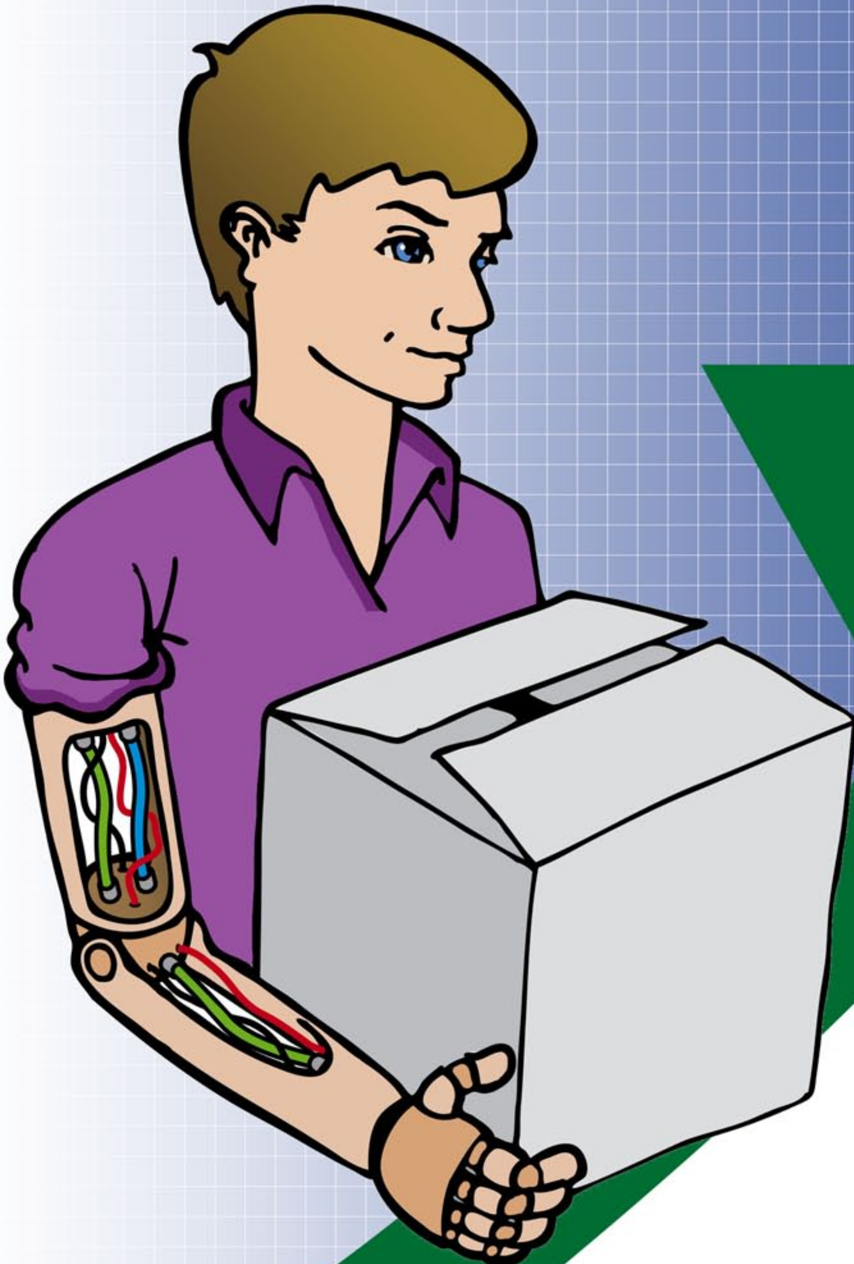


Bionic Arm

Youth
Handouts

TechXcite Discover Engineering

Activity 1: Assistive Technology

Name: ______________________________ Date: ______________

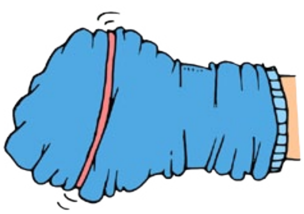
Materials List

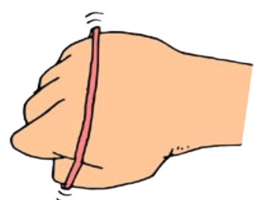
- 3 Rubber bands
- 3 Socks
- 6 Objects of various shapes and sizes
- Container

Procedure

Part 1: One-handed Shoe Tying

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. Try to tie your shoe with your uncovered hand. Can you do it?

