



*Drexel-SDP GK-12 LESSON*

# **Fabrication Lesson: Space Station Remote Manipulator Arm**

**Subject Area(s)** Earth and Space

**Associated Unit** Astronomy, module 2

**Lesson Title** Fabrication Lesson: Space Station Remote Manipulator Arm

**Grade Level** 6 (3-7)

**Lesson #** 1 of 4

**Lesson Dependency** None.

**Time Required** 15 minutes

**Heading**

## **Image 1**

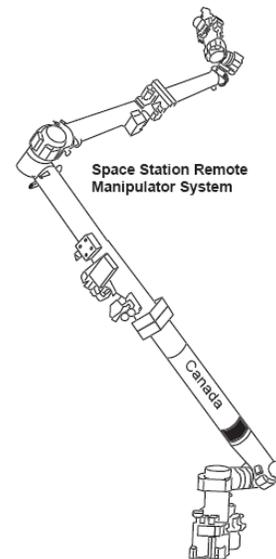
**ADA Description:** Picture shows robotic manipulator arm

**Caption:** Robotic manipulator arm

**Image file name:** img1.pdf

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## **Summary**

In this lesson, students will briefly learn about the role of a remote manipulator arm in space research missions. The objective is to expose students to some of the mechanical devices designed by engineers to assist scientists and astronomers with space exploration and space research. Following this lesson, in the accompanying activity, students will follow a design plan to fabricate a robotic end effector (a gripper) attached to a remote manipulator arm (a robotic arm).

## **Engineering Connection**

The role of robotics for astronauts working on the International Space Station (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.

## **Keywords**

Astronomy, electrical engineer, international space station, mechanical engineer, robotics

## **Educational Standards (PA)**

- Science: Technological Devices – Instruments 3.7.B, Physical Science, Chemistry and Physics – Astronomy 3.4.D, Science, Technology and Human Endeavors – Meeting Human Needs – 3.8.B
- Math: Measurement and Estimation 2.3, Geometry 2.9

## **Pre-Requisite Knowledge**

Familiarity with the degrees of an angle and circle.

## **Learning Objectives**

After this lesson, students should be able to:

- **Explain what an electrical engineer does**
- **Explain what a mechanical engineer does**
- **Explain what the ISS is and know that it is used for space research**
- **Describe how mechanical and electrical engineers are involved in the design of components to assist astronauts on the International Space Station (ISS)**

## **Introduction / Motivation**

What do you think the temperature is in space? In space, the temperature ranges from extreme hot to extreme cold – beyond the normal temperature ranges that human beings can tolerate. Hence, astronauts must cover all parts of their body with protective suiting. This limits their manual dexterity (use of their hands) to manipulate small objects. How do engineers design robotic devices that enable astronauts to manipulate payloads (objects) without the use of their hands?

## **Lesson Background & Concepts for Teachers**

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.

### **Vocabulary / Definitions**

| Word                              | Definition   |
|-----------------------------------|--|
| Remote manipulator arm            | A mechanical device for grasping. May or may not be electronically controller. |
| International Space Station (ISS) | An in-space research laboratory that orbits the Earth                          |
| End effector                      | A mechanical device for gripping   |
| Mechanical engineering            | The study and design of systems having moving parts or                         |

|                        |  |
|------------------------|--|
|                        | involving motion   |
| Electrical engineering | The study and design of systems and components that utilize or generate electrical power |

### **Associated Activities**

Fabrication Activity: Space Station Remote Manipulator Arm

### **Lesson Closure**

Follow with the Fabrication Activity: Space Station Remote Manipulator Arm

### **Assessment**

#### **Lesson Summary Assessment**

Open a discussion with the students to see if they've understood how the end effector is intended to work, and any challenges they confronted in its fabrication or use.

### **Lesson Extension Activities**

More activities for children from the Kennedy Space Center:

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

### **References**

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

### **Owner**

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