



Drexel-SDP GK-12 LESSON

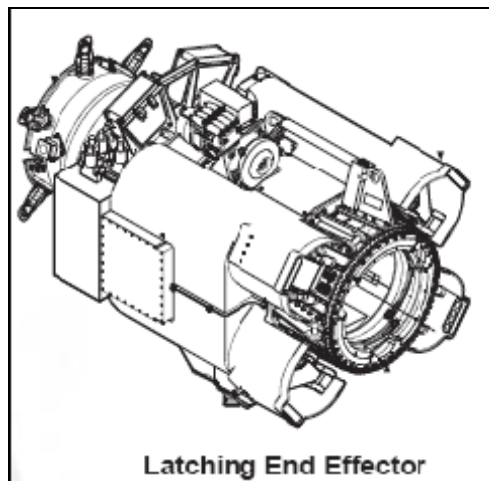
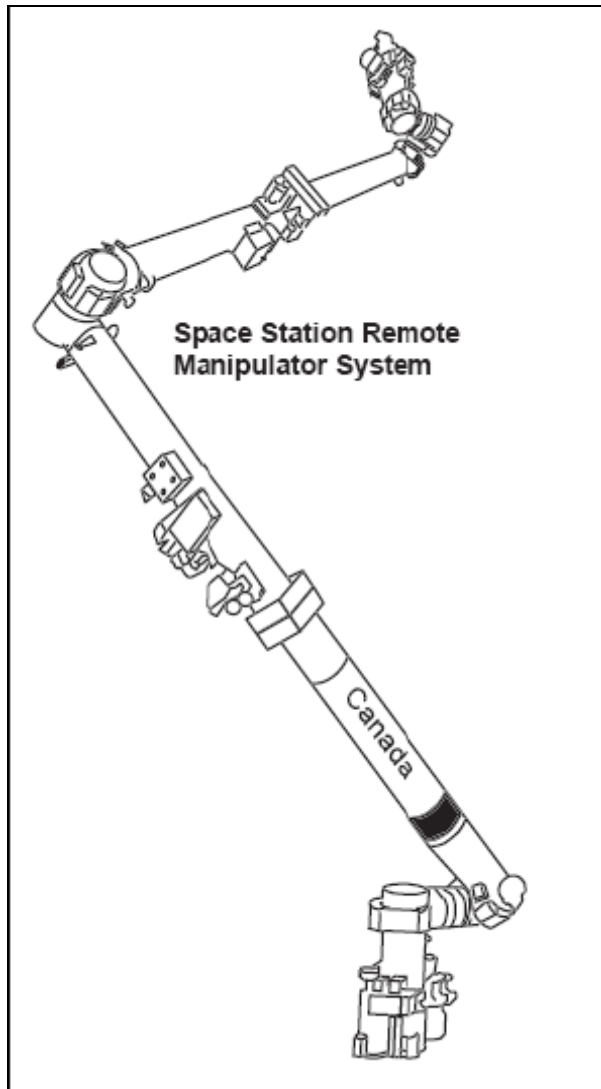
- Lesson Title and Identifier:
Title: Fabrication Activity: Space Station Remote Manipulator Arm
- Module: Astronomy
- Subject Area (Unit): Astronomy
- Concept: Vocabulary
Robotics
Effector
Manipulator System
- Objectives:
In this activity, students will follow a design plan to fabricate a robotic end effector (a gripper) attached to a remote manipulator arm (a robotic arm).
- Keywords: Mechanical Engineering, Electrical Engineering, Robotics, Manipulator
- PA Academic Standards:
Science 3.1.7 Unifying Themes
3.2.7 Inquiry and Design
Math 2.3 Measurement and Estimation
2.9 Geometry
- Grade Level: 6th
- Setting/Group Size: 30 students
- Duration/Time Required: 1-2 class periods
- Materials List (include safety equipment if applicable)
2 styrofoam cups
String
Tape
plastic knives

- Context

Background: This activity will be conducted after some discussion about the role of robotics in assisting astronauts who work on the International Space Station (ISS), plus some discussion on mechanical engineers and electrical engineers.

