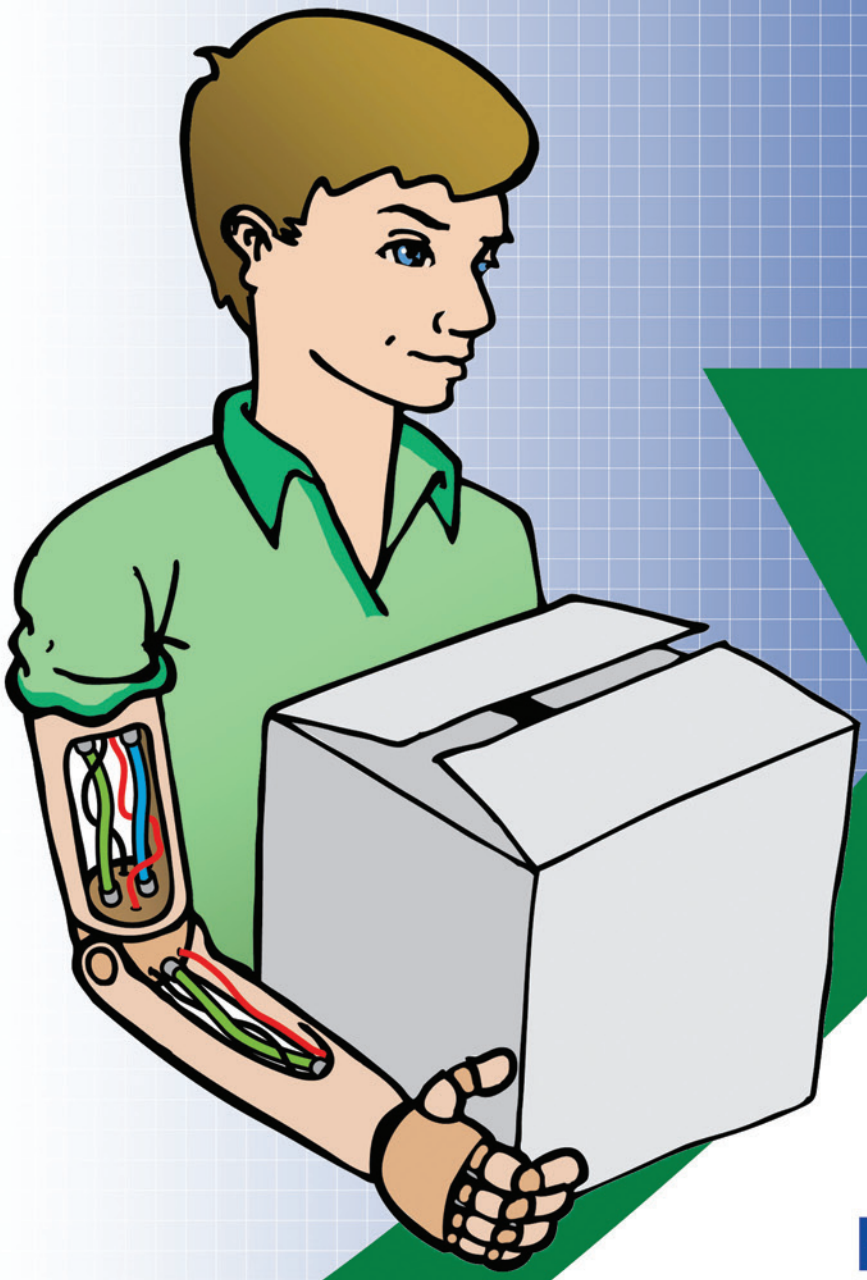

BioMedTech:
Bionic Arm

Pratt School of Engineering, Duke University

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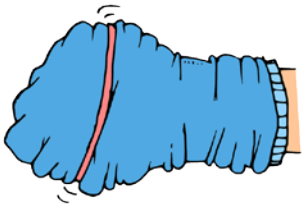
Discover Engineering

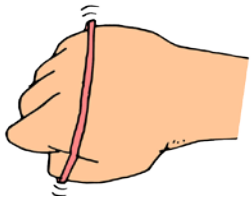
Student Handouts

Activity 1: Assistive Technology

Name: _____ **Date:** _____

1) Place your hand inside the sock and make a fist. Now wrap the rubber band around your fist so that your thumb and fingers cannot move.