Part 2: Mystery Container

3. 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 without opening your fist. Do not remove them from the container. Continue taking turns until everyone in the group has attempted to identify all the objects.
4. Guess the identity of the six objects you touched and list them in the chart below.

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

Activity 1: Assistive Technology

5. Circle the items above that you are confident your group guessed correctly.
6. 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.
7. Finally, open the containers and look at all the items. Did you guess correctly?

Exploration Questions

1. Which objects were hardest to identify with the sock-covered hand and why?

2. What other tasks or activities would be difficult to do with one hand?

Apply

Engineers use creative problem solving to design assistive technologies. As a class, choose one of the difficult tasks from question #2 (above) and design a device to help an impaired person complete this task. Sketch your idea and label its key features.

Activity 2: Pneumatics and Hydraulics

Name: ______________________________ Date: ______________

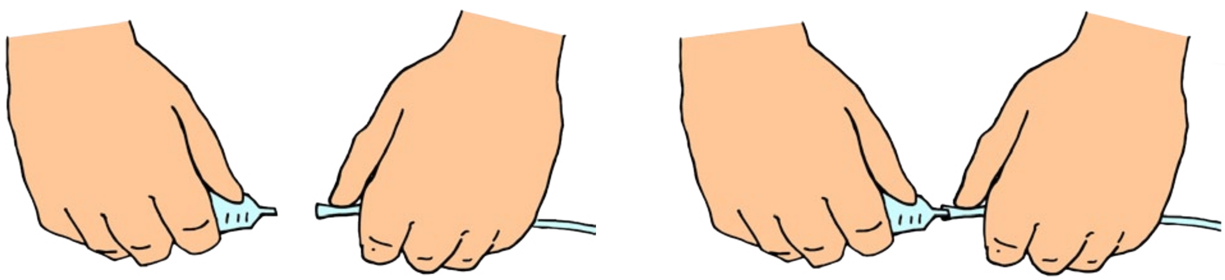
Materials List

- 4 Oral syringes
- 2 Clear plastic tubes
- Scissors
- Water
- Catch basin
- Towels (for spills)

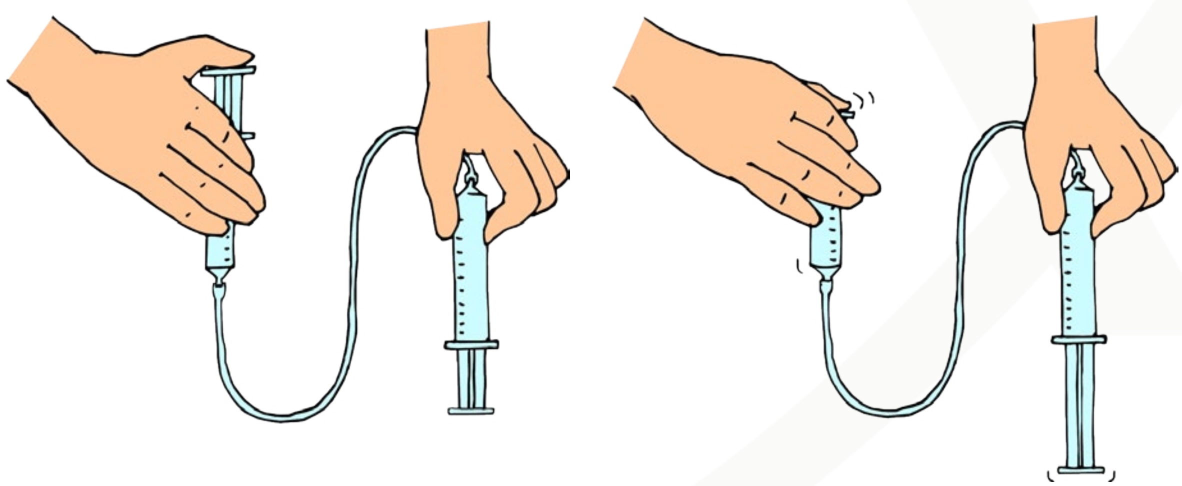
Procedure

Part 1: Pneumatics

1. Retract the plunger of one syringe all the way and press the plunger of the other syringe all the way in.
2. Attach the tips of the syringes to the ends of the tube (on both sides).



