EDUCATOR'S GUIDE

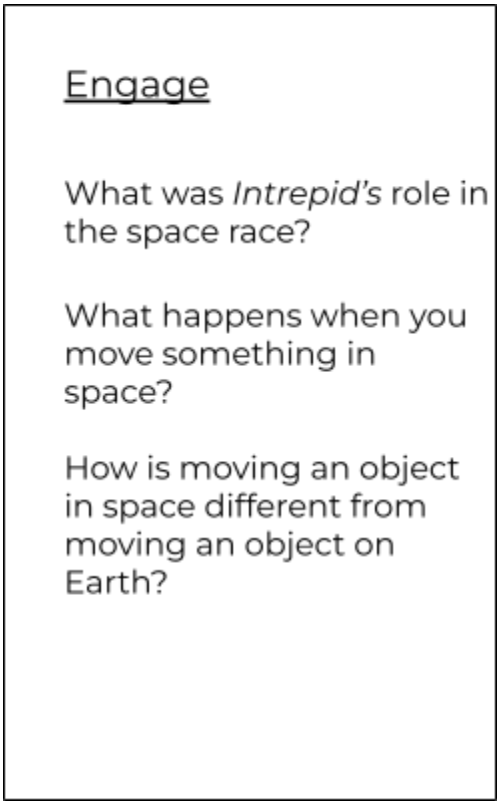
Make a Robotic Hand!

Preparation

Overview and Objectives
This lesson is geared toward family audiences.

Participants will learn how NASA uses technology to move and repair objects in space, including experimenting with toys in space, Hubble and the International Space Station. Additionally, working as a team to manipulate the effector will allow the participants to see how teamwork and critical listening are skills utilized by astronauts.

Participants will identify the differences between moving an object on Earth versus that which is in space. This allows participants to understand the role played by the space shuttle orbiter's robotic arm in the STS. As a result, families will follow a set of instructions to construct and manipulate their own robotic arm effector to move an object, similar to how astronauts work in space.



This lesson includes a slideshow in which an instructor can lead participants through the various objectives, culminating in designing an effector. By the end of this lesson, participants will be able to connect an engineering design challenge to real-life space technology.

Instructional Modalities

This activity was designed for synchronous and asynchronous instruction.

For **synchronous instruction**, we recommend a platform that allows both for whole group discussion and for family members to interact in smaller groups as the family moves through the lesson and into the activity.

For **asynchronous instruction**, we recommend using the slideshow and visual instructions in the worksheet. At least two participants are recommended to complete this format.

Materials

- **Make a Robotic Hand! Slideshow**
- **Make a Robotic Hand! Worksheet**
- **2 cardboard coffee cups per group**
- **3 rubber bands per group**
- **1 pair of scissors per group**
- **1 roll of tape per group**

Lesson

1. **Introductory Activity**
    - Participants will reflect and answer these questions:
        - o **What was *Intrepid's* role in the space race?**
        - o **What happens when you move something in space?**
        - o **How is moving an object in space different from moving an object on Earth?**
    - To better understand *Intrepid's* connection to space, participants will watch the short video.
        - o **What does space have to do with *Intrepid*?** Talk about how a ship like *Intrepid* would not travel to space, even if it were possible. Discuss how NASA utilized the assistance of naval ships to help in the recovery of early space capsules and the astronauts. This was *Intrepid's* role in the early 1960s, serving as the primary recovery vessel for two NASA space missions: Mercury 7 and Gemini 3. These missions tested technology before NASA developed the right space vessels to get to the moon.
        - o **How did NASA design and test space shuttles?** To further the understanding of engineering and moving to future goals in space, watch the short video. Compare the space capsules to the *Enterprise*. Space shuttles were designed to be reusable and help build the International Space Station. With a cargo area called the payload, astronauts could store more and conduct more research in the shuttles than what was possible in a capsule. However, NASA designed this as a prototype to test how it lands upon re-entry into Earth's atmosphere. Imagine if you built the world's first car and drove it from all the way across the continent of Australia. You probably want to test it in many trials first to make sure it can make that trip. That is what NASA did with *Enterprise,* which never went to space.

