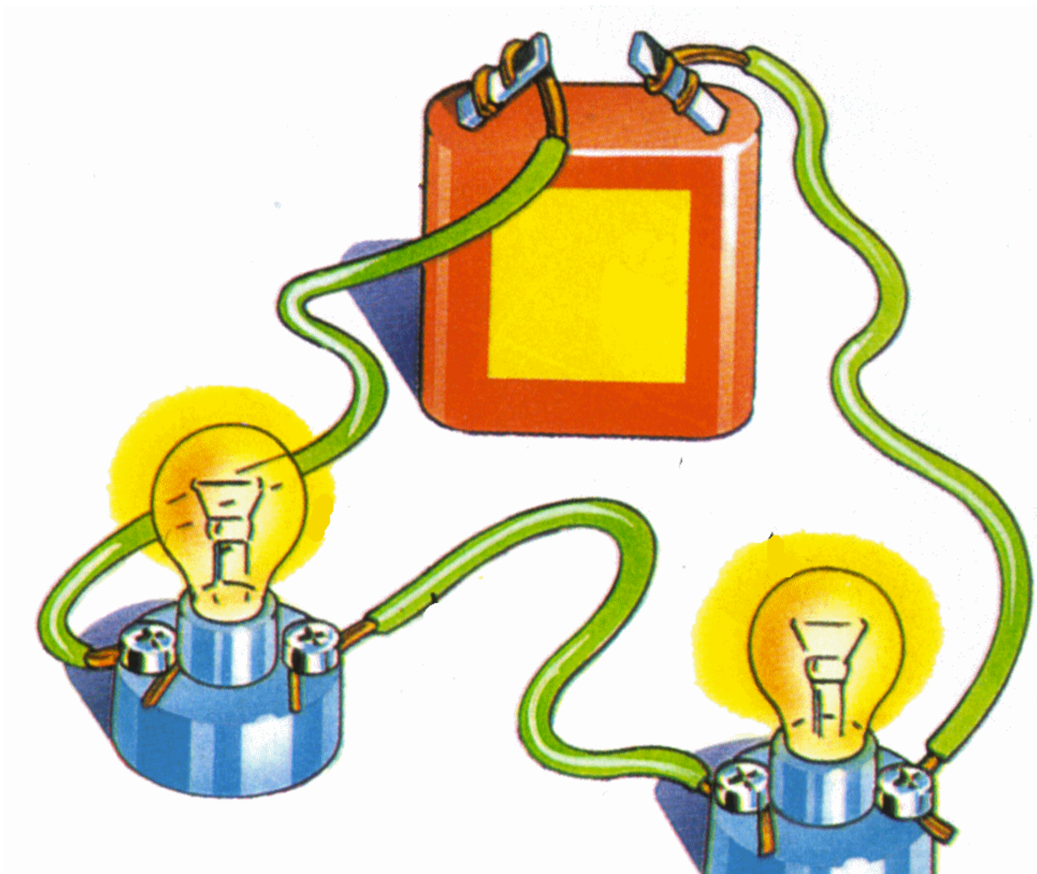
Procedure:

1. Give the students a period of 45 minutes to build their structures
2. At the end of the build period, clean up all remaining supplies and clean up the room for the egg drop competition
3. For the egg drop competition:
    a. Set up the trash bags or plastic table cloths on the ground where the egg structures will be dropped in case of egg breakage.
    b. Have an adult drop the student's' structures to ensure that they are just dropped, not thrown up or down from the designated height
    c. Leave time in between the dropping of each structure to clean up if necessary
4. Optional - Give all students a reward or prize whether or not they won - to prevent students from coming out of the activity feeling like they failed.

Closer / Assessment:

- Have the students discuss what worked with their contraptions and what didn't.
- How did the things that worked well counter the force of gravity on your structures?
- If you had unlimited time and resources, how would you change your structure?

# Unit 6: Circuits



## **Unit 6: Materials List**

### Lesson 1: Flashlight Dissection

Materials:
- Cheap flashlights - dollar store quality (1 per group)
- Screwdrivers
- Blank paper
- Pencils or markers

### Lesson 2: Chibitronics

Materials:
- Copper tape (at least 3 feet per student)
- Cell batteries (2 per student)
- Chibitronics LED stickers (3-6 per student)

# Lesson 1: Flashlight Dissection
*(Engineering, electronics)*

Time duration of lesson: 20 minutes
Group Size: Teams of 2

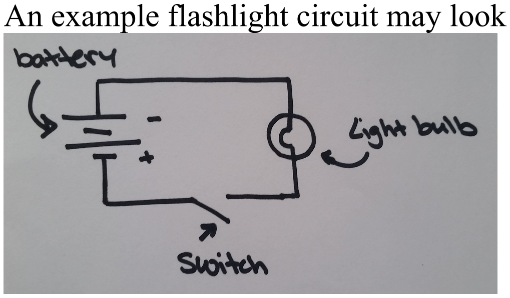
Introduction:

Electricity is present in every part of our lives, from keeping our lights on, to charging phones, and even helping us keep food cold. A circuit is a loop of electricity from which appliances such as lights and refrigerators can gain the electricity they need to function correctly. However not all circuits require something to be plugged into a wall. The simplest of circuits have just a power source and an application like an LED. One such standalone circuit is found in a flashlight, where there is a battery and a light bulb. Our task is to "dissect", or take apart, the pieces of a flashlight to figure out what parts make up that circuit.

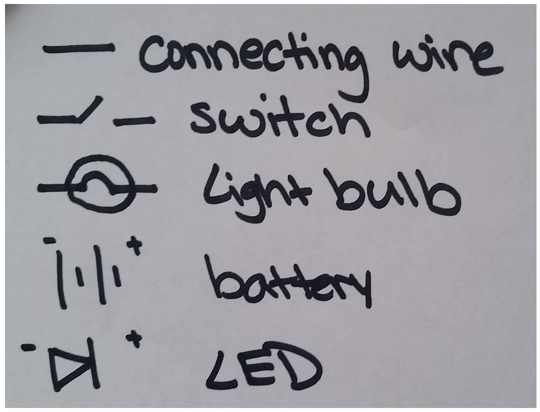
Opening Discussion Points/ Questions:
- What is electricity?
- How do we use electricity?
- What is a circuit?
- What are more circuits we use or can see?

Materials:
- Cheap flashlights - dollar store quality (1 per group)
- Screwdrivers
- Blank paper
- Pencils or markers

For the Teacher Procedure:
- This is an activity where the teacher should try to break down ("dissect") the flashlight beforehand to make sure they have the necessary screwdrivers or other tools necessary to complete this task.
- If not done already, print out the student Circuits handout for reference during the activity
- An example flashlight circuit may look like the following:




Procedure (For the Student):
1. Carefully take apart the flashlight using the tools provided
2. Pay close attention to the pieces which seem to have a part in the circuit
3. Draw the circuit using the given symbols (or make up your own!):




Conclusion/ Closing Discussion Points:

- An electrician is someone who works on the electrical units of people's buildings
- An electrical engineer works on other circuits, like using tiny circuit pieces to make hardware in your computer
- The different things that were in the flashlights could include: a light bulb, connecting wire, a battery, and a switch.