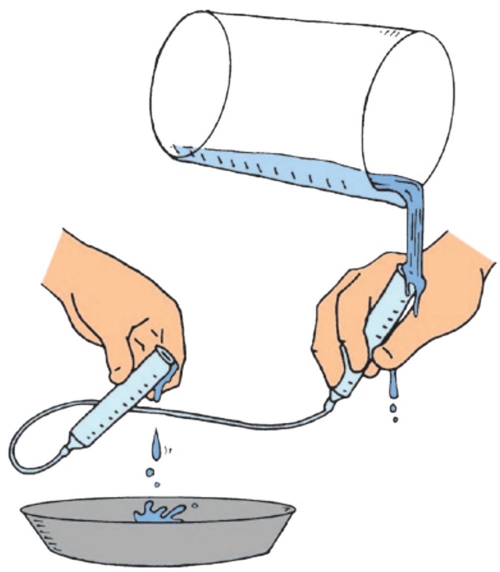
3. Now, press the retracted plunger all the way in. This motion will push air through the tube and cause the plunger in the other syringe to retract. A system that uses air pressure to transfer motion, such as this one, is called a pneumatic system.



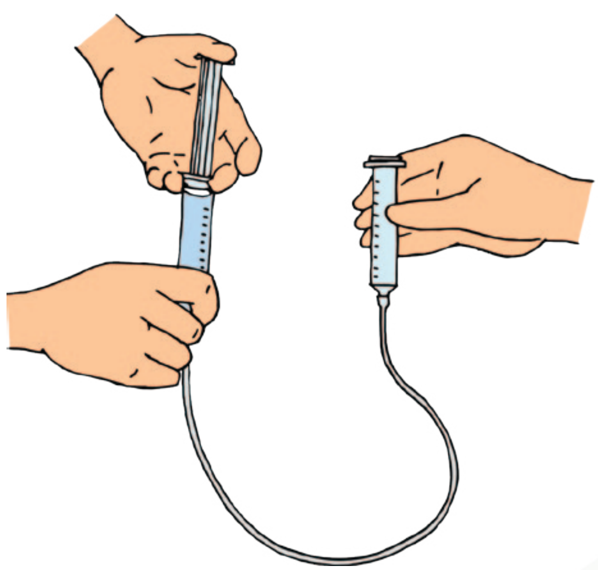
Activity 2: Pneumatics and Hydraulics

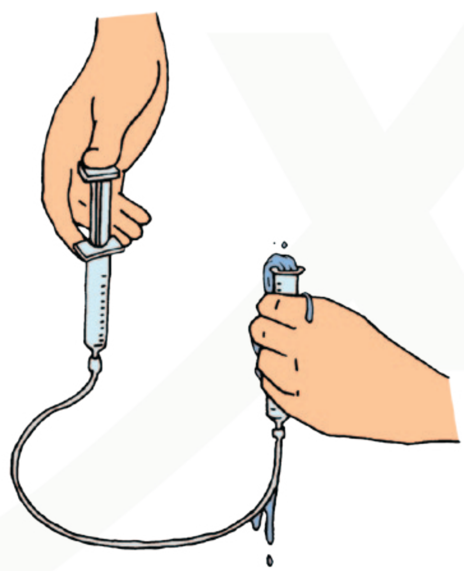
Part 2: Hydraulics

4. Remove the plungers from both syringes in one of the two systems.
5. Pour water into one empty syringe while tilting the other one over a drain or catch basin. Make sure to hold the second syringe slightly lower than the one being filled. The height difference will help the water to flow into the system.



6. When the system is completely filled, hold both syringes level so that water doesn't spill from either end.
7. 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.





