Lesson 10: End Effector

Activity Credit: NASA's Teaching From Space Office at Johnson Space Center

Objectives:

Students will comprehend how the end effector is designed and assembled, as well as gain comprehension of the technological design by assembling a model.

National Standards:

National Science Standards:

Content Standard A: Science as Inquiry
- Understandings about scientific inquiry

Content Standard E: Science and Technology
- Abilities of technological design

Unifying Concepts and Processes
- Evidence, models, and explanation

National Technology Standards:

Standard 8: Students will develop an understanding of the attributes of design.

Standard 11: Students will develop abilities to apply the design process.

Materials:

For each team:
- Styrofoam coffee cups (2 for each team) Note: plastic cups may be used for durability
- 12-cm (4.72 in.) pieces of string (3 each)
- Cellophane tape
- Plastic picnic knives (serrated)
- Straw (1 each) or other items that the "effector" may be able to pick up

Background:

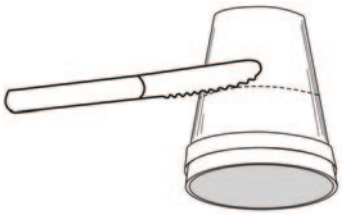
The part of the robotic arm that grabs objects is called an "end effector." This wire-snare device is designed to fit over special grapple fixtures (knobbed pins) on the Shuttle, ISS and ISS modules.

The end effector is like a mechanical hand with a cylinder 33.2 centimeters (13.07 in.) in diameter by 25.8 centimeters (10.16 in.) deep. It contains three cables (like a snare) that close around a grapple pin onto the module. Then the cables become rigid with enough force to prevent the captured object from slipping loose.

Procedure:

1. Have students work in pairs or small groups.

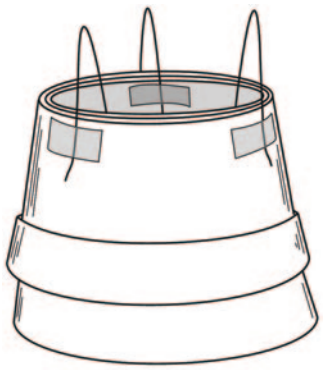
2. Nest the two cups together and cut through both cups where indicated in the diagram by the dashed line. Smooth the cut edges by scraping them with the picnic knife edge.



3. Cut three 12-centimeter (4.72 inch) lengths of strings.

4. Tape the end of the first string to the side of the inner cup just below the cut edge. Tape the other end of the string to the outside of the cup, but do not press this piece of tape tightly yet.

5. Repeat step 4 twice more, but place the strings about a third of the way (120 degrees) around the cup from the first string.



Tape the string loop from the outside of one cup to the inside of the other (as shown).

6. While holding the rim of the inner cup, rotate the outer cup until the three strings cross each other. The strings will have some slack. Pull the end of the strings on the outside until they are straight and intersect exactly in the middle of the opening. Press the tape on the outside to hold the strings.

Open position **Rotate outer cup** **Continue rotating to close snares**

7. Use the end effector to pick up the straw by doing the following: Have someone hold the straw upright. Open the end effector so that the strings are not crossing each other. Slip the end effector over the straw so that the straw extends down the center and not through any of the loops. Rotate the outer cup until the strings grasp the straw. Pick up the straw.

Astronaut holding on to an end effector attached to the robotic arm

Review:

The end effector used on the Space Shuttle's Remote Manipulator System (RMS) is a snare device that closes around special posts, called grapple fixtures. The grapple fixtures are attached to the objects the RMS is trying to grasp. Similarly, the end effector in this activity closes around the object it is trying to pick up and move.

Evaluation:

Have students complete the student worksheet on page 41 to check for understanding and extend the activity.

Extension:

1. Search robot sites on the Internet and review different end effector designs. How does the design of an end effector enable it to pick up and manipulate various objects?

2. Design a system that might use the end effector differently in the future of space flight.

ISS End Effector Worksheet

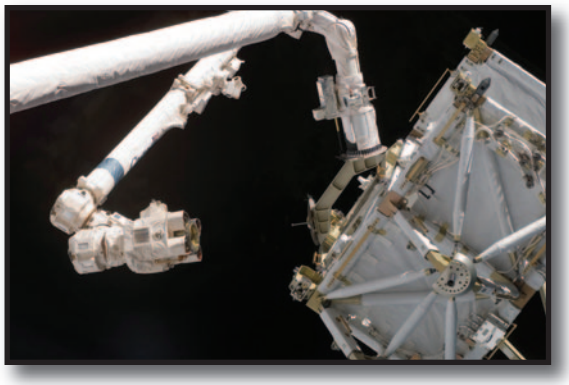
Name: _____ Date:_____

Read the following background information about the Mobile Servicing System and the "end effector" before beginning the activity:

The most complex robotic system on the ISS is the MSS (Mobile Servicing System). It consists of the Space Station Remote Manipulator System (SSRMS), the Mobile Remote Servicer Base System (MBS), the Special Purpose Dexterous Manipulator (SPDM), and the Mobile Transporter (MT). The MSS is controlled by an astronaut working at one of two Robotics Work Stations inside the ISS.

The primary functions of the MSS robotic system on the ISS are to:

- assist in the assembly of the main elements of the station (e.g. aligning newly delivered modules to the structure)
- handle large payloads
- replace orbital replacement units (plug-in equipment designed to be periodically replaced with newer units)
- support astronauts during extravehicular activities
- assist in station maintenance
- provide transportation around the station



The main component of the MSS is the 17-meter (18.59 yd.)long SSRMS robot arm. It is similar to the Shuttle RMS but will ride from one end of the station to the other on the mobile transporter, which will glide along the giant truss beam. After arriving at a worksite, the arm will grasp payloads, modules, or other structures with its wire snare end effector. If a work location is too distant for the arm to reach while still attached to the transporter, the arm can connect to an intermediate grapple fixture. Electrical power will be rerouted through that fixture. The SSRMS will then release its other end and "inchworm" itself through successive fixtures until it reaches the desired site. The SSRMS is also able to pick up and connect to the SPDM. This unit consists of a pair of 3.5-meter (3.83 yd.), 7-joint arms connected to a single joint base. The SPDM can pick up small tools for repair or servicing activities or effect delicate manipulations of smaller objects than the SSRMS can handle.

Answer the following questions after you have completed the lesson activities:

1. What is an end effector and how is your model like the ISS end effector on the Space Station Remote Manipulator System (SSRMS) robot arm?

2. Since the straw that your end effector is supposed to pick up is too slippery to be held securely, how might you modify the straw so that it can be held without changing the straw? (Hint: Design a standard grapple fixture that can be added to the straw so that it can be picked up.) Describe your solution below.

3. Compare your grapple fixture to two other grapple fixtures designed by your classmates. Draw them in the squares below:

4. Which one works the best? Use complete sentences to explain why. Use the back of this sheet for additional space.

5. How can you improve your design? Use complete sentences. Use the back of this sheet for additional space.