Objectives/Outcomes:

- Students are more aware of the presence of electricity and circuits all around them
- Students are introduced to the jobs of electrician and electrical engineer

Common Core:

- Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem (Grade 6-8)

Next Generation Science Standards:

- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2)
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)
- Models of all kinds are important for testing solutions. (MS-ETS1-4)

*Developed by: Alexandra Bittle*

## Lesson 2: Chibitronics Circuit

*(Electronics)*
Resources: http://store.chibitronics.com/collections/all

Time duration of lesson: 45-50 minutes
Group Size: individual

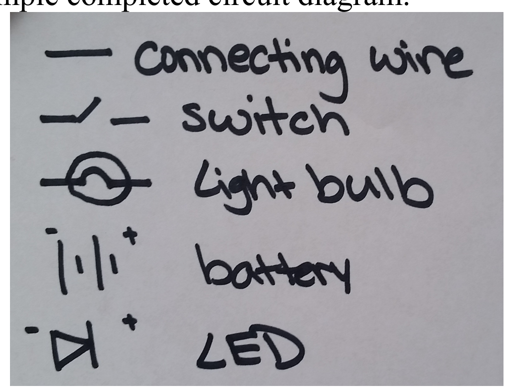
Introduction:

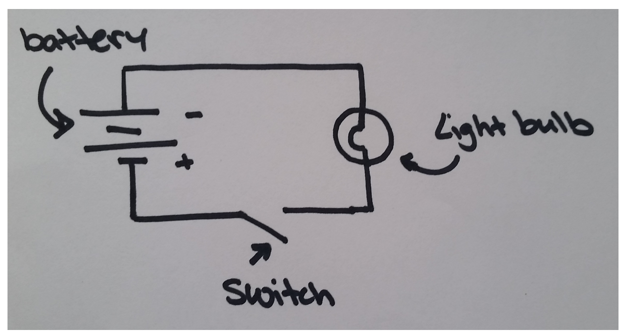
As we learned in our first activity, a circuit is a loop of electricity, which we can find in many different places and effect every part of our modern lives.

An LED - or Light Emitting Diode - is a kind of light that we can put inside circuits. They come in may come in different colors, and depending on the amount of power we have in our circuit, it can be bright or not. We will be using LED stickers, which have all the pieces we need. It is important to remember that the positive (+) end must point to the positive battery, and the negative (-) end must point to the negative battery.

Copper is a type of metal and is used frequently with circuits because it conducts electricity. We will be using it in a form of tape, so it is more fragile than most copper, but it still works for making circuits.

Examples of electronic symbols can be found in the following image along with an example completed circuit diagram.



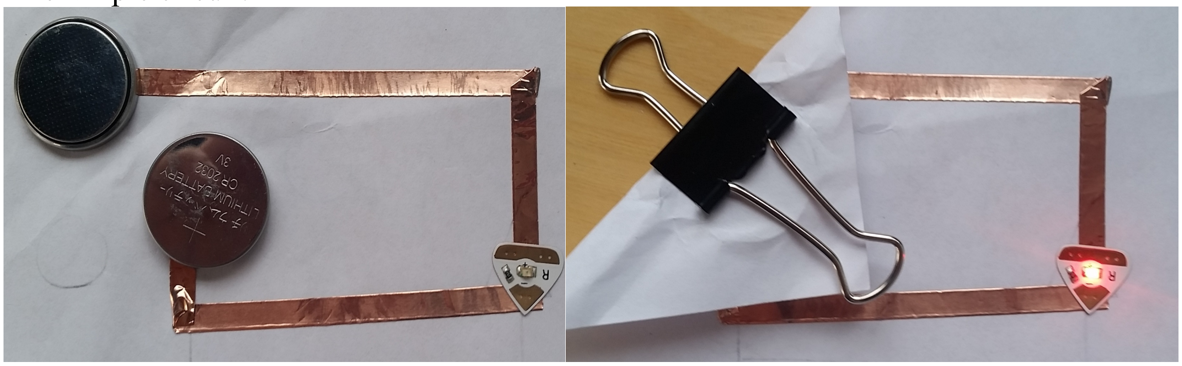

Materials:

- Copper tape - at least 3 feet per student
- Cell batteries - 2 per student
- Chibitronics LED stickers - 3-6 per student

For the Teacher Procedure:

- Print out the student circuit handout if not done already
- Have the students draw a circuit diagram before creating anything with the circuitry components.
- Each circuit must include:
  - A positive- marked battery
  - A negative- marked battery
  - LED's in the correct direction (triangle pointed towards negative battery)
  - Only one loop in the copper tape - no tape intersections

An example circuit:



Procedure (For the Student):

- Draw out a shape (any shape that does not have any crosses - only one loop) in pencil
- Add where you want LED’s (lights) to be put
- Add where you want the batteries to go
    - Make sure the two batteries are in a place where the paper can be folded in half to connect them
- Draw the LED and battery symbols where you plan on putting them
- Have your instructor look over your drawing to make sure you can build your circuit
- Once you have approval, add copper tape to all the connecting lines, making sure to not cut the tape in the corners, but make a corner in the tape
- Put in the two batteries, making sure the flat side is on the positive edge of your copper tape, and the non-flat side on the negative side of your tape
- Finally add your LED stickers
- Use a binder clip to hold the two batteries together and complete your circuit!

Conclusion/ Closing Discussion Points:

- Discuss what was hard or easy about designing circuits
- What would you build if you had unlimited stickers and tape?

Objectives/Outcomes:

- Students are better able to recognize the presence of electronic circuits
- Student become comfortable and confident in their ability to build simple circuits

Common Core:

- Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem (Grade 6-8)
- Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (Grade 6-8)

Next Generation Science Standards:

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MSETS1-4)
- Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (MS-ETS1-4)

*Developed by: Alexandra Bittle*

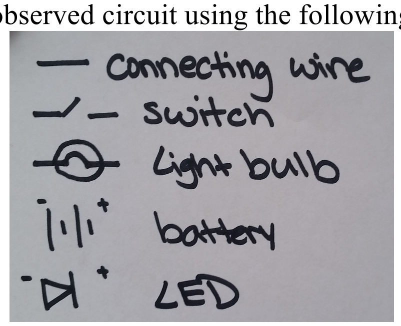
# Flashlight Dissection Activity Teacher Quick Sheet:

Objectives:
- Each student will think of the ways that electricity and circuits affect their lives/many things they use that contain circuits
- Each group will "dissect" a flashlight or related item to observe the circuit inside

