Biomedical Engineering Activity – Building a Biomechanical Hand

Background and Introduction: 15 - 20 minutes

Group Discussion: Biomedical Engineering

Pose the following questions to the group and let discussion flow naturally. Try to give positive feedback to each student that contributes to the conversation.

1. What do you think **bio** (biology) means?
   - The study of life and a branch of the natural sciences that studies living organisms and how they interact with each other and their environment.
   - The study of the environment.
   - The study of living organisms and living systems.

2. What do you think **engineering** is?
   - A technical profession that applies skills in:
     - Math
     - Science
     - Technology
     - Materials
     - Anatomy
     - Environmental Studies

3. Discuss with the students what biomedical engineering is and the broad scope of areas that biomedical engineering includes. For this discussion, provide students with examples of biomedical engineered products and applications.
   - Biomedical Engineering applies engineering principles in the fields of medicine, biology, robotics, and any other living system.
   - Examples of products that have been bioengineered are:
     - Prosthetic Joints
     - Artificial Limbs
     - Hearing Aids
     - Artificial Organs – Heart, Lungs, Etc.
     - Dialysis Machines
     - Contact Lenses

Examples of Bioengineered Products

Prosthetic Legs

Hearing Aid

Dialysis Machine

Biomechanical Hand

Prosthetic Arm

Magnetic Resonance Imaging (MRI) Machine

Mechanical Hand Activity Introduction:

Today we are going to be **mechanical engineers** and **biomedical engineers** who will work together to design a **biomechanical hand**. Remind the students that mechanical or robotic limbs can serve different purposes. They can help people with disabilities live a more normal life by serving as an artificial limb. They can also help doctors perform complex medical procedures. As new technologies become available, there becomes new ways to use these technologies to make human life better.

Pose the following questions to the group:

1. What are Prosthetics? An artificial extension that replaces a missing body part lost by injury, missing from birth, or to supplement a defective body part.

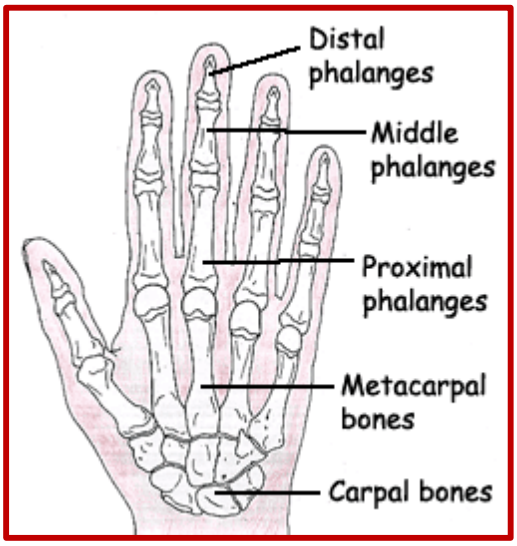
2. What is Biomechanics? The application of mechanical principles to living organisms. Creating a model of a human joints. Designing prosthetics, such as an arm, leg, knee, elbow, teeth, or hip. Designing robots.

3. Why would someone need a mechanical limb?
   - To replace a lost or missing limb.
   - To perform a task that cannot be done by a human.
   - Increase strength or motion of human limb.

4. What do engineers need to know to create a mechanical model of a body part?
   - Range of motion
   - Strength
   - Size
   - Location
   - Shape
   - Purpose

Group Discussion on the Anatomy of the Hand:

A hand has 5 fingers with multiple joints. These joints are controlled by muscles and tendons. The muscles pull on the tendons which will pull on the joints and make them bend.



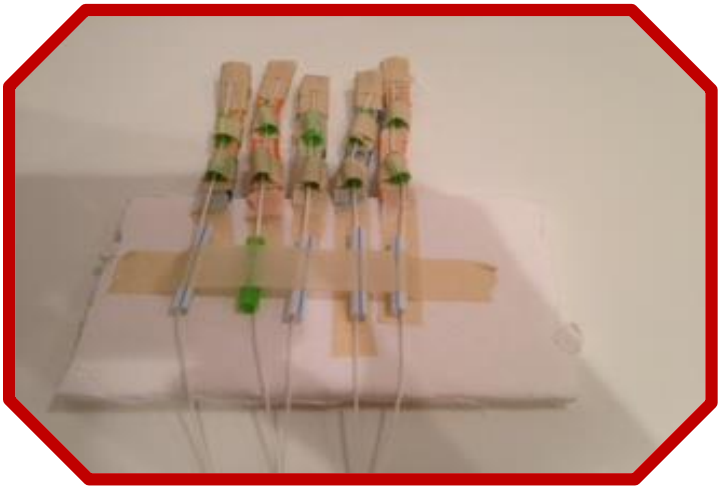
The hand and wrist have 27 bones: 8 wrist bones, 5 bones in the palm, 3 bones in each finger, and 2 bones in thumb. The hand also has 2 main sets of muscles and tendons. The flexor muscles bend the fingers and the thumb and are connected to the underside of the forearm. The extensor muscles are connected to the top of the forearm.