2) Your mystery container holds six objects. Without peeking, take turns reaching into it using the hand with the sock on it. Try to identify the objects inside without opening your fist. Do not remove the items from the container. Continue taking turns until each of you has attempted to identify all the objects. Guess the identity of the six objects you touched and list them on the left side of the chart.

3) Which items are you confident your group guessed correctly? _____

4) Now, still without looking, take turns feeling the objects with the hand that isn't wearing a sock. If you would like to make any changes to your list, enter your corrections on the right side of the chart.

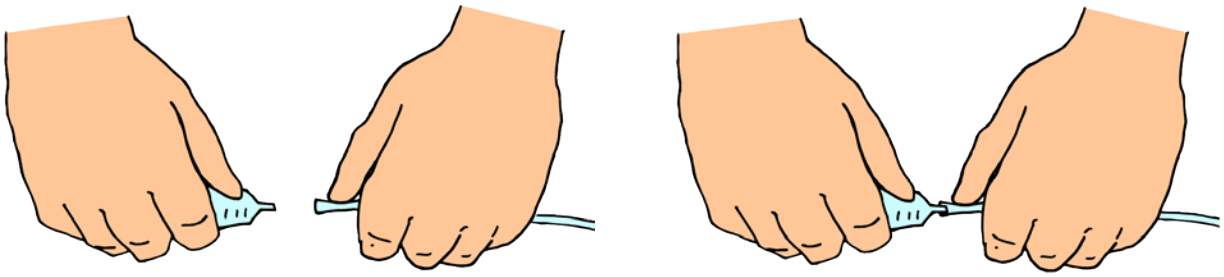
Item	Using hand in sock (impaired)	Using hand without the sock (unimpaired)
1		
2		
3		
4		
5		
6		

Activity 2: Gases and Liquids

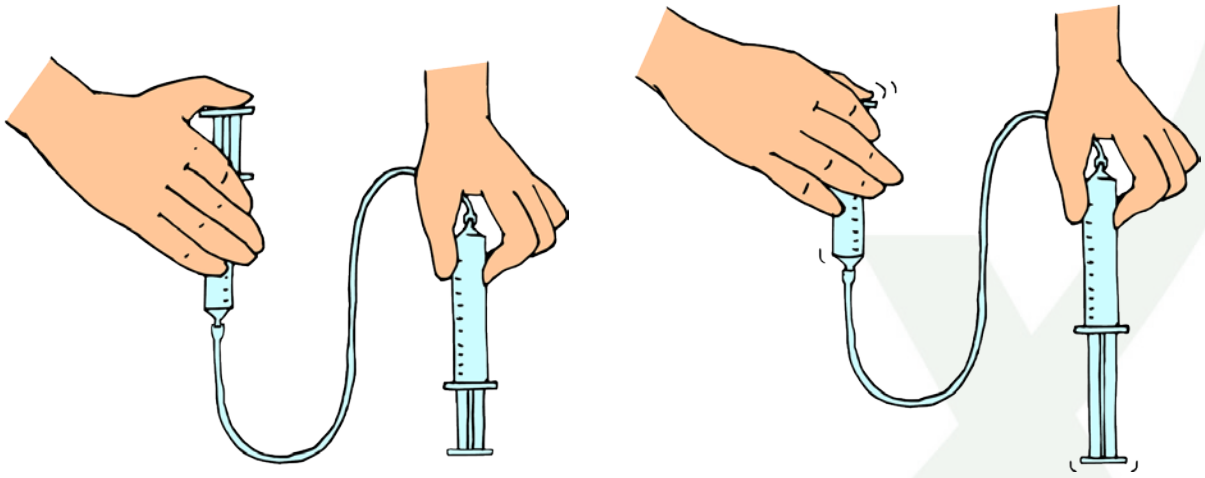
Name: _____ Date: _____

Exercise 1: Transferring Motion Using Air

1) Retract the plunger of one syringe all the way and press the plunger of the other syringe all the way in. Now attach the tips of the syringes to the ends of the tube.

