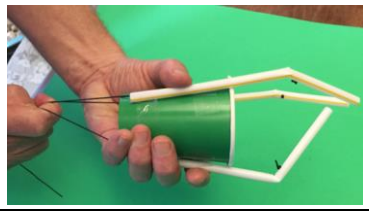


Title: Robotic Hand STEM Challenge

Estimated Time: 1-2 periods

Core Ideas (GSE Standard and elements):

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. c. Ask questions to identify and explain the uses of simple machines (lever, pulley, wedge, inclined plane, wheel and axle, and screw) and how forces are changed when simple machines are used to complete tasks. (Clarification statement: The use of mathematical formulas is not expected.)

S7L2. Obtain, evaluate, and communicate information to describe how cell structures, cells, tissues, organs, and organ systems interact to maintain the basic needs of organisms.
c. Construct an argument that systems of the body (Cardiovascular, Excretory, Digestive, Respiratory, Muscular, Nervous, and Immune) interact with one another to carry out life processes.

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.

Literacy Connections: Books	**Literacy Connections: Close Reads**
Zombies and Forces and Motion, Mark Weakland The Wild Robot, Peter Brown	Why our Hands are Super Handy CR ES Why our Hands are Super Handy CR MS
Science and Engineering Practices: **Developing and Using Models**: Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales. **Constructing Explanations and Designing Solutions:** Construct an explanation using models or representations.	**Crosscutting Concepts:** **Structure and Function:** Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function**.**

STEM Challenge Overview

Our hands are pretty amazing structures. They are made up of a combination of bones, muscles, joints, and tendons and together they provide us with some super effective tools.
But what happens if you get in an accident and lose one of your hands? Sadly, it happens to thousands of people each year.

Fortunately, we have groups of scientists, engineers, and doctors that work together to develop artificial body parts, including hands, that act as replacements for lost limbs. The science of developing robotic hands, along with other artificial limbs, is called prosthetics. Prosthetics are intended to restore as many normal functions as possible for the missing body part. In this STEM Challenge, your task is to design a simple robotic hand that can grasp and pick up a small object.

Ask	Allow the students to **ask** questions about artificial limbs (prosthetics) and discuss their importance with respect to the survival of living things. Present a few interesting examples. Have them read the ***Why our Hands are Handy*** article and discuss the exceptionality of the human hand.
Imagine/Brainstorm	Discuss the important qualities of prosthetic limbs and have students **imagine** how a simple model robotic hand could be constructed. Students **brainstorm** ideas that could serve as possible designs that could produce a simple but functioning limb. After doing so, they should consider the strengths and weaknesses of each idea before deciding on which idea they think will provide the best solution.
Plan/Design	Students **plan and create** a design for their robotic hand. This may include a diagram (sketch) of the hand and/or a procedure as well as a list of any additional materials they may need to build the hand.
Create/Test	Students follow their plan, build their robotic hand as they **create** a potential solution to their problem. Once it is created, students **test** their hand in a measureable way to evaluate the effectiveness of their solution.
Improve	After discussing and evaluating their results as a group, students suggest ways they could **improve** their robotic hand. Following this evaluation, students should attempt to improve on their solution and re-test.

Teacher Notes:

Background:

As discussed in the article, our hands are pretty amazing structures. Multiple body systems assist the functioning of our hands including the skeletal, muscular, nervous, circulatory, and integumentary system. Made up of a combination of bones, muscles, joints, and tendons they provide us with some super effective tools. While the joints provide places for things to bend, muscles in the hand help move our fingers apart and together. But, surprisingly, the muscles that provide most of the force to your hands are located in our forearm. These muscles can work from a distance because they are attached to the bones in your fingers by long string-like cords known as tendons. So bones, joints, muscles, and tendons work together allowing us to complicated stuff like texting on your phone, playing an instrument, or brushing our hair.

