9 Get a Grip

DESIGN

BIOMIMICRY HAS INSPIRED a host of technological tools that work like arms and hands. For instance, robotic arms can work with hazardous materials or in remote environments, such as handling radioactive materials or gathering samples from the ocean depths or from other planets. Robotic arms are also used by brain and heart surgeons for very delicate operations. Most exciting in this field are robotic arms used in new "keyhole" techniques, in which small incisions are made for major operations, including heart surgery. You can probably think of many other ways in which robotic arms could be used. **Robotics** is the field of engineering that builds machines that mimic, replace, or enhance human structures.

You are a mechanical engineer and, today, your supervisor, Dr. Garcia, has given you the task of developing a mechanical hand for grabbing and moving small objects. He tells you that the model hand must be able to move an object out of a designated area without letting the object touch the ground.

Researchers at Simon Fraser University in Canada worked with parathlete Danny Letain (front center) to build a better bionic hand.

GUIDING QUESTION

How can you make a mechanical grabber that can pick up and move an object?

MATERIALS

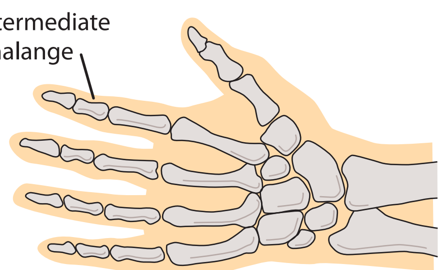
For each group of four students

2 plastic eggs
1 cylindrical container
50 pennies (1 roll)
2 pairs of scissors
4 index cards
4 rulers
straws
assorted tape
string

PROCEDURE

Part A: Finger Design

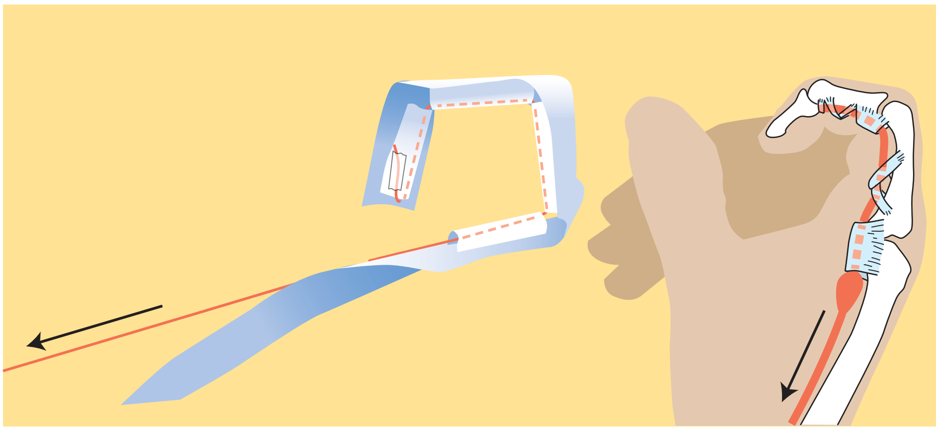
1. Identify your index finger and your intermediate phalange, as shown in the diagram below. Measure the width and length of your right index finger in centimeters (cm). Then measure the length of the intermediate phalange of your index finger. Use the following instructions to construct a mechanical finger.



   a. Cut a strip of paper the same width as your index finger and 3 cm longer than the length of your index finger.
   b. Cut four pieces off of a straw each equal in length to your intermediate phalange. Tape the pieces of straw with small, and approximately equal, spacing along your strip of paper.
   c. Cut a piece of string about 3 cm longer than your paper strip.

d. Thread the string through the straw pieces and tape one of the ends of the string to the last straw piece through which it is threaded.

e. Gently pull on the non-taped end of string and observe your mechanical finger's movement.



2. In your group, test the usefulness of each of your mechanical fingers by trying to grab the cylindrical container. Discuss with your group how your mechanical finger might work differently if it

- were a different length.
- were a different thickness.
- had a different number of straw pieces.
- had straw pieces of different lengths.

Record your observations and ideas in your science notebook.

Part B: Grabber Design

3. Read the criteria and constraint for the grabber described below. Discuss any additional criteria or constraints with your class.