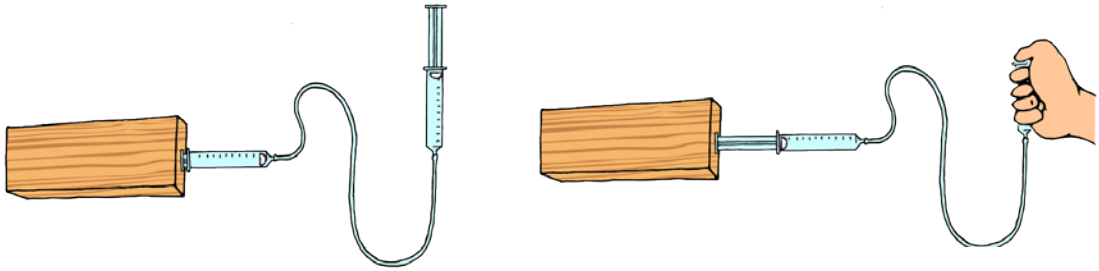


2) To do the experiment, press the retracted plunger all the way in. This motion will push air through the tube and cause the plunger in the other syringe to retract.



Activity 2: Gases and Liquids

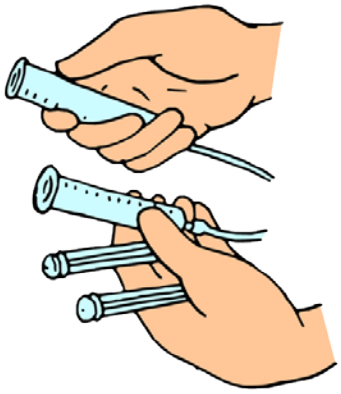
The system you have made transfers motion using air pressure. It is called a pneumatic system. There are many ways to transfer motion. For instance, you could move a wooden block by pushing it with a rod. Or you could move the block using the system you just designed. Why might an engineer want to move an object using air pressure instead of moving it with a rod?



Exercise 2: Transferring Motion Using Water

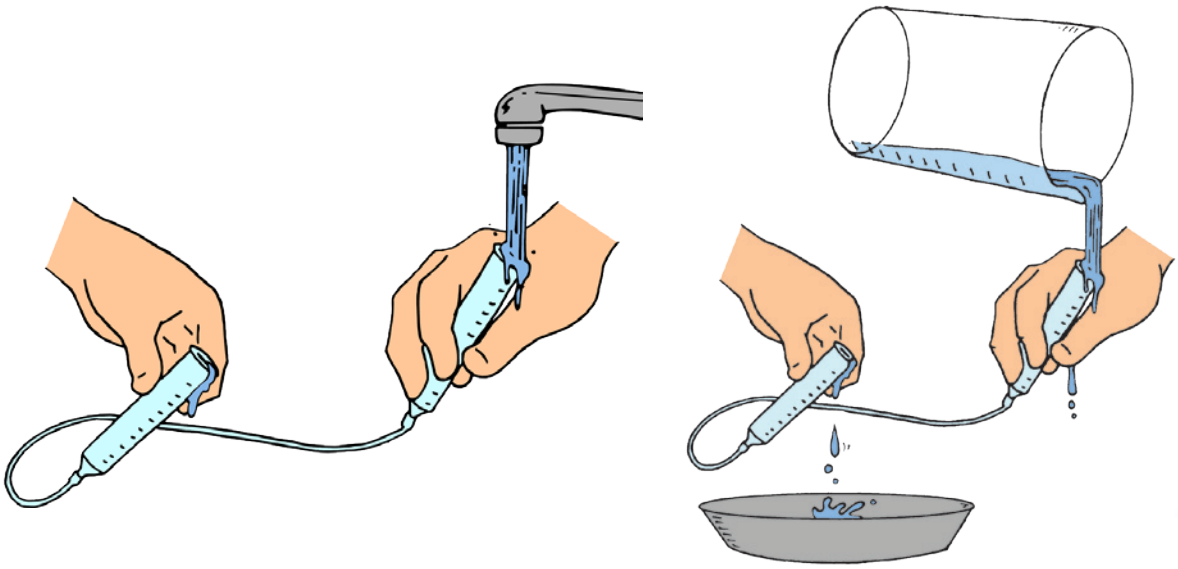
Your instructor will help you and your partner fill one of your systems with water. Pay close attention, as you may have to refill it yourself if you spill any water later. Here are instructions for your reference:

1. Remove plungers from the two syringes.

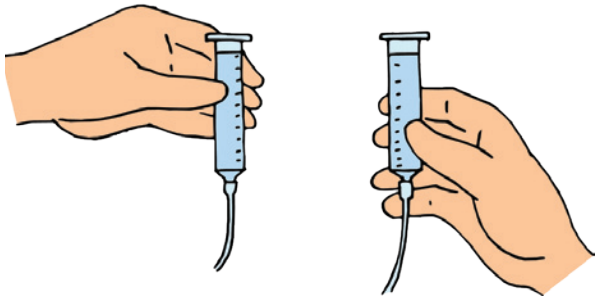


Activity 2: Gases and Liquids

2. Pour water into one empty syringe while tilting the other one over the drain. Hold the second syringe slightly lower than the first. The height difference will help the water to flow into the system.

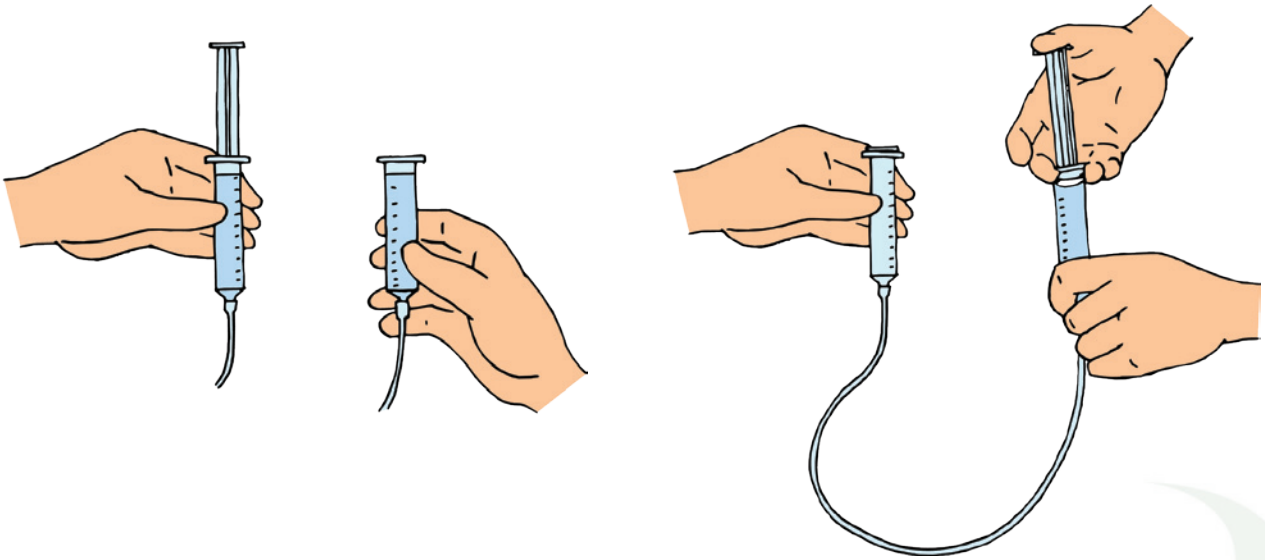


3. When the system is filled with water, hold both syringes level so that water doesn't spill from either end.

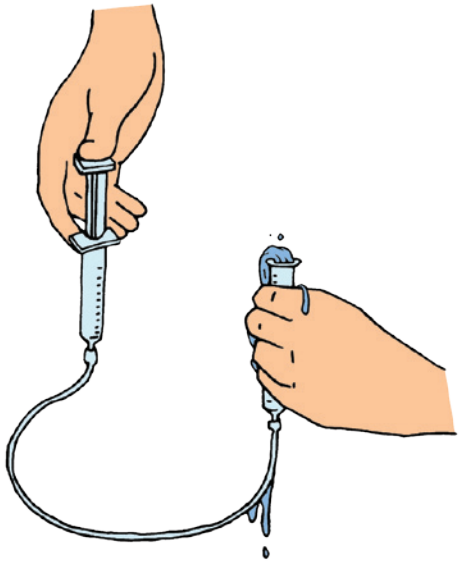


Activity 2: Gases and Liquids

4. While holding your system over a catch basin, insert a plunger into one of the syringes and push it all the way in. Excess water will flow out the top of the other syringe. Now put a plunger into that syringe and gently press down. This should cause the syringe at the other end to retract. Be careful not to push so hard that the other plunger pops off the tube.