2. **Core Activity**
    - **What happens when you move something in space?** Newton's laws of motion work for both Earth and in space, but the environment in space presents other challenges when it comes to working and daily living. Astronauts study and research how toys work in space. To think about this, select a toy and demonstrate this together as a family. Hold up the toy at least table height. Then drop the toy. Discuss what you noticed.
        - **Why does the toy fall to the ground?** When we drop a toy on Earth, gravity is pulling it toward the center of Earth. In space, the force of gravity is different, but there is gravity. Watch the short video of astronauts playing soccer in space on slide 7. Describe what you see happening to the soccer ball.
        - **How is the force of gravity on the soccer ball different in space?** Even in space, there is gravity. Explain how gravity always affects us differently depending on how close we are to the mass we are interacting with. As you move farther away from a mass, like a space capsule leaving Earth, the force of gravity is not as strong.
        - When we see astronauts floating in space, they are actually in free fall, along with all the equipment and even the spacecraft around them. So, relative to the ship they are in, it looks like they are weightless in the microgravity environment of space. What would happen if you threw a ball to another astronaut in space, but the astronaut to whom you're throwing failed to catch it?

          Without something to stop it or grab it, the ball will keep free falling into space. This is dangerous and costly.

    - **What is an effector?** Take a minute to observe the image on slide 9. What might it be designed to do? Then think back to the ball example. NASA does not want its astronauts or equipment to keep free falling around Earth. So NASA looked for a design for something to catch and hold onto objects, especially in building and repairing Hubble and the International Space Station. This object in the image is the robotic arm.
        - The Shuttle Remote Manipulator System (SRMS), also known as the Canadarm for its country of origin, first took flight aboard Space Shuttle Columbia in 1981 (STS-2).
        - The Canadarms could be used to take satellites out of the

payload bay to be placed into orbit; they could capture satellites to be brought back down to Earth for analysis; and most amazingly, they could capture and hold damaged satellites in place while astronauts performed repairs.
    - Like all technology, engineers find ways to improve their designs. The Space Station Remote Manipulator System (SSRMS), aka the Canadarm 2 is an updated version of the Canadarm and is attached to the International Space Station (ISS).
    - The most innovative feature of the Canadarm 2 is the ability to "walk" around the shell of the ISS by detaching and connecting to various points around the station.
- **What does the effector of the robotic arm look like?** The "hand", or effector, of the robotic arm is designed specifically for operating in the microgravity environment of space.

    The job of an effector is simply to capture and move the object to the desired location. To accomplish this, the effector has three wires stored along its inside edge. When it turns, it can latch onto an object and secure it, holding the object in place as it moves.

3. **Make a Robotic Hand!** Now that you have learned about technology used to move objects in space, you will now gather your materials to make your own robotic hand effector to safely pick up and move an object as if you were in space.

   For this activity, you will use the visual instructions and this video to construct your effector. Try picking up a plastic bottle and safely moving it into the payload.

   After designing and testing your robotic hand, reflect on these questions:
   - What did you notice when you tried to move the bottle to the payload cargo?
   - What worked well? What did not work well?
   - What changes would you make in redesigning the effector?

Extension Activities

To deepen participant engagement with this content, you may choose to add the following activities:

Build a Satellite

Touchdown: Engineering a Lunar Lander

Additional Resources/ References

Newton's Laws of Motion

Science on Board CRS-15

Simple Machines in Microgravity

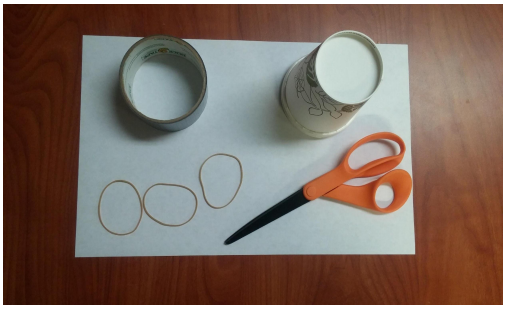
Astro Live - Robotic Arms

The Museum is deeply grateful to the funders that make our education programs possible:

This project was made possible in part by the Institute of Museum and Library Services, Award ID: CAGML-247144-OMLS-20

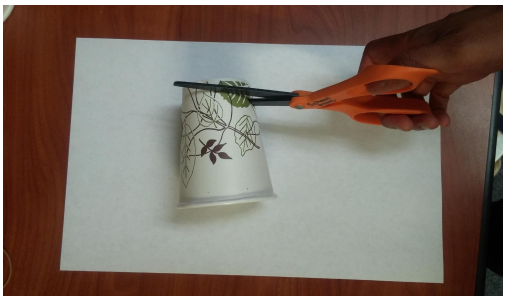
ACTIVITY: Make a Robotic Hand!

Directions:
Gather these materials listed next to the first picture below.
Watch the video to understand how to build your robotic hand. You can also use the visual instructions below to help step by step. Then use your robotic hand to pick up a plastic bottle and move it to the open payload without dropping it.