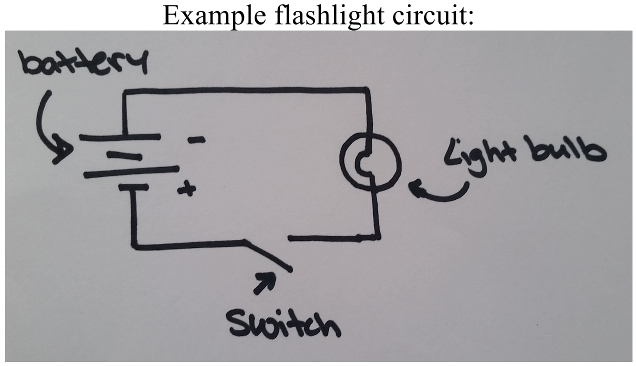
Materials:
- Cheap flashlight or related small circuit item - 1 per team of 2
- Screwdrivers

Opening Discussion Points:
- How electricity affects their day to day life
- Electricity works in loops - aka circuits
- Example standalone circuits - flashlights, phones, remote control cars

Procedure
1. Print out a student Circuit handout for each student if not done already
2. Give each pair of students a flashlight (or related standalone circuit object)
3. Instruct each group to take apart the flashlight to observe how the circuit inside works
4. Have each group draw the observed circuit using the following symbols:




Example flashlight circuit:




Closing Discussion Points:
- Have each group present their circuit diagrams
- Small discussion regarding any differences between diagrams

# Chibitronics Circuits Lesson Teacher Quick Sheet

Objectives: Using the basic knowledge the students gained through the flashlight activity, have the students build a new circuit on their own using the Chibitronics material

Opening Discussion:

- Discuss copper tape, LED's, electricity

Materials:

- 2 Cell batteries per student
- At least 3 feet of copper tape per student
- at least 3 LED stickers per student

Preparation:

- Have the students draw a circuit diagram before creating anything with the circuitry components.
- Each circuit must include:
    - A positive- marked battery
    - A negative- marked battery
    - LED's in the correct direction (triangle pointed towards negative battery)
    - Only one loop in the copper tape - no tape intersections

Procedure (Also in the student handout):

1. Draw out a shape (any shape that does not have any crosses - only one loop) in pencil
2. Add where you want LED's (lights) to be put
3. Add where you want the batteries to go
    a. Make sure the two batteries are in a place where the paper can be folded in half to connect them
4. Draw the LED and battery symbols where you plan on putting them
5. Have your instructor look over your drawing to make sure you can build your circuit
6. Once you have approval, add copper tape to all the connecting lines, making sure to not cut the tape in the corners, but make a corner in the tape
7. Put in the two batteries, making sure the flat side is on the positive edge of your copper tape, and the non-flat side on the negative side of your tape
8. Finally add your LED stickers
9. Use a binder clip to hold the two batteries together and complete your circuit!

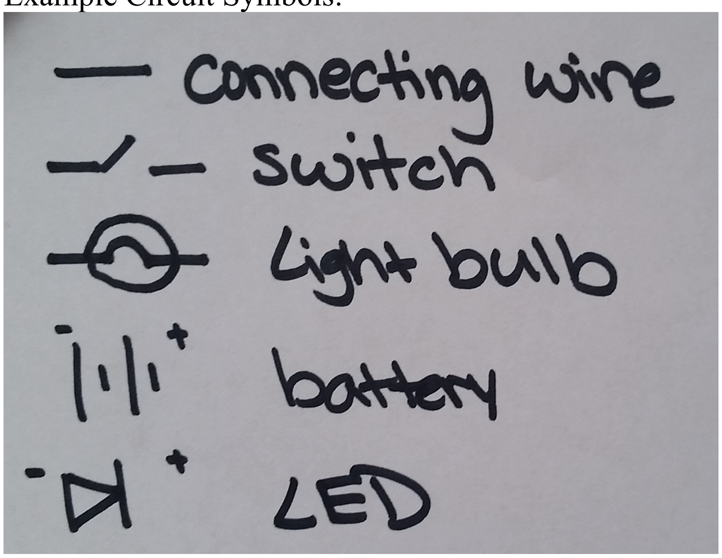
Closer / Assessment:

- Have each student present their creations and explain what worked well or what didn't
- Ask the students about their favorite and least favorite parts of this activity/unit

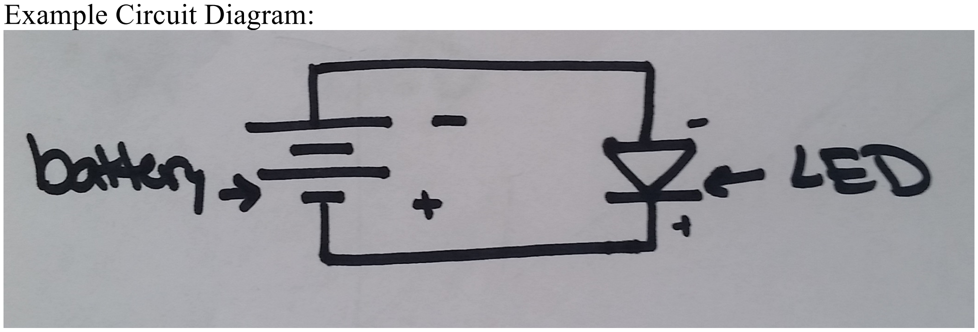
# Chibitronics Circuits Student Quick Sheet

Procedure:
1. Draw out a shape (any shape that does not have any crosses - only one loop) in pencil
2. Add where you want LED’s (lights) to be put
3. Add where you want the batteries to go
    a. Make sure the two batteries are in a place where the paper can be folded in half to connect them
4. Draw the LED and battery symbols where you plan on putting them
5. Have your instructor look over your drawing to make sure you can build your circuit
6. Once you have approval, add copper tape to all the connecting lines, making sure to not cut the tape in the corners, but make a corner in the tape
7. Put in the two batteries, making sure the flat side is on the positive edge of your copper tape, and the non-flat side on the negative side of your tape
8. Finally add your LED stickers
9. Use a binder clip to hold the two batteries together and complete your circuit!