You have now created a system for transferring motion using water. It is called a hydraulic system.



Activity 3: Making the Arm

Name: _____ **Date:** _____

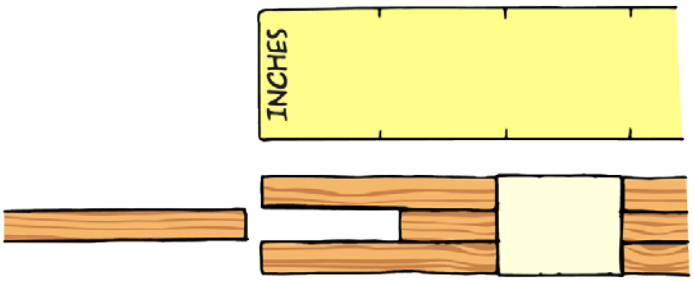
Exercise 1: Building the Arm Prototype

You will be building a prosthetic arm that bends at the elbow. You must devise a way to make the arm move using the hydraulic or pneumatic system you built during the last class.

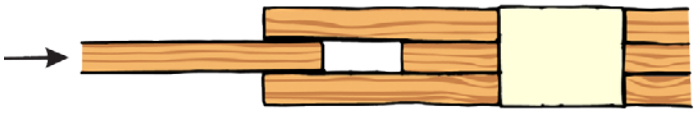
Assembling the Arm

Once you receive the materials, follow along with these directions as your instructor describes how to put the arm together.

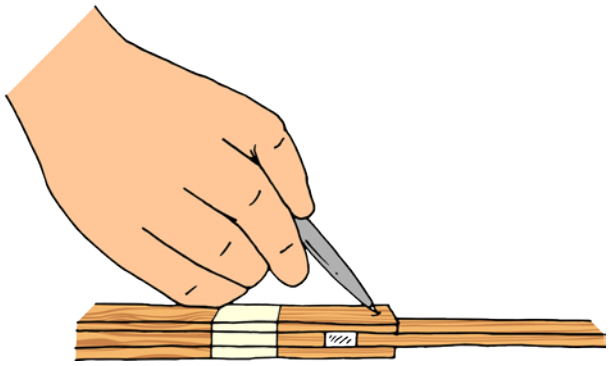
1. Join three strips of balsa wood in layers, keeping the outer two strips 1 inch longer than the inside strip. This will create a 1-inch notch, as shown. Wrap with masking tape at both ends.



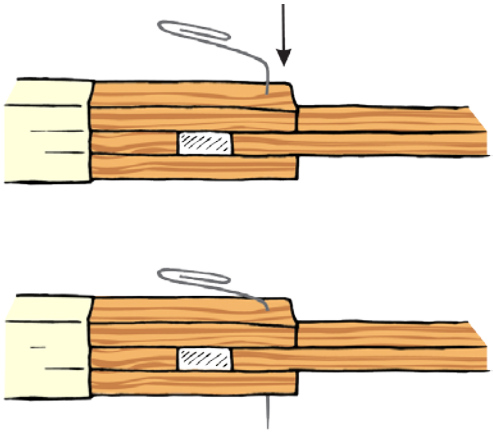
2. Insert the remaining piece of balsa wood ½ inch into the notch. This will create a ½-inch slot.



