Lesson 4: Robot Hand (End Effector)

Activity Credit: NASA

Objectives:

Students will construct a robotic-like hand and demonstrate how it works and what makes it functionally different from a human hand.

National Standards:

National Science Standards:

Content Standard E: Science and Technology
- Abilities of technological design
- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives
- Science and technology in society

Content Standard G: History and Nature of Science
- Science as a human endeavor

Unifying Concepts and Processes
- Evidence, models, and explanation
- Form and function

Materials:

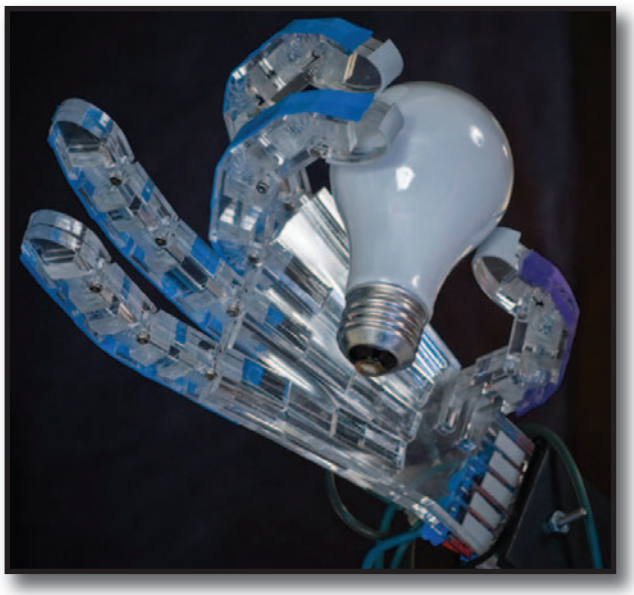
- Styrofoam food tray (or large plate) - one per student
- marker pens (permanent type)
- ballpoint pens
- duct tape
- hot glue and white liquid glue
- scissors
- cellophane tape
- straws (one per student)
- string (two large rolls)
- rubber bands (approximately 3 per student)
- paint stick (one per student)
- robot hand (end effector) handout (one per student)

Background:

Robotic arms and hands are used in the space shuttle and the space station to build, repair, investigate, and more. Robotic hands are being developed to imitate the size, shape, and degrees of freedom of the human hand. The many uses of such a robotic hand include prosthesis, industry, and space exploration, just to name a few.

Many robot hands have three fingers to reduce cost and simplify control, such as those needed by industry. Some robots do not ever have fingers, but, instead, have the needed tools directly attached to them.

In order to study and replicate the human hand, computer models have been used.



Above: Virginia Tech's RAPHaEL (Robotic Air Powered Hand with Elastic Ligaments) robotic hand; Left: Robonaut holding a ball

Procedure:

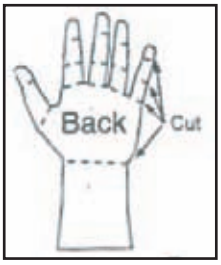
1. Discuss what an end effector is and tell students that they will be creating a rather complex end effector model.

2. Students should place one of their hands, with fingers spread, on the smooth side of a Styrofoam food tray or plate. Use a permanent marker pen to trace the hand up to the forearm.

3. Students should then cover the entire tracing of their hands with duct tape and press it smooth.

4. Next, trace hands again on the duct tape and cut out with scissors.

5. Turn the cut-out hand over and score the Styrofoam on each finger with the point of a ballpoint pen where the knuckles should be. Bend each joint gently (the Styrofoam will make a popping noise). The tape on the other side becomes the hinge on the knuckle. Also, make a wrist joint the same way.



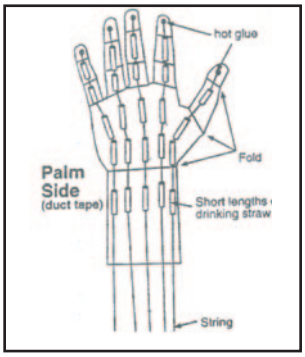
6. Use cellophane tape to tape short lengths of straw on the palm side (duct-taped side) of the hand where indicated on the diagram.