In this STEM Challenge, students consider what happens to people who lose a limb due to an accident, disease, or other cause. They read how scientists, engineers, and doctors have worked together to develop artificial body parts, including hands, that act as replacements for lost limbs. The science of developing robotic hands, along with other artificial limbs, is called prosthetics. Prosthetics are intended to restore as many normal functions as possible for the missing body part.

A person's artificial limb (prosthesis) is designed to enhance both the function and lifestyle of the patient. Some of the most important qualities for a good prosthetic limb include strength, durability, longevity, shock absorption, lifelikeness and comfort. Biomedical engineers research and design new ways to create prosthetic limbs that incorporate as many of these characteristics as possible. In addition, new cutting edge materials such as Kevlar, titanium, and carbon fibers provide excellent strength and durability while keeping the prosthetic limbs as light as possible. Thanks to lots of hard work and ingenuity, prosthetic limbs are continually improving.

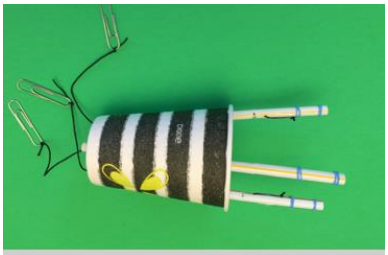
In robotics, the part of the robot that interacts with the environment is called an end effector. End effectors are designed very differently depending on the task they are intended to perform. This STEM Challenge asks students to design a simple robotic hand (end effector) that can grasp and pick up a small object.

Teacher Tips:

While the best content fit for this lesson is human body systems, the engineering applications make it a useful and worthwhile activity for a variety of classes. You can make this a very open-ended challenge or more of a guided inquiry depending on the time available and level of your students. The materials used are cheap and readily available. If possible, I would recommend heavy duty straws (McDonald's works great and they will happily donate) and braiding chord (super cheap) instead of regular string as it is very easy to thread through the straws. Cups work very well for the base of the hand and placing the fingers at the brim of the cups helps space them far enough apart to work effectively. Both paper towel and toilet tissue rolls also work well.

Here are some photos to guide you as facilitate the design of the robotic hands:

Toothpick works best with thin straws

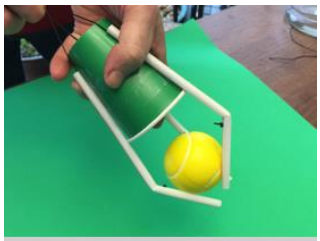


Can attach paperclips to the end of the tendons

Bottom of cup can stabilize fingers

Rubber bands can improve grip

3 sample designs

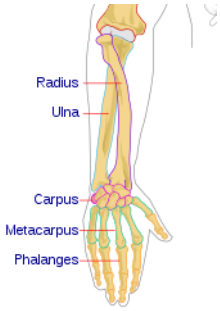
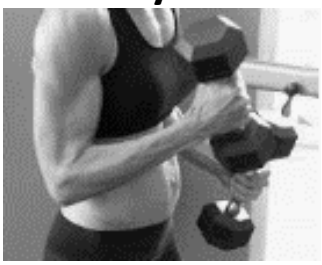
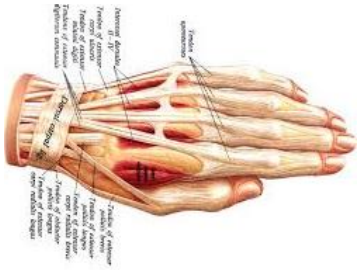
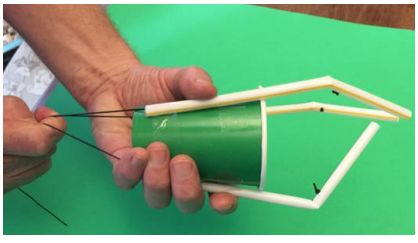