Activity 3: Making the Arm



3. Partially unfold the paper clip. While holding the strips securely to the table, push the paper clip slowly and firmly through all three layers, as shown. This will create a hinge. If it is difficult to insert the paper clip, your instructor can provide you with a nail to make the hole.



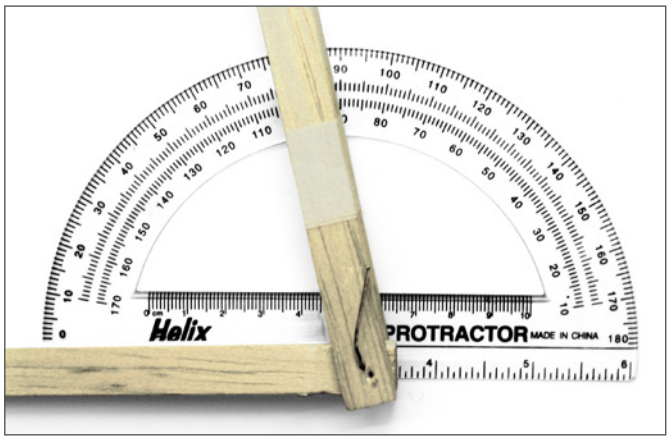
4. Bend the ends of the paper clip so that it will not slide out. Now your hinge is complete.

Activity 3: Making the Arm

Exercise 2: Using a Protractor

In the upcoming design challenge, your objective will be to give the prosthetic arm the greatest range of motion possible. Ideally, a person would be able to extend his or her arm straight out (180 degrees). When the elbow bends, an angle is formed at the inner part of the elbow. To measure the angle, you'll need to use a protractor.

In the first picture, the elbow is bent at a 76-degree angle.



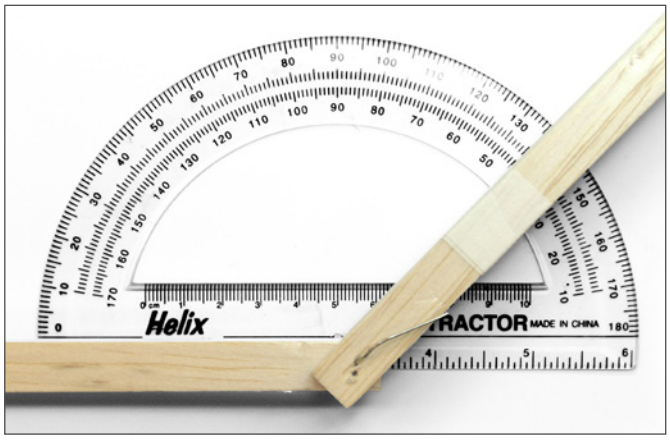
To measure with the protractor:

1) Align one of the sticks with the black line that is near the straight edge of the protractor.
2) Align the inner "elbow" of the sticks with the tiny hole in the protractor.
3) Read the number where the inner edge of the second stick crosses the top of the arc.

As you can see, the protractor has two sets of numbers. Use the one that starts at zero on the horizontal.

Activity 3: Making the Arm

The next picture shows the arm extended at a 135-degree angle.



How many degrees is the angle shown in the following picture? _____

Activity 3: Making the Arm

Engineering Design Challenge – Moving the Arm:

Engineers design systems within particular design constraints. Whenever we provide you with an engineering design challenge, we will give you specific constraints. For today's challenge, you are to devise a way to make the arm move using either pneumatic or hydraulic motion. Your ultimate goal is to obtain the largest range of motion possible.

Engineering Design Constraints:

a. Only one syringe may be attached to the arm. Movement must be controlled using only the unattached syringe.

b. The forearm must move out (straight position) and back (bent position).

c. The elbow must not open wider than 180 degrees.

