

# ROBOT BODIES: BUILDING A ROBOT HAND

## AT A GLANCE

Students will learn that robotic “hands,” or end effectors, are shaped in different ways depending on their intended function.

## OBJECTIVES

Students will:

- Construct a mechanical end effector (a robotic “hand”) and test it with a variety of tasks.
- Design a new end effector for a task.

## KEY VOCABULARY

End effector

## NEXT GENERATION SCIENCE STANDARDS

Science and Engineering Practices:

- Asking questions and defining problems
- Developing and using models
- Planning and carrying out investigations
- Constructing explanations and designing solutions
- Obtaining, evaluating and communicating information

Crosscutting Concepts:

- Structure and function
- Systems and system models

Disciplinary Core Ideas:

- ETS1: Engineering design

## PACE YOURSELF

- 60 minutes



## ADVANCE PREPARATION

Construct an example end effector to use as an example of what the students will be building.



## MATERIALS

Per student:

- 5 plastic drinking straws
- 1 sheet of paper
- 1 sheet of cardstock
- Scotch tape
- 1 glue stick
- scissors
- 5 lengths of yarn or string, measured from the arm to the shoulder



## WHAT YOU NEED TO KNOW

In robotics, an **end effector** is the part of the robot that interacts with the environment. The three most common types of end effector are mechanical, magnetic and vacuum.

End effectors are designed very differently depending on the task they are intended to perform. Industrial grippers come in many different forms. Some physically grasp the object to be manipulated, like the “hand” the students will build, while others puncture objects with needles, or suck them up with a vacuum, or grip the object with glue. Some use electromagnets to pick up and drop magnetic objects. Effectors can also be tools like drills, screwdrivers or welding torches.



## WARM UP

Lead students through a discussion about the types of robots they have seen before. What tasks were those robots intended to perform?

Explain the term “end effectors” (consider showing some of the videos listed in the *Robot Revolution* digital resources). What did the end effectors on those robots look like?

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## ACTIVITY

1. Explain that students will build a robotic “hand” that is similar to their own.



2. Have each student trace the outline of their hand on cardstock and paper. Cut out the hands along their outlines.



3. Have students draw lines on their paper hands where their joints are located (use the wrinkles where their fingers bend as a reference).



4. Cut the cardstock hand along the joint lines. You will be cutting each “finger” into three sections. Glue these sections onto the paper hand, making sure you can see the joint lines of the paper hand underneath (you may have to trim your cardstock fingers a little bit). Glue the cardboard “palm” to the paper hand as well.



5. Add “tendons” to allow the hand to bend. Tape a small piece of drinking straw to the lower two joints of each cardboard finger section, with the hole of the straw pointed toward the palm. Make sure both straws are lined up for each “finger.”



6. Thread a length of yarn into each “finger” of your hand and tape it in place at the fingertip. When you pull on the other end of the string, the “finger” should bend.

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7. Optionally, create a “wrist” by cutting a strip of cardstock 2 inches wide and 8 inches long.  
Tape the wrist of the paper hand to the center of this strip. Tape five 2-inch lengths of straw to the wrist, and feed the five yarn lengths through these straws. Tape the ends of the card strip together, forming a circle.
8. The hand is complete! Students should be able to bend each finger individually by pulling its string and make the hand grip by pulling all strings together.
9. Have students test their effectors by using them to perform the following tasks:
  - Pick up a die and turn it so that the face shows a different number, then put it back down.
  - Pick up a heavier object, like a tennis ball or bean bag, transport it to a target one yard away, and put it down again.
  - Stack three sheets of paper on top of one another.



## CHECK FOR UNDERSTANDING

Ask students to describe their results. Which tasks did their effector perform well? Which tasks did it perform poorly?

Have students select one of the tasks they performed and design a new end effector to perform that task. If time allows, have them construct and test their designs.



## WHAT'S HAPPENING?

Students should have noticed that their hand is good at grasping lightweight, three-dimensional objects, but not as good at lifting papers or heavier objects. Ask your students what type of robot might use an effector like the one they built.



## DIFFERENTIATED INSTRUCTION

More advanced students may have time to build other end effectors and test them at various tasks.

Students can simulate a vacuum effector by sucking air through a cardboard tube to pick things up. You may want to add a membrane of cellophane punctured by two drinking straws at one end of the tube, to minimize the risk of accidentally swallowing smaller objects.

Students can build a simple example of a magnetic effector using a permanent magnet or a simple electromagnet to sort magnetic and non-magnetic materials.



## EXTENSIONS

Mechanical grippers are usually built with two or three “fingers” or prongs, rather than five. Discuss with your students why designers might choose to build robots that look and move similar to humans. What tasks might humanlike robots be better suited for than non-humanoid robots?

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## DIGITAL RESOURCES

**This video shows how to make a simple vacuum effector using a balloon, duct tape, coffee grounds and a vacuum cleaner, and also describes how vacuum grippers work:**

<https://www.youtube.com/watch?v=3OjhoVuAQkQ>

<https://www.youtube.com/watch?v=Hb6PajUGXFg>

**These videos demonstrate how traditional vacuum effectors work:**

<https://www.youtube.com/watch?v=1F9RT8OjHWE>

**Here are some good examples of mechanical grippers:**

<https://www.youtube.com/watch?v=u4ZScJsaepg>

<https://www.youtube.com/watch?v=EcTL7Hig8h4>

<https://www.youtube.com/watch?v=4MQmlvzE0i8>

**And here are some examples of magnetic effectors:**

<https://www.youtube.com/watch?v=Z8t59j9zjjc>

<https://www.youtube.com/watch?v=hpyzfm2r-uU>



## IN THE EXHIBIT

- UR5 Universal Robotic Arm
- Robot grippers

**This lesson was inspired by**

[snapguide.com/guides/make-a-robotic-hand/](http://snapguide.com/guides/make-a-robotic-hand/)

[tryengineering.org/sites/default/files/lessons/robotarm\\_0.pdf](http://tryengineering.org/sites/default/files/lessons/robotarm_0.pdf)

[www.instructables.com/id/Mechanical-Hand-using-only-fast-food-straws-Stra/](http://www.instructables.com/id/Mechanical-Hand-using-only-fast-food-straws-Stra/)