**Catapulting Into the Air Lesson Activity Template**

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| **5-Part Plan Title:** | **Catapulting into the Air** |
| **Engineering Grand Challenge Covered:** | **Restore and Improve Urban Infrastructure** |
| **Fellow Contributor(s) / Group Number:** | **Ifeoma Anyansi** |
| **Grade Level(s):** | **Grade 7 (6-8)** |

1. Subject/Subject Area: Simple Machines / Motion
2. Time Required: 60 Minutes
3. Expendable Cost Per Group: $5.00
4. Group Size: 2
5. Summary: The purpose of this experiment is to introduce the concept of simple machines to students. Simple machines are devices that make work easier. When a simple machine is used, the amount of effort a human needs to expend to do the same amount of work gets reduced. Examples of simple machines include: wheel and axle, inclined plane, and lever. In this experiment, students will understand the components of a lever and how it can be used to lift objects. Through understanding the science behind the levers, students will then act as engineers by using their scientific knowledge to build a compound machine, a catapult, which uses a lever to launch a projectile into the air.
6. Engineering Connection: The understanding of simple machines, the physical principles behind them, and how they can be combined to create better and more efficient tools for people to use is highly important. These same principles have been used throughout the ages in many engineering disciplines. Civil engineers use it to build structures while mechanical engineers apply these principles to continuously innovate and improve upon their devices. By designing more complex tools that lessen the amount of effort to do an equal amount of work, engineers help in solving everyday challenges.
7. Key Search Words: Simple Machines, Force, Work, Fulcrum, Load, Lever, Catapult
8. Educational Standards: NC Essential Science Standards: See attached standards grid for a complete mapping to all pertinent STEM standards.

K12:

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| 5.p.1.1 | 5.p.1.2 | 5.p.1.3 |
| 7.p.1.1 | 7.p.1.2 | 7.p.2.1 | 7.p.2.2 | 7.p.2.4 |

High School:

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| PSC.1.1.1 | PHY.1.2.1 |
| PSC.3.1.3 | PHY.1.2.4 |
| PSC.3.1.4 | PHY.2.1.1 |

Math:

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| 8.s.p.1 |

1. Learning Objectives (After the activity students should be able to):
   1. Explain what simple machines are and list some examples
   2. Describe the parts of a lever and what it does
   3. Understand that simple machines can be combined to form compound machines, in this case a catapult
2. Material List:
   1. 1 pencil, ruler, 10 pennies for one group (2 students)
   2. 9 popsicle sticks, 5 rubber bands, few marshmallows
3. Introduction:

What do axes, lawn mowers, screws, can openers, door knobs, and catapults all have in common? They all are compound machines that combine the principles of simple machines to make work easier for humans. Simple machines are just *that –* simple – and are made with few moving parts. They are beneficial because in using them, humans can exert less force and energy to do the same amount of work. For example, think of a sling shot. Is it easier to throw a stone at greater distances using your arm or a sling shot?

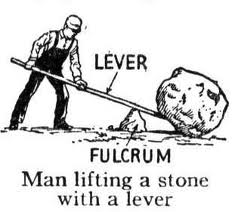
The scientific definition of work is defined as force x distance. Work is done when we apply a force (a push or a pull) to move an object over a distance. Remember, in order to do work, an object has to move. Thus, when you push down on the floor you are not doing any work because the floor is not moving. However, you are still exerting a force. Thus, simple machines are very important as by increasing the distance in which we apply a force, a smaller force can be used to achieve the same amount of work!

In this experiment we will be acting as scientists by learning how a lever works, and then incorporating this knowledge to engineer a catapult. Catapults which were discovered in about 400 BC by the mighty Greeks in the ancient land of Syracus were sometimes used as weapons to launch spears and stones. Nowadays, catapults can be used to carry and transport objects over great distances. This is just one of the countless examples of how simple machines can be used and combined to create better tools to benefit society! How do *you* use simple machines in your everyday lives?