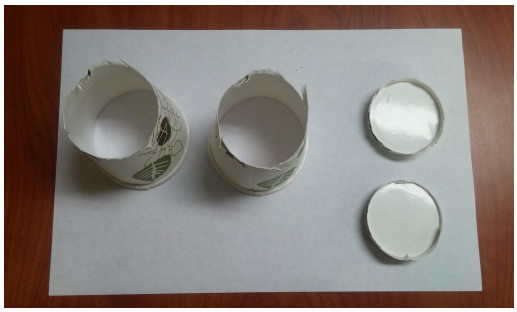


Materials:

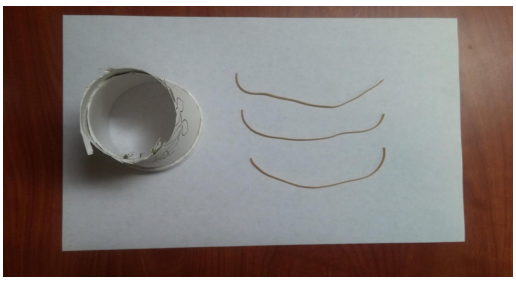
- Two cups
- 3 rubber bands
- Duct tape
- Scissors



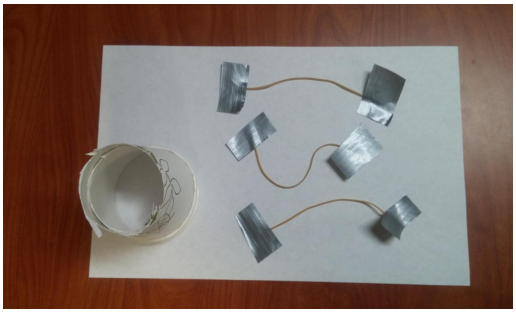
1. Remove the bottom end of each cup by cutting along the curved wall of the cup.



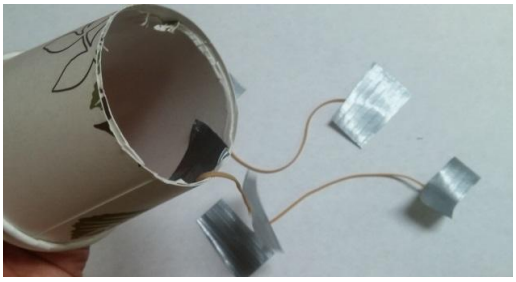
2. Discard the cup bottoms and place one cup inside the other.



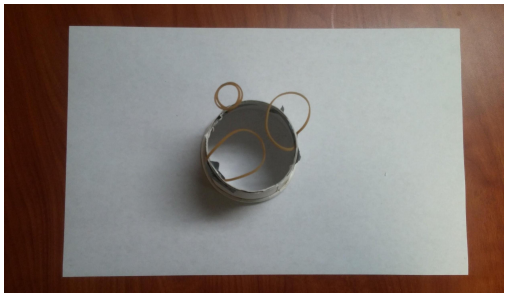
3. Take three rubber bands and cut them so they no longer make loops.



4. Place a strip of tape on each end of the rubber band.



5. Tape one end of a rubber band to the inside of the inner cup. Repeat this process with the other two rubber bands. Space each rubber band out evenly.



6. Tape the other ends of the rubber bands to the outside of the outer cup so that the rubber bands make a small loop over the cut edges of the cups.

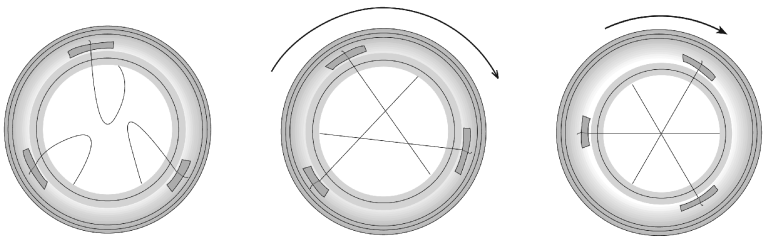


Image credit: NASA

7. Position the cup so the rubber bands are facing down. Twist the inside cup clockwise while holding the outside cup in place. The motion should be similar to using a pepper grinder. The rubber bands should all intersect in the middle of the cups. This is your snare.
8. Adjust rubber bands as needed to make them even.
9. Turn the opposite way to make rubber bands go back to their starting positions.
10. As a team, have one person control the robotic hand effector with their eyes closed. The other participants will give directions to that person so that they successfully land the bottle inside the payload!

Payload must be completely within the red square to be considered loaded.