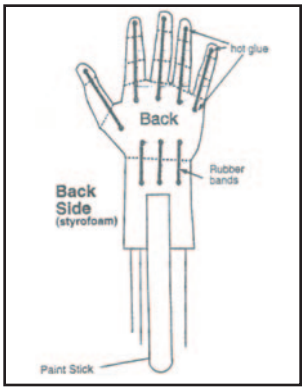
7. Knot 5 pieces of string on one end and hot glue knots to fingertips. Run the other end of the strings through the straws, as shown.

8. Glue or tape a paint stick to the forearm.

9. Tape pieces of rubber bands across each knuckle joint on the Styrofoam side to serve as muscles and tendons. The rubber bands must be stretched enough so that all the fingers on the hand will open automatically.

10. Work the hand by pulling the strings, one at a time to control each finger, or all at once to open and close entire hand.





Review:

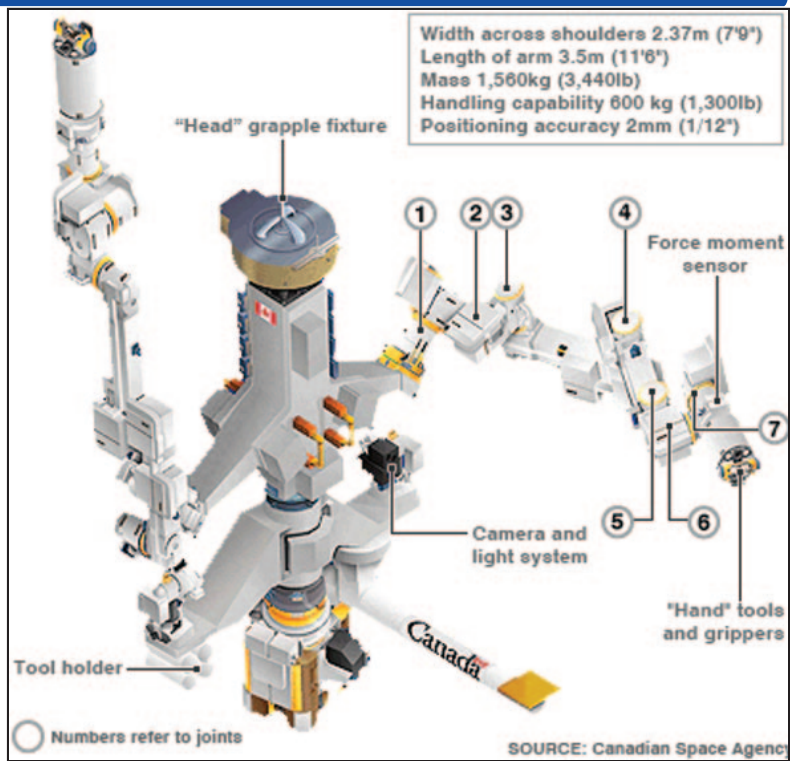
This activity demonstates how an end effector is constructed to resemble a human hand. The robot uses the end-effector to accomplish a task. The end-effector may be holding a tool, or the end-effector itself may be a tool. Scientists are trying to find ways to make the robot hand more like that of a human hand so that the robot can handle detailed and complex tasks.

Extension:

1. Have students research the end effectors used by NASA and tell what duties each is designed to perform. (An end-effector can be a sensor, a gripping device, a paint gun, a drill, a sampling device, an arc welding device, etc.)

2. Have students think of a job that an end effector could do and design an end effector for the job.


Canadian Space Agency robot arms and end effector



Student Directions (End Effector Hand-out)

Name_____ Date _____

After constructing your robot hand, answer the following questions:

1. What is an end effector?_____

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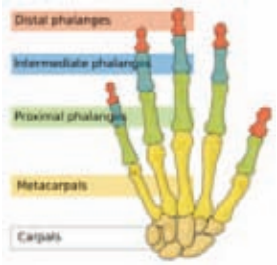
2. Compare your model with the simple model of the hand in the picture:



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3. How do you think robotic hands will be useful in the future?

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(Use the back side of the paper if you need more space.)