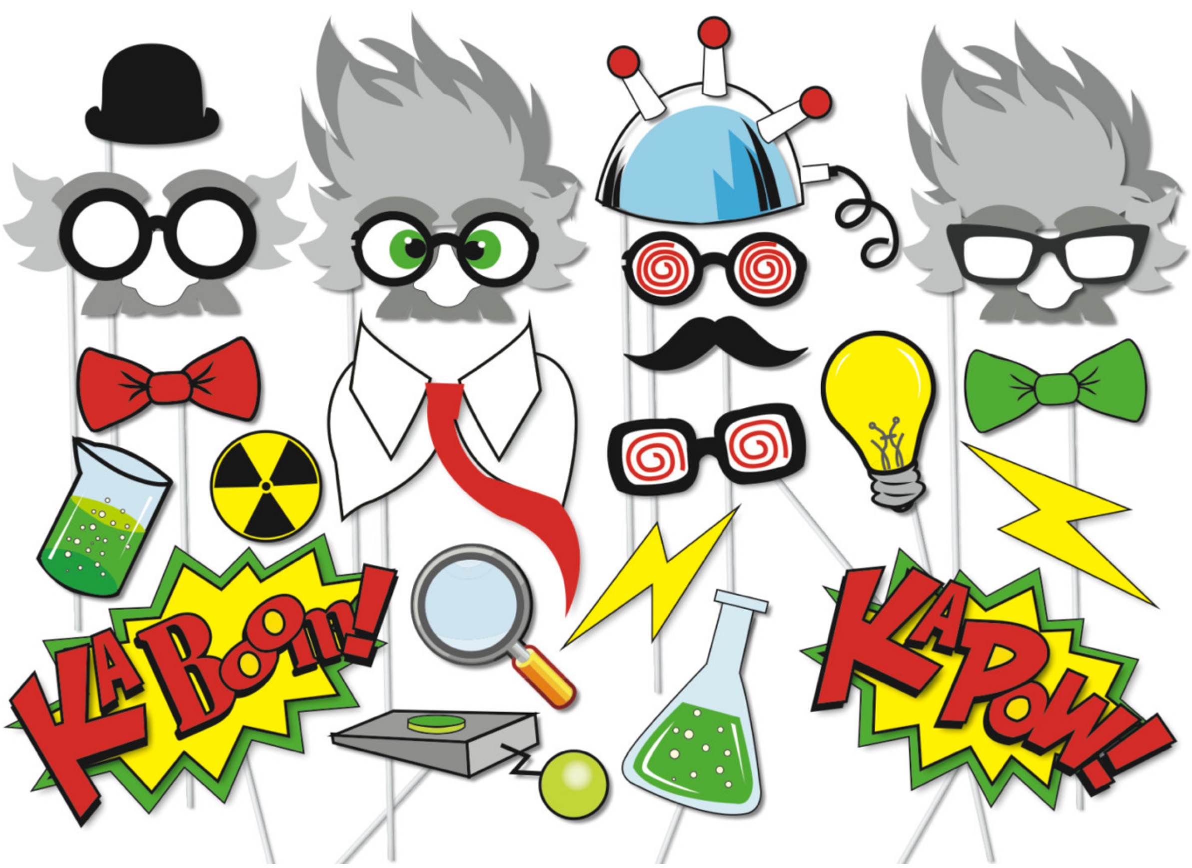
Example Circuit Symbols:




Example Circuit Diagram:



# Unit 7: Party Science



## Unit 7: Materials List

### Lesson 1: Skewer Through a Balloon

Materials:
- Latex balloons (2 per student)
- Wooden cooking skewer (2 per student)
- Cooking oil (1 container per class)
- Sharpie pen/marker (1 per student)

### Lesson 2: Make Your Own Ice Cream

Materials:
- Small zip-lock zipper style bags (1 per student)
- Gallon zip-lock zipper style bags (1 per student)
- ½ cup milk (per student)
- 1 tablespoon sugar (per student)
- ½ teaspoon vanilla extract (per student)
- 4 tablespoons of Kosher rock salt (per student)
- 2+ cups ice cubes (per student)
- Liquid measuring cups
- Measuring spoons
- Measuring Cups or scoops
- Paper Towels
- Lesson Handouts
- Large cooler (to keep items cold)
- Rags or hand towels to cover ice-cream bags when shaking
- Plastic spoons

## Lesson 1: Skewer Through a Balloon

*(Physical Science)*

Time: 15-20 Minutes
Group Size: Individual

Introduction:

In this lesson we are going to do our best to get this skewer through our balloons! By taking your wooden skewers, I want all of us to blow up our balloons and attempt to get the skewer completely through the balloon. This may seem a little crazy, but we will have to test out the experiment ourselves! Before we begin we need to make our first scientific hypothesis so, do you think the balloon will pop? Or is it possible to push the skewer through and through?

Materials:

- Latex balloons (2 per student)
- Wooden cooking skewer (2 per student)
- Cooking oil (1 container per class)
- Sharpie pen/marker (1 per student)

Procedure:

1. The first step is to inflate the balloon until it's almost nearly full size and then let out about ⅓ of the air. Tie a knot at the end of the balloon. The balloon should be smaller than the length of the skewers.
2. Examine the balloon and try to find an area where you can push the skewer through
3. You can try to dip the wooden skewer into the cooking oil, which can act as a sealant.
4. Be careful not to prick yourself or the balloon with the skewer!

For the Teacher:

1. If students are unable to do the task it is likely because they are putting the skewer in the wrong way. Give students a new balloon and a marker. Have the following discussion before showing the correct way. This will assess understanding of the stress placed on the balloon:
2. Tell students to blow up the new balloon, and use the Sharpie pen/marker to draw about 10-15 dots on the balloon. The dots should be about the size of a head of a match. Be sure to draw them at both ends and in the middle of the balloon.
3. Inflate the balloon halfway and tie at the end. Observe the various sizes of the dots all over the balloon.
    a. Where are the dots on the latex molecules stretched out the most?
    b. Where are they stretched out the least?
4. Dip the wooden skewer in the vegetable oil and use your fingers to coat the skewer with oil.
5. Use the observations that you made previously about the dots on the balloon to decide the best spot to put the balloon with the skewer.
6. Have the students place the sharpened tip of the skewer on the thick end of the balloon and push the skewer into the balloon. Just use gentle pressure (and maybe a little twisting motion) to puncture the balloon.

7. Push the skewer all the way through the balloon until the tip of the skewer touches the opposite end of the balloon (other thick portion). Keep pushing until the skewer penetrates the rubber.
8. Gently remove the skewer from the balloon when you are done!

For the Student (*Can be printed or discussed):

1. Take your first balloon and blow it up as much as you can (without popping it), and release a little bit of air so that you can tie it
2. Tie the balloon at its ends
3. Take your skewer and choose a spot on the balloon to push it all the way through!
4. It's okay if you pop your first try! You will have more chances.
5. Take your second balloon from your teacher, and a marker
6. Put small marker dots all over the balloon (like the size of a tic-tac)
7. Follow the teacher's instructions!

Conclusion:

There is a little secret behind being able to put the skewer through the balloon. The secret is in finding the part of the balloon where the molecules are under the least amount of stress or strain. After you all drew on the balloon with the marker, you should have been able to see where the dots were smaller and larger. The small parts were your areas of less stress, and those were found on the ends of the balloon. When the point of the skewer is positioned at the ends of the balloon, the solid object passes through the inflated balloon without popping it.

If you could see the rubber that makes up a balloon under a microscope, you would see many long strands or chains of molecules. These long strands of molecules are called *polymers*, and the polymer chains are so elastic that it allows the rubber to stretch. Even before drawing the dots on the balloon, you probably noticed that the middle of the balloon stretches more than either end. Therefore, to get it through you have to pierce the balloon at a point where the molecules are the least stretched out! However, the molecules around the holes you made that stretched around the skewer, were so tight that they were able to keep the air inside the balloon instead of rushing out.

For engineers, this a way for them to understand the stress and tension placed on certain objects. Before the begin construction, designing, or building, engineers must understand the stress of their materials to make sure they can withstand the pressure!

Objectives/Outcomes:

- Students are able to begin developing hypotheses based on previous knowledge, and test their hypotheses
- Students are able to explain to their peers the phenomena and the discussion behind it
- The discussions of polymers and tension coincide with the common core expectancies of science courses in grades 6 through 8.
- Students are encouraged to test this out at home and have their parent's perform a taste test as well.