Activity 2: Pneumatics and Hydraulics

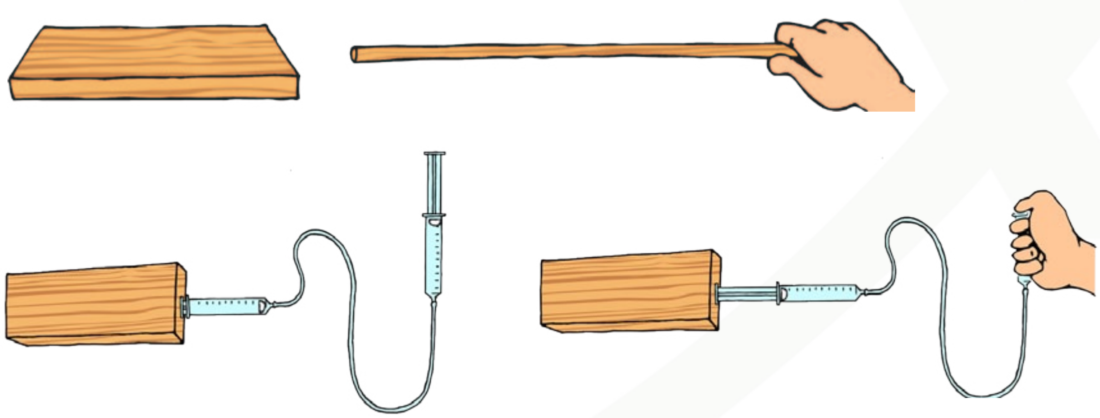
8. Now put a plunger into the other syringe and gently press down. This should cause the first syringe to retract. Be careful not to push so hard that the tube pops off. You have now created a system for transferring motion using water, called a hydraulic system.
9. Experiment with pushing the plungers to transfer water back and forth. Compare the air-filled systems and water-filled systems and note any differences or similarities between them.

Exploration Questions

1. What differences did you observe between the air-filled (pneumatic) system and the water-filled (hydraulic) system?

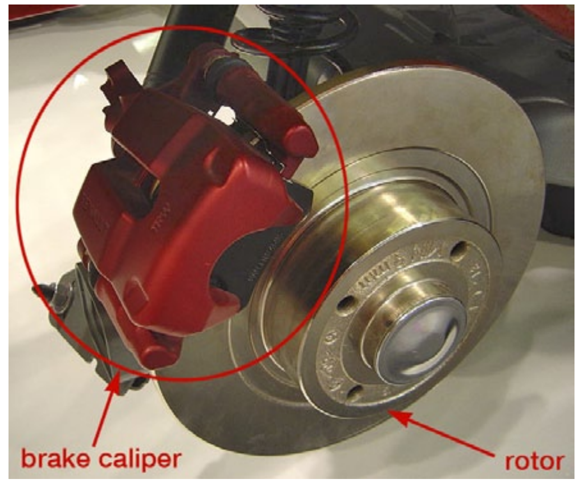
2. What are some examples of hydraulic and pneumatic systems that people use every day?

3. 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 prefer to move an object using air or water pressure?



Activity 2: Pneumatics and Hydraulics

Apply



Now that you've learned a little bit about hydraulic and pneumatic systems, let's revisit our opening question: how do car brakes work? Can you figure out how the force of the driver's foot on the brake pedal is transferred to the wheels? Sketch your theory and describe the steps in the process. Be as detailed as possible.

Hint: Part of an actual car brake system is shown to the right. This is what you would see if you removed the car's tire.

Activity 3: Making the Arm

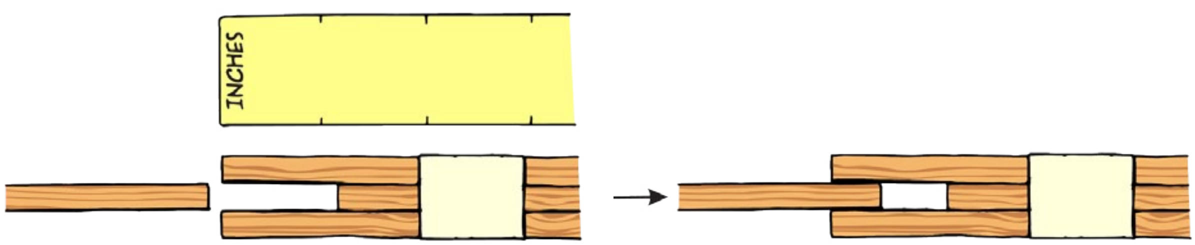
Name: ______________________________ Date: ______________