International Space Station (ISS): The ISS is a multi-national effort to construct a working research laboratory that orbits the earth. On it, astronauts will perform research (following the experimental process – just like students have learned) in a variety of areas. These areas include: *human biology*: the effects of the space environment on space travelers (e.g., muscle atrophy, bone loss, fluid shifts); *biotechnology*: a microgravity environment has enabled researchers to grow three-dimensional tissues that have characteristics similar to body tissues; *materials science*: in low gravity, differences in weight of liquids used to form materials do not interfere with the ability to mix these materials opening the door to a whole new world of composite materials; *combustion science*: the reduction of gravity allows scientists to simplify the study of complex combustion (burning) processes. Since combustion is used to produce 85 percent of Earth's energy, even small improvements in efficiency and reduction of soot production (a major source of pollution on earth) will have large economic and environmental benefits; *earth science*: Space scientists will use the location above the atmosphere to collect and search for cosmic rays, cosmic dust, anti-matter and "dark" matter. Earth scientists can obtain global profiles of aerosols, ozone, water vapor, and oxides in order to determine their role in climatological processes.

The role of robotics for astronauts working on the ISS: Astronauts working on the ISS often must manipulate small objects, which can be very hard to do in cumbersome space suits! To compensate for the limited use of their hands, astronauts use robotic arms with a specialized end effector (a gripper) attached at the end to pick up or place objects of varying size. These devices are designed and fabricated by teams of engineers who work in the mechanical and electrical fields.



Mechanical Engineering: Mechanical engineering involves the application of principles of physics for analysis, design, manufacturing, and maintenance of mechanical systems. It requires a solid understanding of key concepts including mechanics (action of forces), kinematics (motion without consideration of mass and force), thermodynamics (relations between heat and mechanical energy or work) and energy. Mechanical engineers use these principles and others in the design and analysis of automobiles, aircraft, heating & cooling systems, buildings and bridges, industrial equipment and machinery, and more.

Electrical Engineering: Electrical engineering involves the study and application of electricity, electronics and electromagnetism. There is some distinction between electrical engineers and electronics engineers: electrical engineers are usually concerned with using electricity to transmit energy, while electronics engineers are concerned with using electricity to transmit information. The entire field covers a range of sub-disciplines including those that deal with power, optoelectronics, digital electronics, analog electronics, computer science, artificial intelligence, control systems, electronics, signal processing and telecommunications.