Common Core:

- Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real world phenomena, examples, or events. (Grades 6-8)]

Next Generation Science Standards:

- Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS2-2), (MS-PS2-4)

*Inspired by*: Steve Spangler Science Experiments
(http://www.stevespanglerscience.com/lab/experiments/skewer-through-balloon/)

## Lesson 2: Make-your-own Ice Cream

*(Physical sciences, earth science, life science, and chemistry)*

Time: 1 hour (20 minute clean up)
Group Size: Individual

Introduction:
Acting as physicist, chemist, and engineers, students will investigate the ways in which ice-cream begins as a liquid and morphs into a solid student's will first understand shifting qualities.

Opening Discussion Points:

- To get the students interest in understanding the breadth of STEM disciplines, start with a class activity by a whiteboard or poster board. Ask the children what they believe scientists do by simply asking "What do you think a scientist does?", and record the responses (children are encouraged to write words and draw pictures). Allow students to brainstorm alone, then as a team.
    - Give examples:
        - Scientists are trying to save polar bears and honey bees from becoming extinct
        - Scientist use zombies as a model for understanding the spread of contagious diseases.
        - Scientists use robots that might one day be able to do your chores!
        - Scientists are discovering new planets and stars as we speak
        - Scientists are designing life suits that simulate what it feels like at any age of your life
        - Scientist…. make the ice-cream you eat!!

Materials:

- Small zip-lock zipper style bags
- Gallon zip-lock zipper style bags
- ½ cup milk (per student)
- 1 tablespoon sugar
- ½ teaspoon vanilla extract
- 4 tablespoons of Kosher rock salt
- 2+ cups ice cubes
- Liquid measuring cups
- Measuring spoons
- Measuring Cups or scoops
- Paper Towels
- Lesson Handouts
- Large cooler (to keep items cold)
- Rags or hand towels to cover ice-cream bags when shaking
- Plastic spoons

For the Teacher Procedure:

1. Get the students engage and continue the scientific trend of conversation. Before taking out supplies, hand out the "What Do You Know About Ice-Cream" handout OR have a discussion about the following:
    a. What is everyone's' favorite ice-cream?
    b. What ingredients go into making ice-cream
        i. Hold up ingredients to show they are right!
        ii. Ask what the salt is for?
    c. This will get the children discussing hypotheses –also ask the children whether the ingredients are a liquid, solid, or gas?
        i. How do we start with liquids and end with solids?
2. Have the students, in groups, brainstorm ways they think they end up with a solid. (Is it mystery chemicals? Elsa? Unknown forces? science?)
3. Pass out the "Let's experiment with Ice-cream" handout—give extras for students recording more than one bag
4. Pass out the 'recipe sheet'
5. Once the students have completed their trial runs, have then complete the steps again! Encourage students to change at least one ingredient and record/observe their results
6. On their worksheets—have the students describe their ice-cream based on: taste, smell, and any senses. Were the batches different? How does it compare to store brand?

For the Student

1. Get small Ziploc bag and label it with your name
2. Add ½ cup of milk
3. Add ½ teaspoon of vanilla extract
4. Add 1 tablespoon of sugar
5. Seal your Ziploc bag and leave as little air as possible
6. Place the smaller bag inside of the Gallon Ziploc bag
7. Cover the small bag with ice, filling your whole gallon bag
8. Add 4 tablespoons of the Kosher salt to the top of the ice
9. Get all of the air out of the bag and wrap your bag in a hand towel
10. Shake, roll, or move the bag around for a full 8-10 minutes (making sure the ice is still covering the milk mixture bag)
11. Change at least one ingredient to see if it changes the final result.
12. On your sheets—describe your ice-cream based on: taste, smell, and any senses. What was the difference between your batches? How does it compare to your favorite ice cream?

Closing Discussion Points:

As the students eat their work have them talk about their findings. This means have them discuss the ingredients they used, and what might happen if you change those. *How did we end up with frozen ice-cream?* The answer comes from the student's understanding of matter. The ice (solid) absorbs energy causing it to melt going into a liquid.

- Ask the students where energy comes from! (*In this case, the energy comes from anything touch the ice cubes!)*

By adding the salt, we are able to stop the melting process. Salt lowers the freezing point of the ice making the cold ice—colder. This allows the milk to freeze while shaking the bag before the ice melts! (What temp. does water freeze?! 32 degrees Celsius) By adding salt we created a cold enough environment.

Objectives/Outcomes:

- Much deeper understanding of the STEM disciplines and what a 'scientist' does. This is seen in breaking the 'lab coat' stereotype as children would be able to show progress in the understanding of the vastness of the STEM disciplines.
- Students discuss matter and the change of matter based on chemical reactions
- The discussions of dissolving and content matter coincide with the common core expectancies of science courses in grades 6 through 8.
- Students are encouraged to test this out at home and have their parent's perform a taste test as well.
- Most importantly, the thrill of discovering and curiosity of an unknown phenomena will be what leads children to further interest in the future.

Common Core:

- Science knowledge is based upon logical and conceptual connections between evidence and explanations. (Grade 6-8)
- Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena (Grade 6-8)
- Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real world phenomena, examples, or events. (Grade 6-8)
- Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion. (Grade 6-8)

Next Generation Science Standards:

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-3)
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4)
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. (MS-PS1-4)
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). (MS-PS1-1)
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (MS-PS1-4)

*Inspired by:*

826 National. (2015). *STEM to Story: Enthralling and Effective Lesson Plans for Grades 5-8* (J. Traig, Ed.). Jossey-Bass.

# Skewer Through Balloon Teacher Quick Sheet

Opening Discussion:

In this lesson we are going to do our best to get this skewer through our balloons! By taking your wooden skewers, I want all of us to blow up our balloons and attempt to get the skewer completely through the balloon. *Do you think the balloon will pop?* This may seem a little crazy, but we will have to test out the experiment ourselves! Before we begin we need to make our first scientific hypothesis so, do you think the balloon will pop? Or is it possible to push the skewer through and through?

Preparation for the Teacher:

1. If students are unable to do the task it is likely because they are putting the skewer in the wrong way. Give students a new balloon and a marker. Have the following discussion before showing the correct way. This will assess understanding of the stress placed on the balloon:
2. Tell students to blow up the new balloon, and use a Sharpie to draw about 10-15 dots on the balloon. Be sure to draw them at both ends and in the middle of the balloon.
3. Inflate the balloon halfway and tie at the end. Observe the various sizes of the dots all over the balloon.
    a. Where are the dots on the latex molecules stretched out the most?
    b. Where are they stretched out the least?
4. Dip the wooden skewer in the vegetable oil and use your fingers to coat the skewer with oil.
5. Have them decide the best spot to put the balloon with the skewer
6. Have the students place the sharpened tip of the skewer on the thick end of the balloon and push the skewer into the balloon. Just use gentle pressure (and maybe a little twisting motion) to puncture the balloon.
7. Push the skewer all the way through the balloon until the tip of the skewer touches the opposite end of the balloon (other thick portion). Keep pushing until the skewer penetrates the rubber.
8. Gently remove the skewer from the balloon when you are done!

