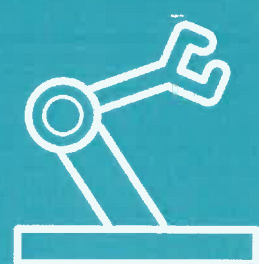


COSMIC CLAW

COSMIC CLAW

In this activity, youth will use the Engineering Design Process to design, build and operate a model of a robotic claw. Working together, the group will create a model of a hydraulic-powered robotic arm and claw and test it by completing an agricultural task. Ultimately, the mechanical claw should be able to perform a simple grasping, scooping, or raking action to gather "crops" that have been located on a world in the outer realm of the galaxy.

Goals, Objectives and Outcomes

By the end of the lesson, youth will be able to:

- understand the Engineering Design Process;
- recognize the mechanics involved in moving parts, robots, and hydraulics; and
- tinker with and optimize a hydraulic claw.

Full Activity Time (60 minutes)

Introduction: **5 minutes**

Activity: **45 minutes**

Reflection: **10 minutes**

Materials

Hydraulic claw kit:

- 4 plastic strips
- 8 screws
- 2 cylinders
- 2 cylinder screws
- Tubing
- 4 zipties

One Youth Guide per youth

Not in the kit

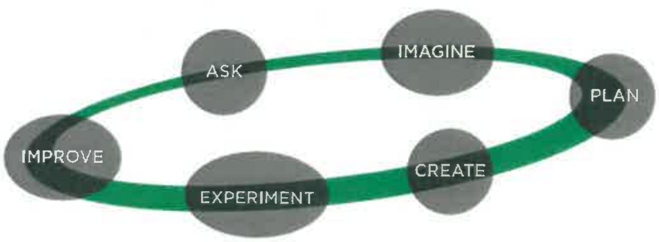
- Phillips-head screwdriver
- Masking or duct tape
- String
- Small container of water
- Items for the end of claw (small cups, plastic utensils, bottle caps, suction cups, etc.)
- Items to pick up (small candy,small balls, rice, sand, etc.)
- Starting location (bin or designated area)
- Ending location (bin or designated area)
- Wire cutters or scissors (optional)

IMPORTANT VOCABULARY

- **Agriculture:** The art and science of growing and harvesting crops and raising animals to provide the food and raw materials that humans need to survive.
- **Arm:** Moveable mechanical part of a robot usually connected by joints.
- **Claw:** Gripper or tool at the end of the arm designed for a specific task like grasping, holding, or pinching.
- **Cultivate:** The act of preparing the soil and caring for crops.
- **Cosmic:** Relating to the universe outside Earth.
- **Engineering Design Process:** Using a cycle of developing, testing, and refining design ideas to solve a problem.
- **Hydraulics:** The function of moving liquid (water) through pipes or hoses and channeling the pressure to power mechanics.
- **Joint:** The point where two or more parts connect allowing for movement or motion.
- **Mechanization:** The process of introducing machines or automatic devices into an activity previously performed by hand or using animals.
- **Robotics:** The science or study of technology associated with any machine (robot) that does work on its own.

Overall Steps

1. Designate the "crop" to be collected.
2. Split youth into small groups or pairs, depending on the number of youth participating.
3. Read the Suggested Script section out loud to the entire group.
4. Engage the group by asking the Opening Questions.
5. Pass out kit supplies to each group or pair.
6. Facilitate the Experience by instructing groups to design, produce, and test a hydraulic arm and claw utilizing the **Engineering Design Process** (pictured below).
7. Facilitate the reflection section at the end of the activity.



TIPS FOR ENGAGEMENT

1. Make sure that the youth have a clear open workspace so that all the components can be spread out and viewed.
2. If working with additional tools such as scissors or wire cutters, remind the youth about safety practices and have adults handle those tools for younger youth.
3. Allowing youth to work together in pairs or small groups allows them to more comfortably brainstorm and troubleshoot their design.
4. Younger youth may need more detailed assembly instructions, whereas older youth may be able to use the Engineering Design Process with little instruction.
5. Allow youth to brainstorm other games and activities that would simulate the use of robotics in agriculture or space exploration.

SUGGESTED SCRIPT

Robots are ideal for doing repetitive or even dangerous tasks that require precision. Robotic arms are used in the military, medical, industrial, and even agriculture fields! Agriculture is another word for farming. It provides the food and raw materials humans need to survive. Farmers use robots to cultivate crops and care for livestock. Robots will play a big role in the future of space exploration and may have to perform a variety of tasks that would be too dangerous or labor-intensive for humans. For example, the Mars Perseverance rover is a robot that has traveled to the surface of Mars, which is too dangerous for humans. The robotic arm attached to Perseverance is seven feet long and composed of shoulder, elbow, and wrist joints that make it as flexible as a human arm. The rover's hand can take geologic samples and record microscopic images of Martian rocks.