There are approximately 20 muscles in the hand and another 15 in the forearm that work to make the hand do its jobs.

Ask these questions to the group:

1. What are the jobs of the bones in your body?
   a. Food digestion
   b. Movement
   c. Sense the world around you
   d. Support, structure, and protection - Answer
2. How do your bones move?
   a. With Nerves
   b. With your muscles – Answer
   c. On their own
   d. With your respiratory system
3. What jobs do your muscles perform in your body?
   a. Support your body
   b. Give you strength
   c. Make you look cute
   d. Give your body motion – Answer
4. What connects bones and muscles together?
   a. Ligaments
   b. Tendons – Answer
   c. Nerves
   d. Cartilages
5. Which muscles move your bones
   a. Smooth
   b. Cardiac
   c. Skeletal – Answer
   d. All of the above

Biomechanical Hand Instructions - 75 – 80 minutes

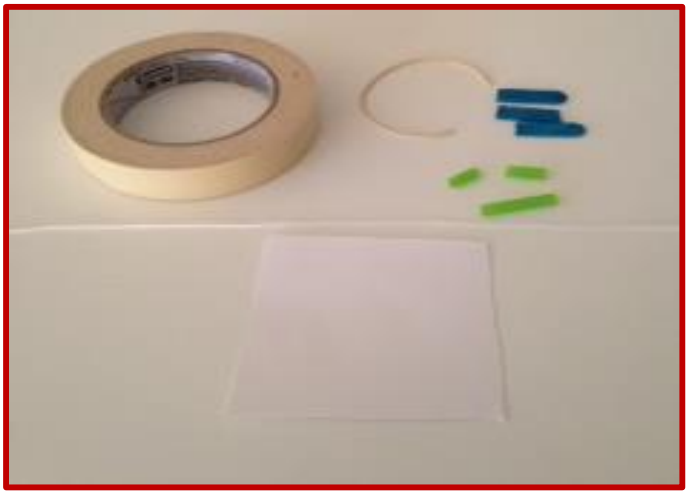


What we are going to do today as **biomechanical engineers** is to use wood, string, rubber band, straws and cardboard to make a **biomechanical hand** and try to pick up an object. The gaps in the wood that have tape with serve as your joints. The string through the straws and rubber band will ask as your tendons. Pulling on your string will cause your joints to bend.

Students should work in pairs to create their mechanical hand. They will have material to create 5 fingers on their hand but can create only 3 if that's all time allows. They will also have the option to create the fingers with larger pieces of wood. There is enough in the kit for a 3 finger hand with the larger wood. The instructions use specific materials but there are some different string types in the kit if the students want to use those instead.

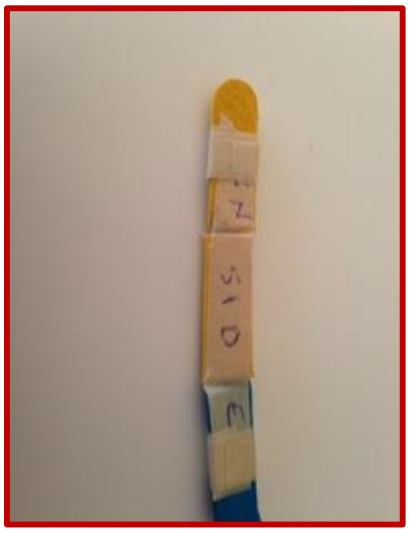
After construction of their hand, have the students try to operate their hand and pick up items at the table such as a small piece of paper, a coin, etc. These are in you kits. Also there are items such as magnets, double stick Velcro, and double stick tape that the students can choose from to put on the tips of the fingers in order to pick up the objects with their biomechanical hands.