Closing Discussion:

There is a little secret behind being able to put the skewer through the balloon. The secret is when you find the parts of the balloon that have the least amount of stress or strain. Where would those spots be? The smaller dots on your balloon show areas of less stress, and those were found on both ends of the balloon! Under a microscope, you would see many long strands/chains of molecules that are called *polymers*. These polymers are so elastic that it makes the rubber stretch, but to be able to pierce through the balloon we pierce through the stretchy polymers!

For engineers, this is a way that they might understand stress and tension, just like when we tested the strength of our marshmallow towers! During the designing process, and before building, engineers must understand the stress of the materials they are using!

# Make Your Own Ice-cream Teacher Quick Sheet

(Physical sciences, earth science, life science, and chemistry)

Opening Discussion Points:

- Ask the children what they believe scientists do by simply asking "What do you think a scientist does?", and record the responses.
    - Give examples:
        - Scientists are trying to save polar bears and honey bees from becoming extinct
        - Scientist use zombies as a model for understanding the spread of contagious diseases.
        - Scientists use robots that might one day be able to do your chores!
        - Scientists are discovering new planets and stars as we speak
        - Scientists are designing life suits that simulate what it feels like at any age of your life
        - Scientist…. make the ice-cream you eat!!
- Ask these questions:
    - What is everyone's' favorite ice-cream?
    - What ingredients go into making ice-cream
        - Hold up ingredients to show they are right!
        - Ask what the salt is for?
        - How do we start with liquids and end with solids?

For the Teacher:

- Pass out the 'recipe sheet'
- Once the students have completed their trial runs, have then complete the steps again! Encourage students to change at least one ingredient and record/observe their results. On their worksheets—have the students describe their ice-cream based on: taste, smell, and any senses. Were the batches different? How does it compare to store brand?

Materials:

- Small zip-lock zipper style bags
- Gallon zip-lock zipper style bags
- ½ cup milk (per student)
- 1 tablespoon sugar
- ½ teaspoon vanilla extract
- 4 tablespoons of Kosher rock salt
- 2+ cups ice cubes
- Liquid measuring cups
- Measuring spoons
- Measuring Cups or scoops
- Paper Towels
- Recipes Sheet
- Large cooler (to keep items cold)
- Rags or hand towels to cover ice-cream bags when shaking
- Plastic spoons
- Any toppings (chocolate sauce, sprinkles, etc.)

Concluding Discussion:

- Who can tell me the freezing point of water?
    - *32 Degree Celsius*

- How did we end up with frozen ice-cream? The answer lies in the student's understanding of matter.
    - *The ice (solid) absorbs energy causing it to melt going into a liquid.*
- Where does the energy come from to change a liquid to a solid and vise versa?
    - *It comes from all around us, and in this case it came from anything touching the ice during the process*
- What did the salt do to affect our energy?
    - *The salt stops the melting process and lowers the freezing point of the ice, making it colder! This allows the milk to freeze why you were shaking the bag, so by adding the salt we lower the freezing point to 20 degrees Celsius! Just cold enough to make ice-cream!*
- Who can tell me what other parts of chemistry are we using? What do people use chemistry for?

## Make Your Own Ice-Cream Student Quick Sheet:

Ice-Cream Recipe:

- Small zip-lock zipper style bag
- Gallon zip-lock zipper style bag
- ½ cup milk
- 1 tablespoon sugar
- ½ teaspoon vanilla extract
- 4 tablespoons of rock salt
- 2+ cups ice cubes
- Hand Towel

After Adding Materials:

1. Shake your bag, with all of the contents, for 8-10 minutes! (Or until it feels like ice cream!
2. Enjoy!

# Back-up Units

## **Back-up Units: Materials List**

### Spacecraft on Mars

Materials:

- 2 worksheets
- 1 Styrofoam cup
- 3 Beakers or baby food jars
- 3 Soil samples (one in each jar)

(*Note*: this is a list of materials per group)

### Make Your Own Watercraft

Materials:

- Container filled with water
- 36 inches (1 yard) of transparent tape
- Paper cups (8-ounce or larger)
- 10-to 12-inch strip of plastic wrap
- 10 straws
- Towels (paper or cloth)
- Notebook/ paper and pen/pencil to sketch design
- 25 pennies
- A yardstick (or 3 rulers)

(*Note*: this is a list of materials per group)

## Lesson 1: Spacecraft on Mars

*(Engineering and Life Science)*

Group Size: 2 per group (3 groups)
Time: 1.5 Hour

Introduction:

Engineers design inventions and transportation devices that can explore environments that are unsafe for people like us! *Who can name some of these places?!* One of the most talked about environments like this is outer space! Engineers build robots that are made to look for signs of life (water?) on Mars. They designed rovers that come with many scientific instruments to investigate specific rock and soil targets. For example, these devices have microscopes that take pictures to show really up-close images of rocks, and even come with a tool that tests the rock and soil surfaces.

Explain to the students that today is (**state the current month and day**), 2032, and they have just successfully landed on Mars. Also, they are currently at the Mars Science and Engineering Research Station. *Ask the class if they are tired after their long journey?*

Tell the students they are not the first on this planet, and other scientists are trying to figure out the old question: "Is there life on Mars?" Explain that it is their responsibility to analyze the three soil samples that were collected by the previous manned mission to Mars and left at the Mars Space Station for them to test. By the end of the lesson, they should be able to tell you about life on Mars, and the contents of their soil!

Opening Discussion:

Before the children begin, they must be able to discuss what classifies something as 'living'.

- What are some things that might be found on Mars that would indicate the existence of life? *[Possible answers: water, fossils, vegetation or other life itself]*
- Can you find these sorts of characteristics by testing soil samples? *[Answer: Yes]*.
- Why are there so many different types of soil and why might some have evidence of life while others do not?
    - *[Possible answers: the existence of life may depend on – nutrient content of soil (can they eat in it), what the soil feels like (can they move through it), water content of the soil (can they get water from it), etc.]*

Show the students the examples of living and nonliving things that you have collected and ask students:

- "What characteristics make an individual item alive or not alive?"
    - *[Answers: growth; reproduction, replication or cell division; independent movement; evidence of metabolic processes (respiration, gas or solid material exchange); response to stimuli.]*
- List the answers on the board as student's answer, and pass out the *Are We Alone?* Worksheet
- No idea is too silly, and each student will have the chance to fill out the table on their worksheet before the activity begins
- Have the students state their hypothesis about what they think will happen

**SAFETY:**

- DO NOT RUB YOUR EYES AFTER TOUCHING SAMPLES
- DO NOT TASTE ANY OF THE SAMPLES

Materials (per group):

- 2 worksheets
- 1 Styrofoam cup
- 3 Beakers or baby food jars
- 3 Soil samples (one in each jar)

Procedure:

1. Pass out the worksheets
2. Fill out the "Criteria for Life" on the *Are We Alone?* Worksheet
    a. Fill out the characteristics on the left, and describe the function on the right
3. Distribute the samples (A, B, & C) to the groups
4. Each team should make a hypothesis about their soil samples and write it on their worksheet
5. Observe the samples, touch and smell them, but DO NOT TASTE! Record observations on Question 1
6. Each group will get a Styrofoam cup of hot water, carefully pour the water over **SAMPLE A** until the sample is covered with water
7. Carefully pour water over **SAMPLE B** until the sample is covered with water
8. Carefully pour water over **SAMPLE C** until the sample is covered with water
9. WAIT FOR 5 MINUTES. Now, observe the samples again and record in question 2
10. Analyze your findings and based on observations conclude if there is any evidence of life (Why is it alive?)
11. Complete questions 3 and 4 and discuss the rest as a class

Closing Discussion:

- You can have the students complete the *Are We Alone*? Worksheet
- Students can present findings in a discussion to their peer.
    - Talk about their trip to mars, what they found, and is there life on Mars?
- Ask the following questions and **write on the board**:
    - Name a living thing that grows?
        - *Plants, animals*
    - Name a living thing that reproduces, replicates, or divides itself?
        - *Bacteria, single-celled organisms, plants, animals*
    - Name a living thing that moves independently
        - *Any animal*
    - Name a living thing that produces gases and performs respiration
        - *Any bacteria, plant, and animal*
    - Name a living thing that responds to a stimulus for protection
        - *Any plant, animal, etc.*

Objectives/Outcomes:

1. Students are able to identify characteristics of a living thing
2. Children are able to explain why some living organisms survive better than other (dependent upon setting)
3. Children systematically investigate and analyze soil samples
4. Students are able to record their observations and conclude that life on Mars exists, based on the results of their soil samples (construct an argument)
5. Students are able to explain why engineers and scientists are interested in finding signs of life within soil samples

Common Core:

- Able to use data from a random sample to draw a hypothesis about an unknown population of interest. Students are able to generate multiple samples of the same size to gauge any variation in estimates or predictions. Gauge how far off the estimate or prediction may be (Grade 7)
- Construct an argument with evidence that in a particular habitat some organism can survive well, some survive less well, and some cannot survive at all. (Grade 3-6)
- Make observations and measurements to identify materials based on their properties (Grade 5-6)

Next Generation Science Standards:

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1)
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2- 1)
- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. (MS-LS4-4),(MS-LS4-5),(MS-LS4-6)
- Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena. (MS-LS4-4)

*Inspired by:* eGFI and NASA's Searching for Life on Mars and Destination Mars. (http://teachers.egfi-k12.org/are-we-alone/)

# Space Unit Teacher Worksheet

<u>Introduction:</u>

Tell the students they are not the first on this planet, and other scientists are trying to figure out the age old question: "Is there life on Mars?" Explain that it is their responsibility to analyze the three soil samples that were collected by the previous manned mission to Mars and left at the Mars Space Station for them to test. By the end of the lesson, they should be able to tell you about life on Mars. *Ask the class if they are tired after their long journey?*

<u>Opening Discussion:</u>

Before the children begin, they must be able to discuss what classifies something as 'living'.

- What are some things that might be found on Mars that would indicate the existence of life? *[Possible answers: water, fossils, vegetation or other life itself]*
- Can you find these sorts of characteristics by testing soil samples? *[Answer: Yes]*.
- Why are there so many different types of soil and why might some have evidence of life while others do not?
    - *[Possible answers: the existence of life may depend on – nutrient content of soil (can they eat in it), what the soil feels like (can they move through it), water content of the soil (can they get water from it), etc.]*

Show the students the examples of living and nonliving things that you have collected and ask students:

- "What characteristics make an individual item alive or not alive?"
    - *[Answers: growth; reproduction, replication or cell division; independent movement; evidence of metabolic processes (respiration, gas or solid material exchange); response to stimuli.]*
- List the answers on the board as student's answer, and pass out the *Are We Alone?* Worksheet
- No idea is too silly, and each student will have the chance to fill out the table on their worksheet before the activity begins
- Have the students state their hypothesis about what they think will happen

<u>Materials (per group):</u>

- 2 worksheets
- 1 Styrofoam cup
- 3 Beakers or baby food jars
- 3 Soil samples (one in each jar)

<u>For the Teacher (Set-up):</u>

- Create the soil samples for the students before the session begins
    - Soil Sample A: (**Physical change of sugar dissolving)**
        - 1 Teaspoon (5ml) of sugar mixed into less than ¼ cup (50ml) of sand or sandy soil

Soil Sample B: **(Seltzer contains a non-living chemical reaction)**

- 1 Teaspoon (5ml) of sugar and 1 Teaspoon (5ml) of active dry year mixed into less than ¼ cup (50 ml) of sand or sandy soil.
    - Soil Sample C: (**Yeast contains a living chemical reaction—long term)**
        - 1 Teaspoon (5ml) of sugar and 1 crushed Alka-Seltzer tablet mixed in with a little less than ¼ cup (50 ml) of sand or sandy soil
- Class will share hot tap water (**Not too hot---like bath water)**

- Have laid out 10 examples of living and non-living organisms (5 living, 5 non-living). This will start the discussion once you go through the lesson. (Examples: pencil, book, rock, plant, apple, grasshopper or other insect, etc.)

Closing Discussion:

- You can have the students complete the *Are We Alone*? Worksheet
- Students can present findings in a discussion to their peer.
    - Talk about their trip to mars, what they found, and is there life on Mars?
- Ask the following questions and **write on the board**:
    - Name a living thing that grows?
        - *Plants, animals*
    - Name a living thing that reproduces, replicates, or divides itself?
        - *Bacteria, single-celled organisms, plants, animals*
    - Name a living thing that moves independently
        - *Any animal*
    - Name a living thing that produces gases and performs respiration
        - *Any bacteria, plant, and animal*
    - Name a living thing that responds to a stimulus for protection
        - *Any plant, animal, etc.*

## Student Quick Sheet to Spacecraft on Mars

*Criteria for Life Table*

| FUNCTION: | DESCRIPTION OF FUNCTION: |
|---|---|
| | |
| | |
| | |
| | |

**Hypothesis for Experiment:** ____________________________________________
____________________________________________

**Before:** Before you begin the experiment, write down your observations of your samples.

**Sample A:** ____________________________________________
____________________________________________

**Sample B:** ____________________________________________
____________________________________________

**Sample C:** ____________________________________________
____________________________________________

**After:** After you finish adding hot water to your samples, take note of your observations.

**Sample A:** ____________________________________________
____________________________________________

**Sample B:** ____________________________________________
____________________________________________

**Sample C:** ____________________________________________
____________________________________________

| Sample | Contains Life | |
|---|---|---|
| | Yes? | No? |
| Mars Sample A | | |
| Mars Sample B | | |
| Mars Sample C | | |

*Inspired by:* eGFI and NASA's Searching for Life on Mars and Destination Mars. (http://teachers.egfi-k12.org/are-we-alone/)

# <u>Lesson 2: Make Your Own Watercraft</u>

*(Engineering, Buoyancy, Displacement)*

<u>The duration of the lesson:</u> 30 to 45 minutes
<u>Group Size:</u> 2-3 people per group

<u>Introduction:</u>

In this activity, students will learn about the Engineering Design Process when building a boat, in teams, out of straws and plastic wrap that can hold 25 pennies for at least 10 seconds before sinking. Also, students will learn about the physical principles of buoyancy and displacement.