Did you know that our Moon will be a testing ground for future space missions? NASA's Artemis program is preparing humans to return to the Moon. In Greek mythology, Artemis was the sister of Apollo. You may recognize the name Apollo from the Apollo missions that NASA ran in the 1960s and 70s that put the first humans on the Moon. With the Artemis program, NASA intends to put humans back on the Moon by 2024, including the first woman, to establish means for sustainable space exploration. Exploring space to the farther reaches of our solar system and beyond will require a lot of resources, and returning to Earth every time astronauts need more will be too time consuming. Therefore, we want to figure out a way to support the long-term survival of humans independent of Earth's resources. For example, the International Space Station (ISS) typically has enough food and other supplies to last astronauts for several months. Most of the water and oxygen are recycled on board the space station (even sweat, urine, and water vapor from the air) and are purified and reused. However, if a resupply shuttle with food gets delayed, right now the astronauts have no choice but to try and conserve food supplies by simply eating less. The next generation of space explorers will be tasked with discovering ways to increase food, water, and oxygen supplies while traveling in deep space. Agriculture—and mechanical arms that help harvest resources on inhospitable worlds—will be a key component to the future of sustainable space exploration!

Opening Questions

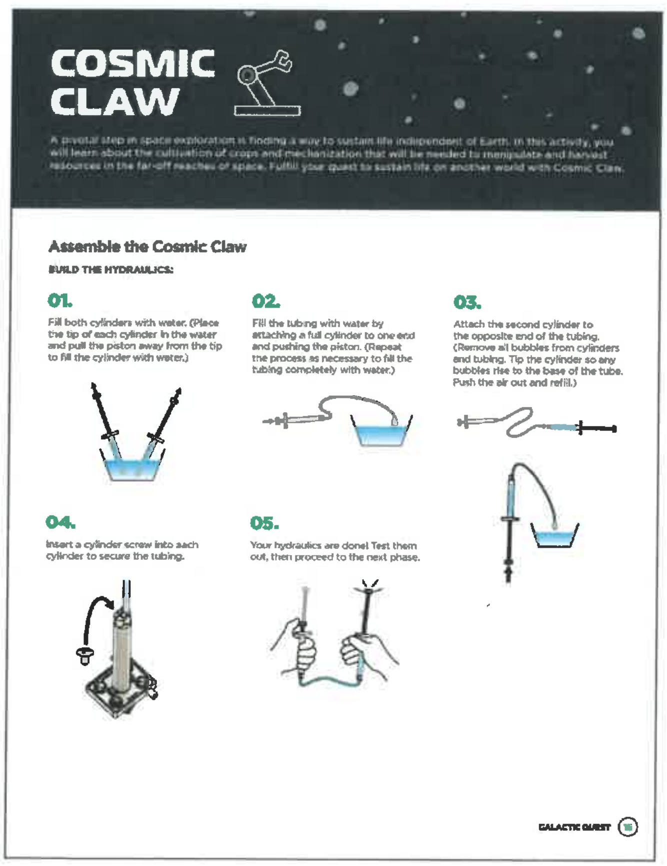
Ask the group the following questions to anchor them in the learning experience and stimulate wondering:

1. What are some robots you encounter in everyday life?
2. What do you want to know about robots in agriculture or in space?
3. What did you learn about how robots can benefit human space exploration? (This question can be repeated at the end of the activity too.)

Experience - Detailed Instructions

Build the Hydraulics

1. Fill both cylinders with water. (Place the tip of each cylinder in the water and pull the piston away from the tip to fill the cylinder with water.)
2. Fill the tubing with water by attaching a full cylinder to one end and pushing the piston. (Repeat the process as necessary to fill the tubing completely with water.)
3. Attach the second cylinder to the opposite end of the tubing. (Remove all bubbles from cylinders and tubing. Tip the cylinder so any bubbles rise to the base of the tube. Push the air out and refill.)
4. Insert a cylinder screw into each cylinder to secure the tubing.
5. Your hydraulics are done! Test them out, then proceed to the next phase.


COSMIC CLAW

A pivotal step in space exploration is finding a way to sustain life independent of Earth. In this activity, you will learn about the cultivation of crops and mechanization that will be needed to manipulate and harvest resources in the far-off reaches of space. Fulfill your quest to sustain life on another world with Cosmic Claw.

Assemble the Cosmic Claw

BUILD THE HYDRAULICS:

01. Fill both cylinders with water. (Place the tip of each cylinder in the water and pull the piston away from the tip to fill the cylinder with water.)

02. Fill the tubing with water by attaching a full cylinder to one end and pushing the piston. (Repeat the process as necessary to fill the tubing completely with water.)

03. Attach the second cylinder to the opposite end of the tubing. (Remove all bubbles from cylinders and tubing. Tip the cylinder so any bubbles rise to the base of the tube. Push the air out and refill.)