1. Motivation

The motivation behind this activity is to familiarize students with the concept of simple machines and how they can be designed to create tools to help each other. Specifically, students will learn how levers work in order to make a catapult to launch projectiles (marshmallows) into the air. In doing so, students will be able to see firsthand, how with just a little bit of creativity and knowledge of physical principles can accomplish difficult tasks much easier and be encourage to create their own.

1. Vocabulary/Definitions
   1. Simple machines – a machine with few moving parts that make work easier.
   2. Compound machine – a machine that combines two or more simple machines
   3. Work - force x distance
   4. Force - effort (push or pull) required to do work
   5. Load – the object you want to lift or move
   6. Fulcrum – the point in which the lever turns or rotates
   7. Lever – A simple machine that consists of a beam (or rod/stick) that pivots about a point (fulcrum). It helps to lift heavy loads with less force or effort. Ex. See Saws or crow bars.



1. Procedure
   1. Lever Activity ( Have students fill out Lever Activity Sheet)
      1. Place pencil flat on desk.
      2. Lay 12-in ruler across the pencil so that the system looks like a see saw.
      3. Outline the parts of the lever. Pencil = Fulcrum. Ruler = Beam Pennies = Load and/or force depending on what you are using it for.
      4. Put 5 pennies on each end of the ruler and encourage students to find the point in which it balances.

*Answer: The middle of the ruler.*

* + 1. Tell students to take two pennies of each ends of the ruler. Where should the ruler balance?

*Answer: The middle as well.*

* + 1. Remove 3 pennies from one side and stack it on the other end’s pennies. Does it balance?

*Demonstrate that they made a lever. One side (two pennies) is lifting 4x (8 pennies) its weight.*

* + 1. Have students figure out a way to have two ends of the ruler to balance without adding any more pennies or moving the pennies. It can teeter totter; does not need to perfectly balance. If students are stuck, recommend that students move the fulcrum. Have students move the pencil around so that they can balance the two ends. Is the fulcrum closer to the load or force?

*Answer: Closer to load. Reiterate to students that the closer the fulcrum is to the load, the less force needed to lift it.*

* + 1. To demonstrate the above concept, have students place 4 pennies on each end of the ruler with the pencil in the middle. It should balance.
    2. Now move the ruler halfway to each side (so that it’s ¾ of the way along the length). How many pennies are needed to balance the ends now?
    3. Now move the ruler so that it’s right near the pennies on the left end. How many pennies are needed on the right side now to balance?
    4. Have students describe the relationship between the fulcrum, load, and force.

b. Catapult activity (Have students fill out the Catapult Activity Worksheet)

1. Place 4 Popsicle sticks on each other. Use a rubber band to tightly secure them together.

2. With the last two Popsicle sticks, tie one end together with a rubber band.

3. Slide the bundle of 4 Popsicle sticks in between the two Popsicle sticks in step 2 in such a way that it makes a cross. Make sure you slide the bundle all the way in.

4. Next, secure the two bundles together by repeatedly criss-crossing a rubber band at the point in which they meet.

5. Put a mini-marshmallow at the end of the stick that is angled upwards into the air and launch

6. (Optional). You can use a rubber band to secure spoon across the Popsicle stick to act as a “launching pad” for your projectile of choice.

1. Safety Issues and Guidelines

Carefully watch the students when they get to the point where they are launching their projectiles. If marshmallows are not available, cotton balls or similar soft items can be used, instead.

1. Trouble Shooting Tips: N/A
2. Contributors: Ifeoma Anyansi
3. Supporting Program: Duke Boeing Grand Challenge K12 Outreach Fellows Program
4. Sources

<http://teacher.scholastic.com/dirt/lever/lab.htm>

<https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=10&cad=rja&ved=0CFYQFjAJ&url=http%3A%2F%2Fwww.connectamillionminds.com%2Fassets%2Fmedia%2Fdownloads%2FTWC-Studios_History-Catapults.pdf&ei=gvoQU7TCEubr0gGx34CoAw&usg=AFQjCNEdrR7fHYfVZAomC9G2LJJaaYfs_g&sig2=M3AscOhTizxy8ck98c2UDQ&bvm=bv.62286460,d.dmQ>