You are attending a birthday party located in a house across Indian Lake, and you are in charge of bringing all the party supplies. The only way you can get across the lake is by a boat. You must build a boat that is able to carry all the supplies across the lake without sinking, or else the birthday party will be canceled. How are you going to build the boat? How will you make the boat strong enough to carry all the supplies?

<u>Opening Discussion Points:</u>

1. Introduce the challenge by telling the students that they will work with a partner to design and build a boat with materials such as straws, tape, cups, and plastic wrap that will be able to withhold 25 pennies, and can last a duration of 10 seconds without sinking. The Engineering Design Process will be used by the students in order to solve this problem and should be completed with limited time and materials.
2. Give the students some information as to why things float to help them understand the objective of this challenge. For example, ask them: *If you had a large and small empty soda bottle, both with their caps on, which bottle would be harder to keep down if you pushed them underwater?* (Answer: the big bottle)
3. Why? (As you are pushing the bottles down into the water, they will push water out of the way. This is called “displacement.” The water that is displaced, pushes back on the bottles with an upward force. This upward force is known as “buoyancy.” The more water that is displaced, the bigger the upward push of the water on the bottle. The bigger the bottle will displace more water than the smaller bottle, and thus, there is more force pushing it back up. The bigger bottle will have more buoyancy. The more buoyancy an object has, the higher it floats.)
4. Ask the students how they can design a boat, with the given material, that will displace a large amount of water or will be buoyant.
5. Ask the students to brainstorm and imagine possible ideas on how they will build their boats.
    a. What are the best materials to use when making a boat that is able to support a large load without it sinking?
    b. Should the boat be a flat platform such as a raft, or should it be an open boat?
    c. How big should your boat be in order for it to hold 25 pennies?
6. Allow the students to plan which type of boat they will create and build. Ask the students to fold a piece of paper in half lengthwise and again in half widthwise, creating four rectangular divisions on the paper.

7. Tell the students to draw four different types of boats, one in each rectangle, and then decide on which boat will work best based on the designs.
8. To create their design, students will acquire material from the materials table and will return to their workspace.
9. To test their designs, have the students place their boats in the water, and then add one penny at a time until it sinks or reaches 25 pennies.

Materials:
*Per team

- Container filled with water
- 36 inches (1 yard) of transparent tape
- Paper cups (8-ounce or larger)
- 10-to 12-inch strip of plastic wrap
- 10 straws
- Towels (paper or cloth)
- Notebook/ paper and pen/pencil to sketch design
- 25 pennies
- A yardstick (or 3 rulers)

Procedure for the Teacher:
Preparation:

- To set up the testing stations, follow the procedure below
- To avoid water spills, cover the surface on which the water-filled container will rest with either plastic wrap, recycled newspaper, or vinyl tablecloth.
- To avoid water spills, place the testing stations on a stable table or on the floor. Fill the containers about halfway (or less) with water. (Note: Do not fill the container more than halfway)
- Place the pennies in a cup near each of the testing stations.

Set up materials table:
**to manage traffic, it is preferred that the materials table is set up way from the testing stations*

- Use a yardstick (or tape down three rulers end to end) as a general measuring guide when dispensing tape and plastic wrap.
- The plastic wrap should be distributed upon request, as it sticks together and is difficult to handle. To limit the amount of plastic wrap that the teams can use, tear off approximately a 10-12 inch long strip for each group (the length doesn't have to be exact).
- The tape should also be distributed upon request. Tear off approximately 36in for each group (again, length doesn't have to be exact).

Conclusion/Closing discussion points:

1. Which boat design worked the best? Why?
2. How can you improve your boat to hold 50 pennies instead of 10?
3. What materials (that were not provided), can help make your boat stronger?

Objectives/Outcomes:

1. Identify how stability and buoyancy are related, and the tradeoffs between them
2. Understand the physical forces that allow objects to sink or float
3. Understand the engineering design process
4. Develop teamwork skills

Common Core State Mathematics Standards:

- Recognize volume as an attribute of 3-dimensional space and understand volume measurement concepts. (Grade 5)
- Solve mathematical problems that can apply to the real world. These problems involve area, volume, and surface area of 2- and 3-dimensional objects. (Grade 7)

Next Generation Science Standards:

- Engineering design: Analyze data from tests to determine similarities and differences among a few solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria. Ultimately, this will lead to successful results. (MS-PS3-3)

Activity Extension: (~25 minutes)
Using half of the materials, build a boat that can also hold 25 pennies for a duration of 10 seconds.

*Inspired by:* eGFI Teacher Resources (http://teachers.egfi-k12.org/watercraft/)

# Make Your Own Watercraft Teacher Quick Sheet

Intro:

In this activity students will be building a boat, in teams, out of straws and plastic wrap that can hold 25 pennies for at least 10 seconds before sinking. They will learn about the physical principles of buoyancy and displacement.

You are attending a birthday party located in a house across Indian Lake, and you are in charge of bringing all the party supplies. The only way you can get across the lake is by a boat. You must build a boat that is able to carry all the supplies across the lake without sinking, or else the birthday party will be canceled. How are you going to build the boat? How will you make the boat strong enough to carry all the supplies?

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*Per team

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Procedure:

Preparation:

- To set up the testing stations, follow the procedure below
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Opening Discussion Points:

1. Introduce the challenge by telling the students that they will work with a partner to design and build a boat with materials such as straws, tape, cups, and plastic wrap that will be able to withhold 25 pennies, and can last a duration of 10 seconds without sinking. The Engineering

Design Process will be used by the students in order to solve this problem and should be completed with limited time and materials.

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    a. *(Answer: the big bottle)*
3. Why? (As you are pushing the bottles down into the water, they will push water out of the way. This is called "displacement." The water that is displaced, pushes back on the bottles with an upward force. This upward force is known as "buoyancy." The more water that is displaced, the bigger the upward push of the water on the bottle. The bigger the bottle will displace more water than the smaller bottle, and thus, there is more force pushing it back up. The bigger bottle will have more buoyancy. The more buoyancy an object has, the higher it floats.)
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9. To create their design, students will acquire material from the materials table and will return to their workspace.
10. To test their designs, have the students place their boats in the water, and then add one penny at a time until it sinks or reaches 25 pennies.

Closer/Assessment:

1. Which boat design worked the best? Why?
2. How can you improve your boat to hold 50 pennies instead of 10?
3. What materials (that were not provided), can help make your boat stronger?

Activity Extension: (~25 minutes)

Using half of the materials, build a boat that can also hold 25 pennies for a duration of 10 seconds.

## Make Your Own Watercraft Student Quick Sheet

Materials:
*Per team
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