Shuttle End Effector

Adapted from NASA article *Astronauts' Little Helpers*

Objectives

Students will:

- Construct a Shuttle end effector
- Use a Shuttle end effector to pick up and move objects

Suggested Grade Level

3rd – 12th

Subject Areas

Science, Technology

Timeline

60 minutes

Standards

- **3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.**
- **3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.**
- **3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.**
- **MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.**
- **MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**
- **MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.**
- **MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.**
- **MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.**
- **HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.**
- **HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.**

Background

The 15.2 meter long Remote Manipulator System robot arm used on the Space Shuttle and the 17 meter long Space Station Remote Manipulator arm that is used on the International

Space Station (ISS) both employ a wire snare device for grasping objects. This device, called an end effector, is placed over a post-like grapple fixture mounted on a satellite, an experiment module, or any device to be grasped. The end effector rotates, causing three metal cables to close tightly around the post. The wires come together in a manner similar to the way the diaphragm on a camera closes.

Materials

- Styrofoam coffee cups
- String
- Tape
- Scissors
- metric ruler
- sand paper

Lesson

1. Nest the two cups together and cut through the cups about half-way down the cup.
2. Smooth the cut edges by running over a piece of sand paper.
3. Cut 3 pieces of string to 3 centimeters long.
4. Tape the end of the first string to the inside of the inner coffee cup near where you cut the cup.
5. Tape the other end of the string to the outside of the cup but do not press this piece of tape tightly yet.
6. Repeat steps 4-5 twice more but place the strings about 1/3 of the way around the cup from the first string.
7. Rotate the outer cup until the three strings cross each other while holding the rim of the inner cup. 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.
8. Use the end effector to pick up an object such as a pencil.

Extensions

- You may find that the pencil is too slippery to be picked up. Modify the pencil so that it can be held by designing a grapple fixture that can be mounted to other objects so that they can be picked up.
- Allow the students to decide where to cut the cups as well as how long the string should be.
- Have students design and build an object using the end effector as the only means to move and manipulate objects.

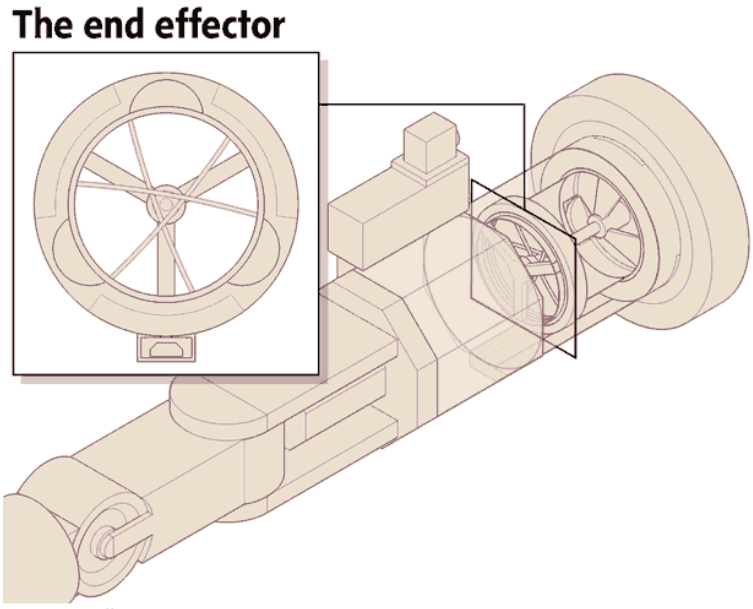
Resources

T. (2010, October 20). Make your own space shuttle robot arm end effector. Retrieved from https://www.youtube.com/watch?v=x0u3LbB11HI

Space Shuttle Robot Arm. (n.d.). Retrieved from http://iss.jaxa.jp/iss/3a/orb_rms_e.html

Gregory Vogt, Robot Arm End Effector Lesson, 2001

How the Canadarm changed spaceflight. (2017, May 30). Retrieved from https://www.theglobeandmail.com/news/national/canada-150/how-the-canadarm-changed-spaceflight/article33906987/



MURAT YÜKSELIR / THE GLOBE AND MAIL
SOURCE: MDA CORPORATION; CANADIAN SPACE AGENCY