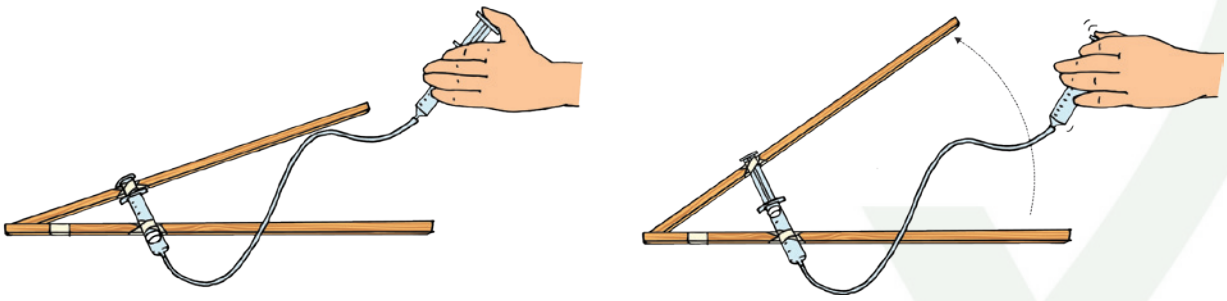
d. You may use one or both pairs of syringes.

e. You may use either the hydraulic system or pneumatic system.

f. You may use only the materials provided.

g. You have a specified amount of time to complete the design.

Note that you can obtain a small angle by mounting the syringe as pictured. Your task is to increase that range of motion following the above guidelines.

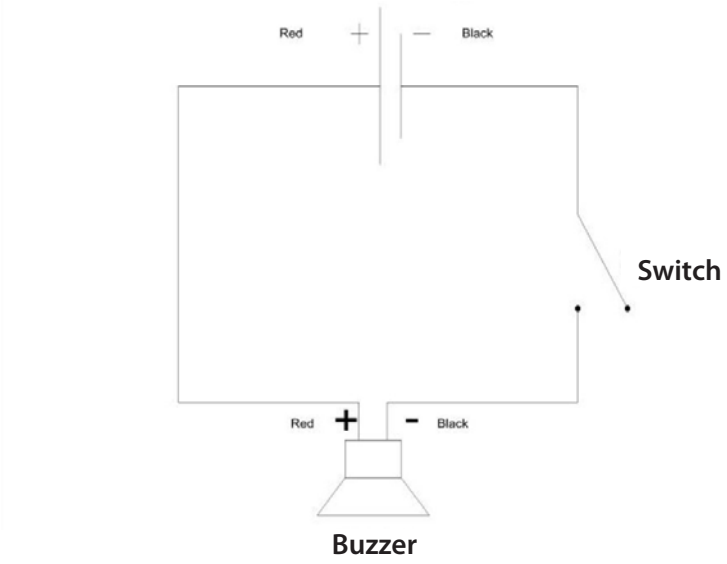


In the next activity, you will work on creating a sense of touch for the arms.

Activity 4: Prototype Buzzer Circuit

Name: _____ Date: _____

Buzzer Circuit **9 Volt Battery**



Materials:

- Three wires with alligator clips
- One 9-volt battery
- One 9-volt battery snap
- One buzzer
- One push-button switch

Rules:

- Do not lose any of your parts. They are expensive and will be used by other classes.
- Do not connect the battery terminals to each other. This will cause the battery to discharge ("go dead"). The battery will heat up as it runs out of power and might leak dangerous chemicals.

Procedure:

Use the parts to build the circuit in the diagram.

Note: Red wires attached to a component mean *positive*. The + signs on the diagram correspond to the red wires from the battery and the buzzer.