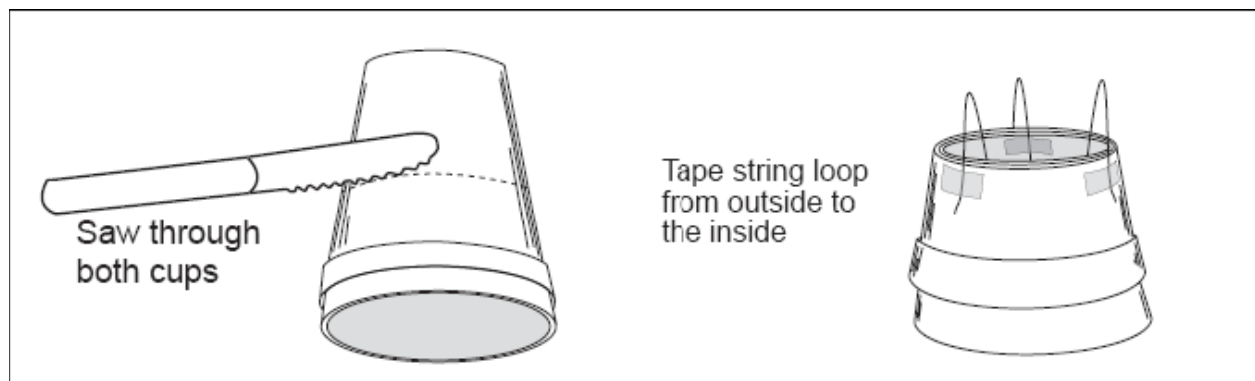
- **Methods and Procedure:**

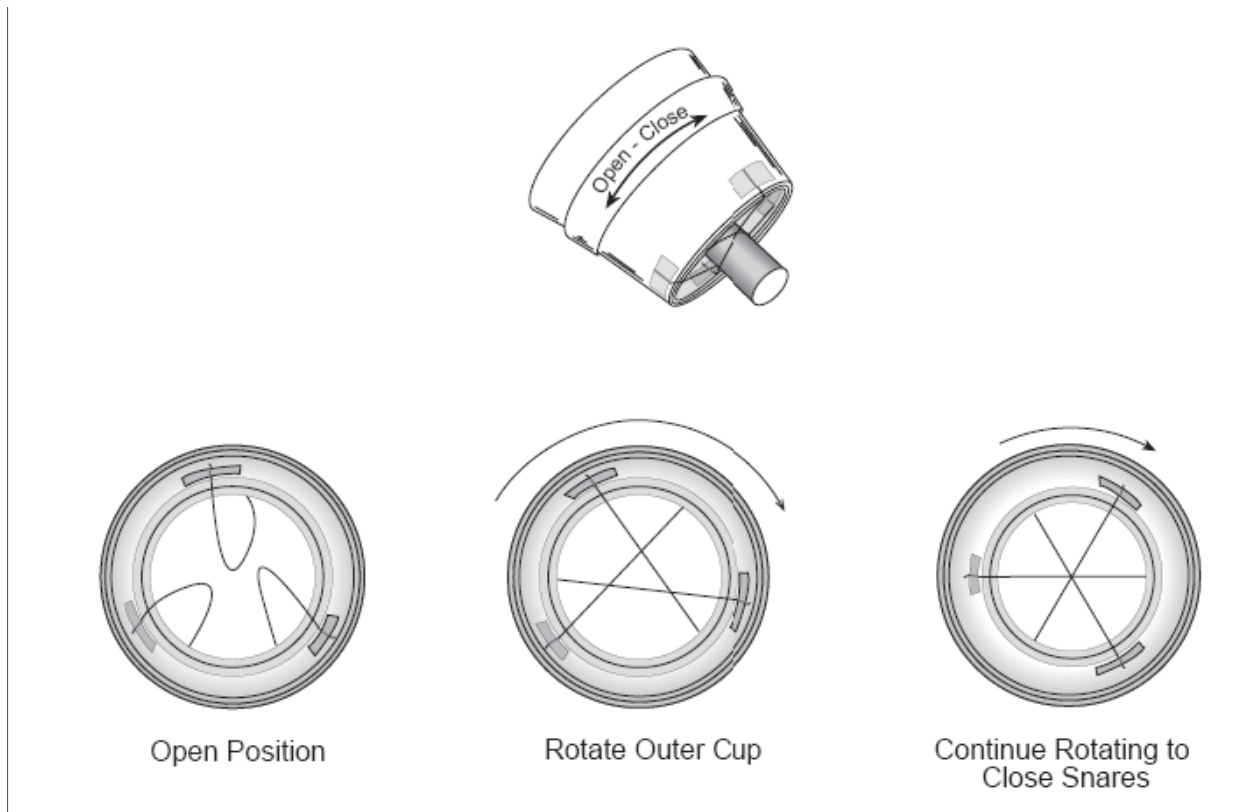
Step 1: Each student gets two paper cups, a plastic knife, and a few pieces of string.

Step 2: The student will use the plastic knife to saw out the bottoms of each of the cups, as depicted in the figure below. Then, place one cup inside the other.

Step 3: The student will attach three strings placed 120 degrees apart. One end of the string is taped to the outside of the outer cup. The other end of the string is taped to the outside of the inner cup, as depicted in the figure below.

Step 4: Students will perform stress testing to determine the mass (using a double-pan balance) of the heaviest object their end effector is capable of picking up.





Analysis:

- Question 1: What is the mass of the heaviest object your end effector can pick up?
- Question 2: How can we improve the design? What materials could we use? Where are the weak points in this mechanical device?
- Question 3: What would you do differently next time?

- Assessment

Students will be evaluated on a scale from 0 to 4 on:

Task Completion

Successful construction of device

Participation in discussion

- References & Web Sites:

The reference source for this activity is the Kennedy Space Center Educator's Activity Guide for Grades 6-8:

<http://www.kennedyspacecenter.com/PDF/KSCEdGuide6-8.pdf>

- Authors

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