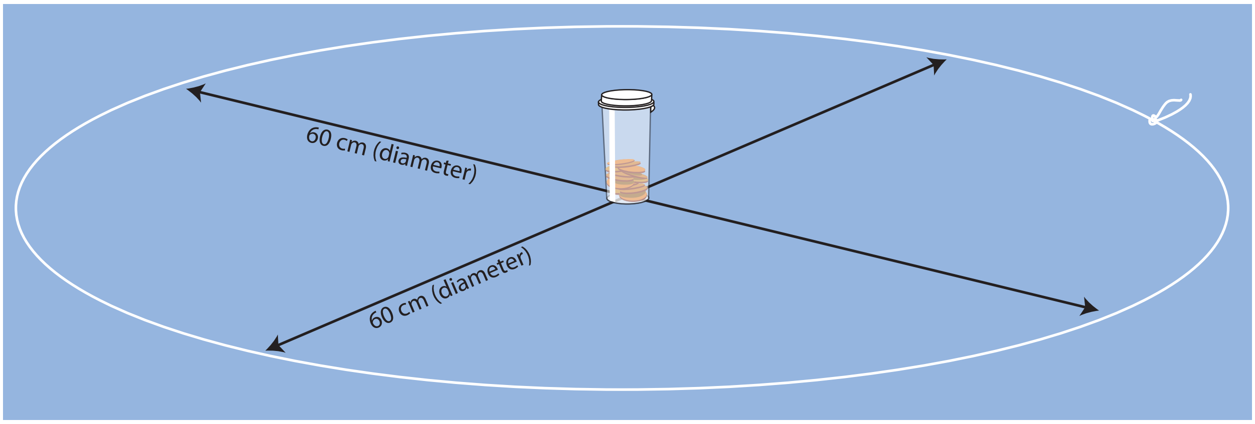
Design Criteria

The design must

- be able to remove both a plastic egg and the cylindrical container from the test arena by picking up each object individually and lifting it out of the arena.
- be operated by one person who holds the grabber with one hand and uses the other hand to trigger the mechanism.

Design Constraint

The design is limited to construction from only the materials given to you for this activity.



The "test arena" for the mechanical grabber

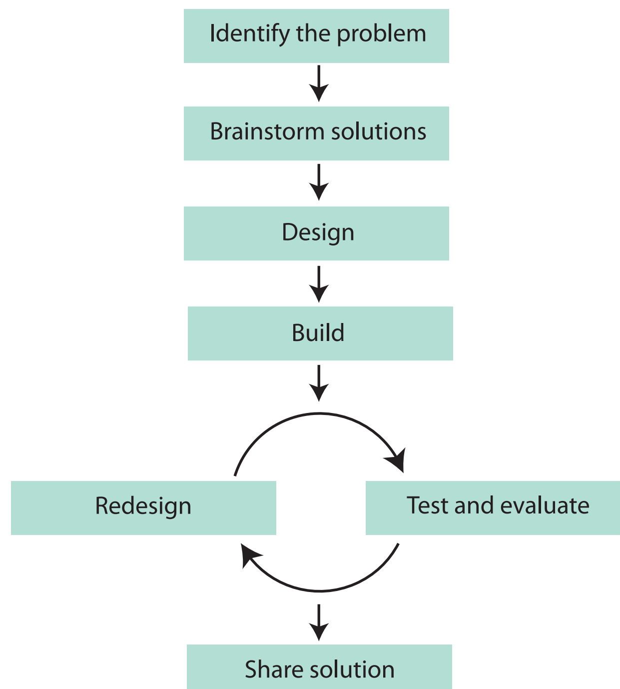
4. Discuss with your group how your mechanical fingers could be combined to create a mechanical grabber. To develop this solution, follow the design process. In your science notebook, record your group's work for all the steps of your design process, including any data you collect during testing.

5. Once you have developed a mechanical grabber within the criteria and constraints described in Step 3, optimize your grabber for one of the following options.

   Optimization Option 1:
   Remove as many plastic eggs as you can from the test area in 60 seconds. (Have a group member replace each egg in the arena after it has been removed.)

   Optimization Option 2:
   Pick up as much weight as you can. Use the pennies as weights, and fill either the egg or the cylinder with the weights. Test your grabber by adding more and more pennies, incrementally, until your grabber fails at picking up the weighted object.

6. Present your optimized design to the class by
   - demonstrating how your design met the initial criteria.
   - explaining how the test data helped you optimize your solution.
   - explaining how each component of the optimized design contributes to its function.
7. With your class, discuss the design process.



EXTENSION

Build a complete elbow-to-hand structure that can move the cylinder out of the test area.

ANALYSIS

1. What were the most rewarding and most frustrating parts of your engineering design process?
2. How did your redesign improve your product?
3. What were the limitations of your grabber model?
4. What are some of the benefits of designing your mechanical arm as a group compared with working individually?
5. Thomas Edison, with the help of those working in his lab, invented over 1,000 devices, including the movie camera, the telegraph, and the phonograph (record player). He once said, "It is what you do after failure that counts." What did he mean? Explain your answer with an example from your work during this unit.
6. How could your design be used in a real-world biomedical application? Describe a potential problem and who could benefit from it.