Materials List

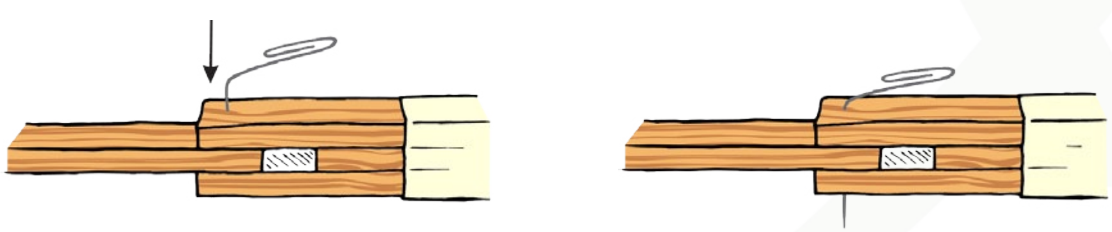
- Hydraulic system (from Activity 2)
- Pneumatic system (from Activity 2)
- 4 Rubber bands of any size
- Masking tape
- Scissors
- String
- Protractor with ruler
- Paper clip
- 4 Balsa wood strips ¼” x ½” x 18”

Assembling the Arm

1. Join three strips of balsa wood, keeping the outer two strips 1 inch longer than the inside strip. This will create a 1-inch notch, as shown below.
2. Wrap the layered arm with masking tape at both ends.
3. Insert the remaining piece of balsa wood halfway into the notch.



4. Partially unfold the paper clip. While holding the arm securely to the table, push the paper clip slowly and firmly through all three layers of balsa wood, 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.
5. Bend the ends of the paper clip so that it will not slide out. Now your hinge is complete.



Activity 3: Making the Arm

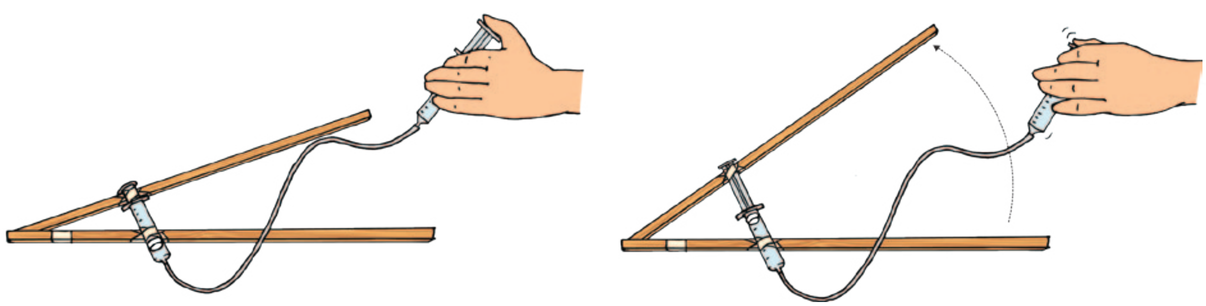
Engineering Design Challenge

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.

Design Constraints

- Only one syringe can be attached to the arm
- Movement must be controlled using only the unattached syringe
- Forearm must fully extend (straight position) and fully retract (bent position)
- Elbow must not open wider than 180 degrees
- You may use one or both pairs of syringes
- Only use the materials provided
- Design must be completed within the specified amount of time

Hint: 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.

