# Title: Catapults are Cool STEM Challenge

**Estimated Time: 1-2 periods**

**Core Ideas (GSE Standard and elements):**

**S2P2. Obtain, evaluate, and communicate information to explain the effect of a force (a push or a pull) in the movement of an object (changes in speed and direction).**

a. Plan and carry out an investigation to demonstrate how pushing and pulling on an object affects the motion of the object.

b. Design a device to change the speed or direction of an object.

c. Record and analyze data to decide if a design solution works as intended to change the speed or direction of an object with a force (a push or a pull).

**S4P3. Obtain, evaluate, and communicate information about the relationship between balanced and unbalanced forces.**

a. Plan and carry out an investigation on the effects of balanced and unbalanced forces on an object and communicate the results.

b. Construct an argument to support the claim that gravitational force affects the motion of an object.

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**S8P3. Obtain, evaluate, and communicate information about cause and effect relationships between force, mass, and the motion of objects.**

b. Construct an explanation using Newton's Laws of Motion to describe the effects of balanced and unbalanced forces on the motion of an object.

| **Science and Engineering Practices:** | **Crosscutting Concepts:** |
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| **Planning and Carrying Out Investigations:**<br>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.<br>**Constructing Explanations and Designing Solutions:**<br>Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system. | **Structure and Function:**<br>The way an object is structured/designed determines many of its properties and functions.<br>**Stability and Change:**<br>For designed systems, conditions that affect stability and factors that control rates of change are critical to consider and understand. |

**STEM Challenge Overview:**

In this STEM Challenge, the student's task is to build a working model of a catapult that uses the force stored in a bent object to launch a marshmallow over a protective wall.

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| **Ask** | Have you ever wanted to launch something way farther than you could throw it? Have you ever craved to hurl something into the next county? Well luckily, we have a device called a catapult that can be used to launch lots of stuff a long ways without the help of an explosion. You can even use catapults to chuck pumpkins for Halloween. Check out the first few second |

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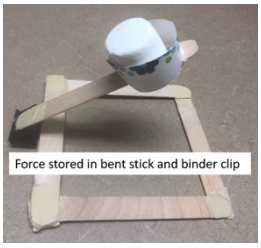
| | seconds of this video of a pumpkin chunking catapult. https://www.youtube.com/watch?v=qC6RJxFEMfY |
| **Imagine/Brainstorm** | Students **brainstorm** ideas for how they could design and construct their own catapult. The catapult should be capable of launching a marshmallow at least a few feet. After brainstorming, they should consider the strengths and weaknesses of each idea. |
| **Plan/Design** | In order to learn more about topic, have them read the ***Catapults are Way Cool*** article and discuss how catapults are used to launch objects into the air. It is a good idea to briefly discuss how catapults store forces that can then be used to push objects into the air.<br>After learning about catapults, students **plan** and **design** a simple model catapult that can shoot a marshmallow a measureable distance. Depending on the level of your students and the time you have for this challenge, you can make this open-ended or more of a guided inquiry for your students. If you take a more open-ended approach, provide a greater variety of materials that can be used to construct the catapult and encourage more out of the box designs. |
| **Create/Test** | Students follow their plan, and **create** their model catapult. Once it is created, students **test** their elevator in a measureable way to evaluate the effectiveness of their solution. In this case, they test to see if their catapult can successfully launch a marshmallow over the protective wall. Their results should be recorded, organized, and analyzed. |
| **Improve** | After discussing and evaluating their results, students improve their solution and re-test if possible. |

## Teacher Notes:


Forces are interactions between objects that cause a push or a pull between them. Forces can move objects that are at rest or stop objects that are moving. A **catapult** is a device used to launch an object a great distance without the aid of an explosive bang. Catapults have been used effectively for centuries especially for hunting and as weapons during times of war. The Greeks, Romans, and Vikings all used a variety of catapults as weapons of siege during times of conquest. Catapults were even used during trench warfare to launch grenades in World War I.




Catapults work by storing **force** either in twisted ropes, stretched bands, or flexed pieces of wood. The force stored in these bent objects is used to push other objects of choice into the air and toward a target. These objects might include an arrow shot from a bow, a pebble shot from a slingshot, or a boulder shot from a massive army catapult. Younger elementary students should understand that the force (push) supplied by the catapult can be used to change the motion of object of interest. The STEM Challenge also requires them to design a device (catapult) that can change the speed and direction of the marshmallow.