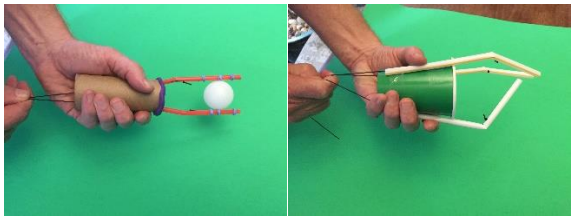
Foam or ping pong balls work great

Materials Needed (per group):

Cup, paper towel roll, or toilet paper roll (let kids choose if possible)
5-6 Drinking straws (the thicker the better but all work okay)
Braiding chord (or string) - 30 inches or so
Sharp pencil or toothpick
Scotch tape and/or a couple of mounting squares (Dollar Store)
Mini-rubber bands (if possible)
Piece of clay or Playdoh (if possible)
3-4 Paper clips
Scissors

Vocabulary Cards:

force **a push or pull** 	**prosthetics** **the science of making artificial body parts** 
bones **hard tissues that forms the skeleton of a body** 	**muscles** **tissues that produce movement by contracting** 
tendons **tissues that attach muscles to bone** 	**engineer** **to design, build, and improve things** 



Robotic Hand STEM Challenge:

Can you design and build a simple robotic hand that can pick up a small object?

In this STEM Challenge, your task is to design a simple robotic hand that can grasp and pick up a small object. When people lose a limb due to an accident or disease, scientists, engineers, and doctors work together to develop artificial replacement for the lost limb. The science of developing robotic hands, along with other artificial limbs, is called prosthetics. Prosthetics are intended to restore as many normal functions as possible for the missing body part. Some of the most important qualities for a good prosthetic limb include strength, durability, longevity, shock absorption, lifelikeness and comfort. In this challenge, our primary task will be to build a simple hand that can function to pick up small objects.

Criteria of the challenge:

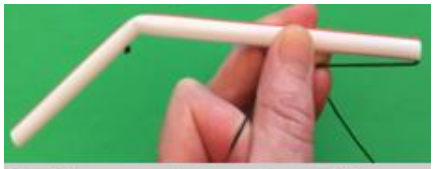
- You will have straws, string, a sharp pencil or toothpick, scissors, scotch tape, and mini-rubber bands to design the "fingers" of your robotic hand.
- You will have paper cup (or toilet paper roll), scotch tape, scissors, and two mounting squares, and a piece of clay or Playdoh to design your "hand".
- Your hand should be able to pick up a ping pong ball and/or a small ball or foam toy for at least 5 seconds.

Constraints of the challenge:

- You are limited to the materials provided by the teacher.
- You must complete the challenge by the end of the allotted time.

Procedure:

1. Using your scissors, cut a triangular joint about 1/3rd down your straw.
2. Using a sharp pencil or a toothpick, poke a hole for your tendon (string) about 1 cm from the joint.
3. Insert your tendon into your finger and tie it to the straw (bone).
4. Repeat this process to construct as many fingers as you need (2-4 recommended).



Plan/Create/Test

1. With your partner, brainstorm ideas regarding how you **plan** to attach the fingers to the base of the hand. For the base, you can use a cup of your choice, a toilet paper tube, or a paper towel tube. Develop a design for your hand and sketch and label it in detail.

2. Follow your plan and build your robotic hand as you **create** a potential solution.

3. Once it is created, students **test** their hand in a measureable way to evaluate the effectiveness of their solution.

Plan:

Improve

4. After discussing and evaluating your results as a group, discuss ways that you could **improve** your robotic hand. Make at least one improvement and re-test to see if it was beneficial.

Class Discussion/Wrap-Up

1. Compare your design to those of other groups. How did your design compare with other groups?

2. Describe how the hand uses a combination of bones, muscles, joints, and tendons to allow the hand to accomplish many different functions.

3. Some of the most important qualities for a good prosthetic limb include strength, durability, longevity, shock absorption, lifelikeness and comfort. Suggest one thing that you could do to improve your robotic hand with respect to one of these qualities.

4. Do you think that STEM Challenges like this are useful and helpful learning experience? Explain your answer.