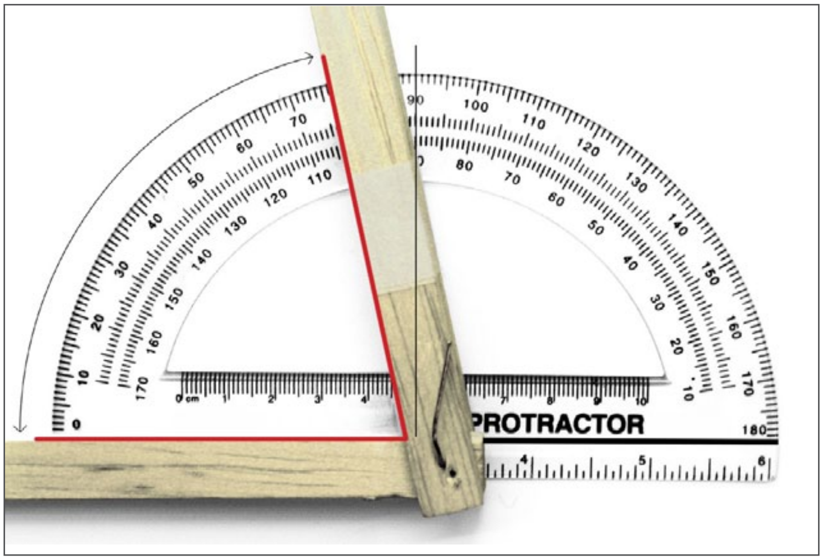


Testing Procedure

1. To measure the angle of your arm, align the inner edge of one stick with the baseline near the bottom of the protractor (see example on the next page).
2. Then align the inner "elbow" with the center point of the baseline.
3. Read the number where the inner edge of the second stick crosses the top of the arc. Note: The protractor has two sets of numbers. Use the one that starts at zero on the horizontal.
4. Calculate the angle of rotation, or your arm's range of motion, by subtracting the minimum angle created when the arm is bent from the angle created at maximum extension:

   Angle of rotation = maximum angle – minimum angle

Activity 3: Making the Arm



Example Measurement: 76 Degree Angle

Exploration Questions

1. What angle of rotation was your prosthetic arm able to attain? How does that compare to the angle of rotation of your own arm?

2. What are the similarities and differences in performance between the pneumatic and hydraulic arms?

3. How did you decide on your design? What would you do differently next time?

Activity 3: Making the Arm

Apply

Use a ruler to draw two lines that form an angle and then measure the angle using your protractor.

If you were a real engineer and could use any materials you wanted, how would you design a better elbow joint? Note: Your design doesn't have to use a hydraulic or pneumatic system.

Activity 4: Buzzer Circuit

Name: ____________________ Date: ____________

Materials List

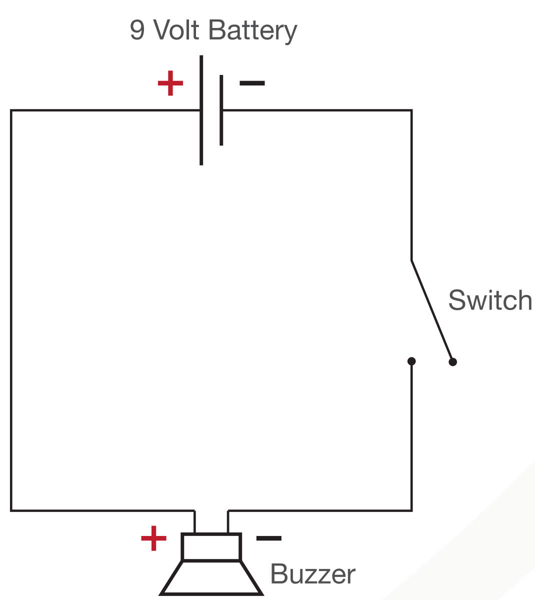
- 3 Wires with alligator clips
- Battery (9 volt)
- Battery snap (9 volt)
- Buzzer
- Push-button/momentary switch
- Aluminum foil

Procedure

1. Use the provided parts to build the circuit in the schematic diagram below.

   Note: Do not connect the battery terminals directly to each other. The battery will get hot as it runs out of power and might leak dangerous chemicals.

2. Once you have created a working circuit, disconnect the two alligator wires from the switch and try to make the buzzer turn on by touching the metal ends of the wires together.
3. Now clip one of the alligator wires onto the insulation (plastic covering) of the other wire. Did the buzzer turn on? Why?
4. Finally, clip a small piece of aluminum foil in the mouth of each alligator wire and touch the two pieces of foil together. The buzzer should come on. This is another simple way to create a homemade switch.



Activity 4: Buzzer Circuit

Exploration Questions

1. Does the color of the insulation covering the wire affect the electric circuit?

2. What are some common items that might contain a buzzer circuit like the one you built today?

3. How might you use the circuit you built to improve the function of a prosthetic arm? Could you incorporate it in such a way that a user would know when he or she had touched something?