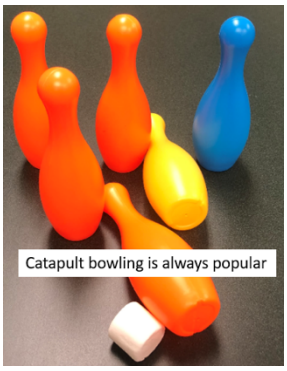
Older elementary students can also discuss how the unbalanced force provided by the catapult can be used to propel the marshmallow into space. They can use their observations and results to construct an argument to support the claim that gravitational force affects the motion of the marshmallow. The force of gravity is the attractive force between any two objects that have a mass and the amount of attractive force depends on the mass of the objects and the distance between them. Since the earth is by far the most massive object in our vicinity, it exerts the strongest attractive forces on the objects around it. Hence, the marshmallow is quickly pulled back to the earth.


This exploration can also be used in middle or high school to investigate Newton's Laws of Motion. Instructional focus could be placed on how the marshmallow at rest will stay at rest until the unbalanced force supplied by the bent stick acts on it to compel its movement (1st Law). In addition, the quantitative relationship be the force applied to the marshmallow, it's mass, and the acceleration it attains can be explored (2nd Law). An exploration of Newton's 3rd Law of Motion noting that for every action there must be an equal and opposite reaction can even be investigated.

In the STEM Challenge itself the students' task is to to build a catapult that can shoot a marshmallow as far as possible. If it seems to appropriate, you may challenge them to propel it over some type of barrier or wall. Perhaps the wall protects the fortress of an evil king and queen inside who cruelly rule over their suffering people. If you can bombard the fortress with deadly marshmallows from your catapult, the evil rulers will certainly be overcome and the people can be freed.

**The catapult should include a:**

1. Strong base
2. Fleixible arm to store the force
3. Cup or device to hold your ammo (this could be as simple as the end of a spoon).

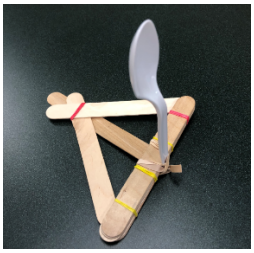


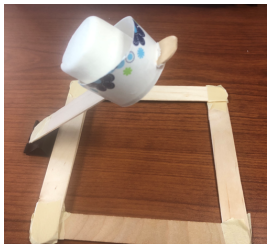

**Suggested materials for students to use:**

6 craft sticks, 6 popsicle sticks, 10 tiny craft rubber bands, 2 regular rubber bands, 10 inches of masking tape, 1 binder clip, 1 plastic spoon, dixie cup, 1 marshmallow

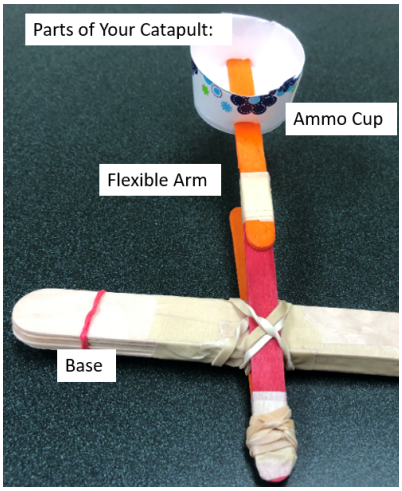
# Catapults are Cool STEM Challenge:

## Can you design, build, and test a model catapult that uses the force stored in a bent object to launch a marshmallow over a protective wall?





### Designing and constructing your elevator:




1. After learning about catapults, **plan** and **design** a simple model catapult that can propel a marshmallow over a protective wall.
2. Using the materials provided and your plan, **construct** your model catapult. Your catapult should include a base, a flexible arm to store the force, and a cup or device to hold your ammo.
3. As time permits, decorate your catapult to make it look as cool as possible.
4. Once the catapult is constructed, carefully **test** it trying it out with your marshmallow. Observe and record how it responds.

### Evaluating and Improving:

1. As a group, discuss how you were able to construct your catapult and explain how the catapult was used to store energy and then propel your marshmallow.

2. As a group, **evaluate** the effectiveness of your design and discuss how you would change your design moving forward to **improve** the performance of your catapult. If time permits, make these improvements and re-test.