Activity 5: Designing a Touch Sensor

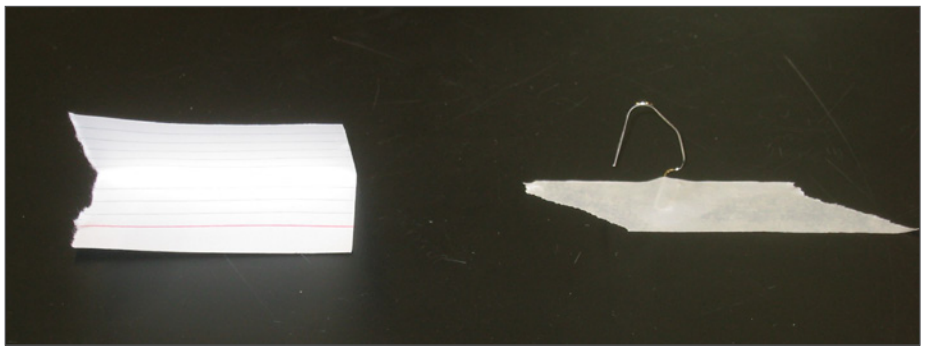
Name: _____ **Date:** _____

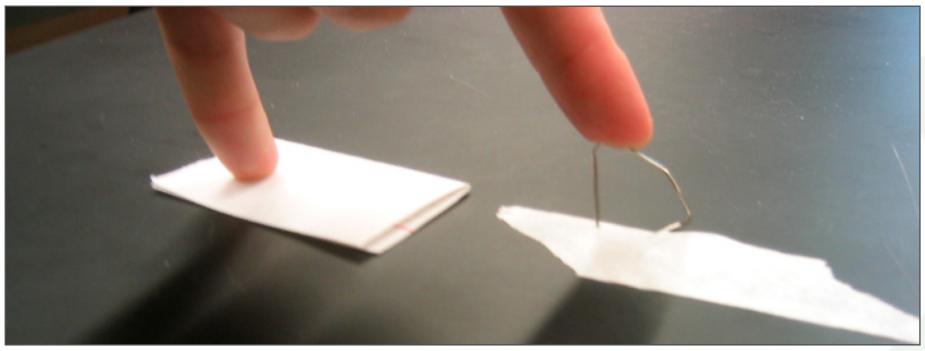
Engineering Design Challenge:

Let's look at the push-button switches you used during the last activity. What is happening inside the switch? In today's challenge, you're going to design and build a switch that will function as a touch sensor for the prosthetic arm.

1) When you press the switch, it should cause two metal conductors to touch each other, completing a circuit. You will use aluminum foil and/or paper clips to make the conductors. Use whatever configuration you think will be most effective.

2) There should be some type of spring-release action that makes the conductors separate when you stop pressing the switch. This will break the circuit. You may use any method you can think of to break contact. The examples shown here use an index card and a paper clip. You may use any materials provided to you.





Activity 5: Designing a Touch Sensor

Engineering Design Constraints:

a. The switch must complete a circuit by causing two wires to connect when the end of the arm touches an object.

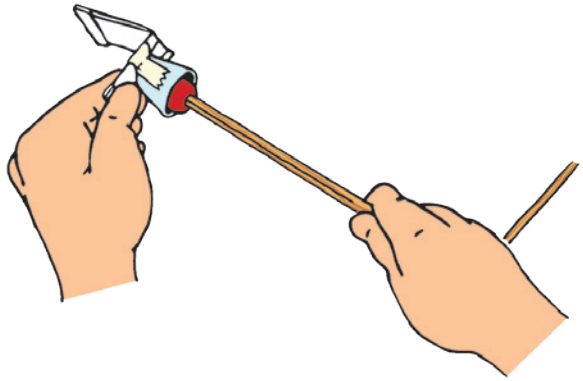
b. The switch must cause the wires to disconnect when the end of the arm no longer touches the object.

c. The switch must be mounted on the bottom of the paper cup.

d. The switch must engage whether the arm touches an object directly or at an angle. This will enable the switch to function at as wide a range of angles as possible when the arm touches an object.

Assembling the Arm

Your instructor will show you how to attach the sensor to your prosthetic arm. Once it is attached, answer the following question.



How might you make your prosthetic arm and touch sensor work better for the user?