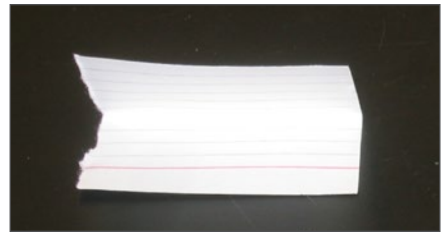
Apply

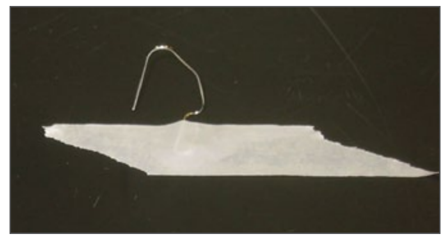
Now that you've learned how an electronic buzzer circuit works, what kind of useful invention could you create with it? Sketch your idea.

Activity 5: Designing a Touch Sensor

Name: ______________________________ Date: ______________

Materials List





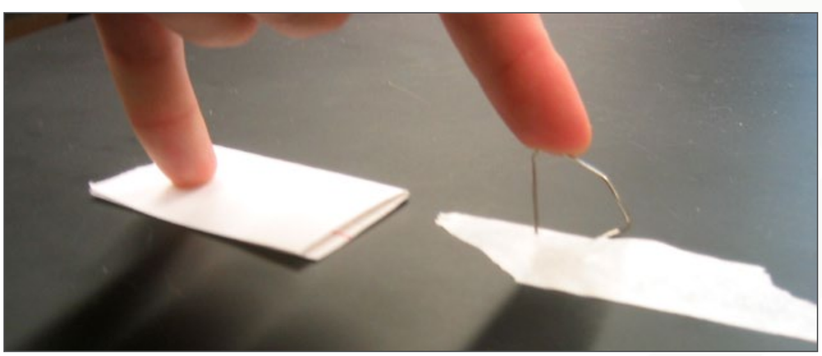
- Wires with alligator clips
- Battery (9 volt)
- Battery snap (9 volt)
- Buzzer
- Push-button/momentary switch
- Small paper cup
- Paper clips
- Rubber bands
- Masking tape
- Aluminum foil (2 square feet)
- Index cards (3x5)
- Foam ball
- String

Engineering Design Challenge

Design and build a switch that will function as a touch sensor for your prosthetic arm.

Notes

- When the switch is pressed, it should cause two metal conductors to touch each other, completing an electric circuit. Aluminum foil and/or paper clips can be used to make the conductors (in whatever configuration you think will be most effective).
- The switch should have some sort of spring-release that causes the metal conductors to separate when you stop pressing the switch. This will break the circuit. The examples shown here use an index card and a paper clip.



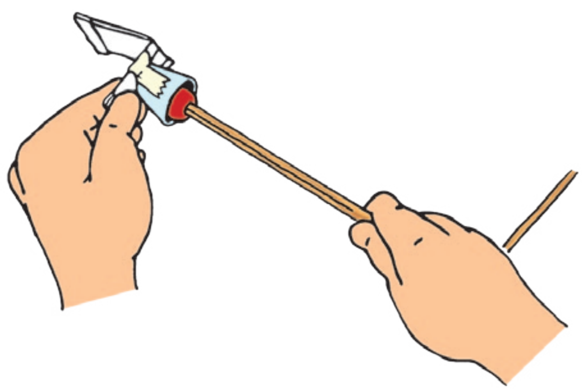
Activity 5: Designing a Touch Sensor

Design Constraints

- Switch must create a closed circuit when the arm touches an object
- Only use the materials provided
- Switch must be mounted on the paper cup
- Buzzer must turn on whether the arm touches an object directly or at an angle
- Buzzer must turn off when the arm is no longer in contact with the object

Testing Procedure

1. Mount your switch on the small paper cup.
2. Stick the foam ball onto the end of your prosthetic arm and then place the cup securely over the ball.
3. Try touching different objects at a variety of angles.



Exploration Questions

1. How did you decide on your design?

2. How might you improve your touch sensor?

Activity 5: Designing a Touch Sensor

Apply

If you were a real electrical or mechanical engineer with the ability to design any electronic circuit or mechanical device, what would your dream bionic arm look like? Sketch your idea. Label and describe its features.