Materials:



- Masking Tape
- 9 Pieces Popsicle Size Wood (1/2 in each) (3 pieces per finger)
- 9 Pieces Jumbo Size Wood (1/2 in each) (3 pieces per finger)
- 3 Pieces of Rubber Band (1 piece per finger)
- 1 String – approx. 12 inches
- 1 Piece of Cardboard (or Whiteboard) – 3 in x 3 in
- 15 Pieces of Straw (1/2 in or less)
- Different string types are in the kit if the girls want to change

Instructions:



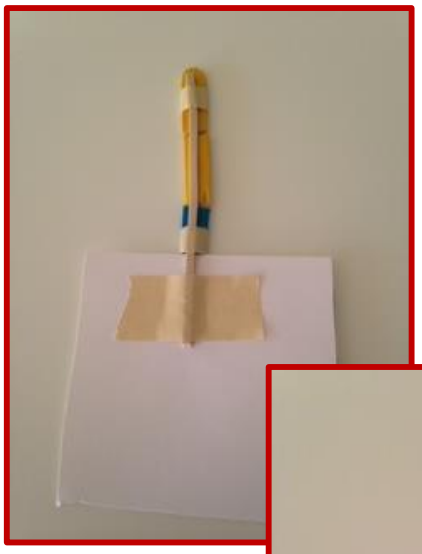
1. Lay the three pieces of wood next to each other the long way (like a finger).
2. Tape across the two seams in the middle of the finger; label this side the “Inside”.

3. Turn the finger over (so the inside is face down) and place the rubber band down the middle of the finger sections as shown.
4. Tape around the middle of each end piece of wood making sure to leave the ends of the elastic un-taped and hanging over one side, as shown. Make sure you tape the rubber band tightly.
5. Bend the short end of elastic over the tape and tape around the finger once more to prevent the rubber from slipping

6. Turn the finger over (so the inside is face up) and tape the finger to the piece of cardboard (the hand).

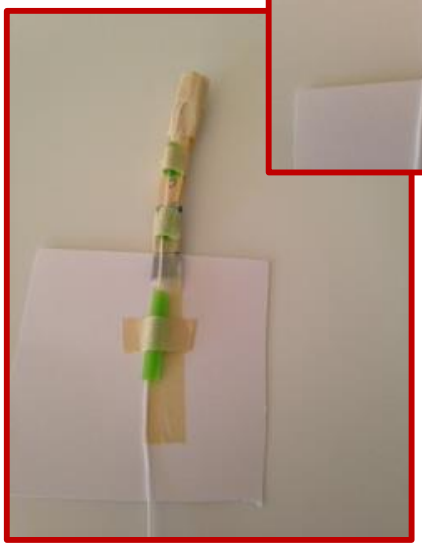
Instructions - Continued:

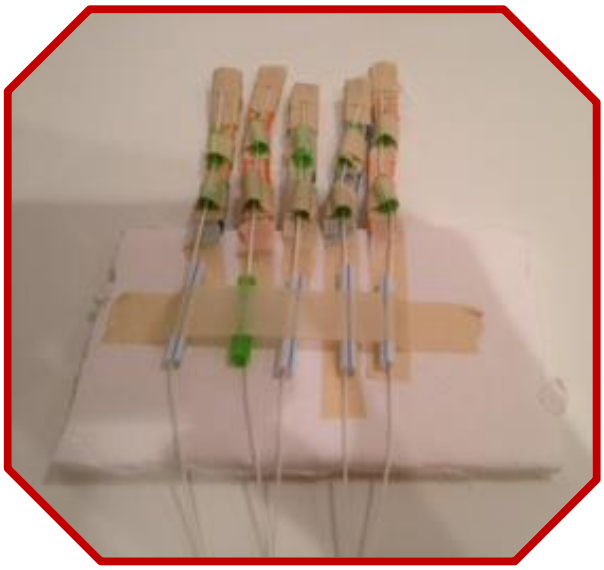
7. Turn the hand over and tape the rubber band to the hand.



8. Turn the hand over and tape the piece of string over the end of the finger.

9. Thread the string through 3 pieces of straw.
10. Tape 2 straws in the middle of the lower two finger sections and one to the hand as shown below.





11. Repeat for however many fingers you want to add. Then, operate the finger by pulling the strings.
12. Using their hands, have the students try to pick up items at the table, such as a small piece of paper or coin. Also, there are items such as magnets, double stick tape, and double stick Velcro that the students can put on the tips of the fingers in order to pick up the objects with their biomechanical hands.

Concluding Discussion: 10 Minutes

What were you able/unable to pick up with your hand?

What were some of your limitations?

- Strength of material
- Size of fingers
- Spacing of fingers
- Shape of hand/fingers

What are some improvements you would make to your mechanical hand to make it work more like your real hand?

- Use a stronger material. (metal or plastic)
- Use a material with more friction
- Make a thumb