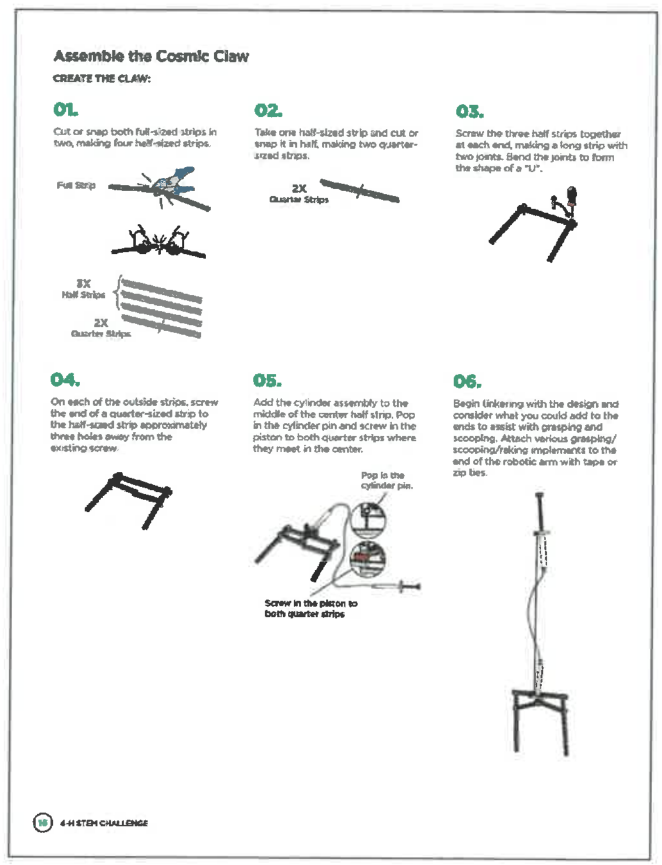
04. Insert a cylinder screw into each cylinder to secure the tubing.

05. Your hydraulics are done! Test them out, then proceed to the next phase.

GALACTIC QUEST 15

Create the claw

6. Cut or snap both full-sized strips in two, making four half-sized strips.
7. Take one half-sized strip and cut or snap it in half, making two quarter-sized strips.
8. Screw the three half strips together at each end, making a long strip with two joints. Bend the joints to form the shape of a "U".
9. On each of the outside strips, screw the end of a quarter-sized strip to the half-sized strip approximately three holes away from the existing screw.
10. Add the cylinder assembly to the middle of the center half strip. Pop in the cylinder pin and screw in the piston to both quarter strips where they meet in the center.
11. Begin tinkering with the design and consider what you could add to the ends to assist with grasping and scooping. Attach various grasping/scooping/raking implements to the end of the robotic arm with tape or zip ties.


Assemble the Cosmic Claw

CREATE THE CLAW:

01. Cut or snap both full-sized strips in two, making four half-sized strips.

Full Strip

3X Half Strips

2X Quarter Strips

02. Take one half-sized strip and cut or snap it in half, making two quarter-sized strips.

2X Quarter Strips

03. Screw the three half strips together at each end, making a long strip with two joints. Bend the joints to form the shape of a "U".

04. On each of the outside strips, screw the end of a quarter-sized strip to the half-sized strip approximately three holes away from the existing screw.

05. Add the cylinder assembly to the middle of the center half strip. Pop in the cylinder pin and screw in the piston to both quarter strips where they meet in the center.

Pop in the cylinder pin.

Screw in the piston to both quarter strips

06. Begin tinkering with the design and consider what you could add to the ends to assist with grasping and scooping. Attach various grasping/scooping/raking implements to the end of the robotic arm with tape or zip ties.

16 4-H STEM CHALLENGE

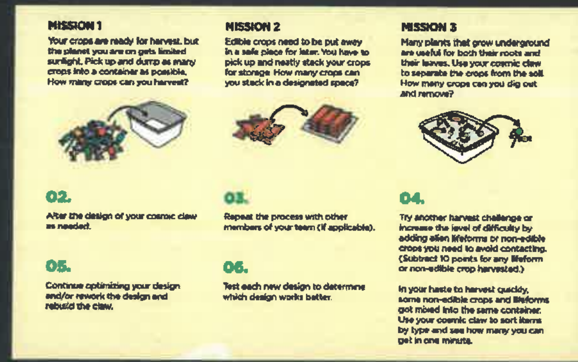
Harvest Challenge

1. In one minute, have youth harvest as many "crops" as they can and record the result. Select a harvest challenge. (Earn 5 points for every crop harvested and an additional 1 point for every second remaining.)
    - **Mission 1:** Your crops are ready for harvest, but the planet you are on gets limited sunlight. Pick up and dump as many crops into a container as possible. How many crops can you harvest?
    - **Mission 2:** Edible crops need to be put away in a safe place for later. You have to pick up and neatly stack your crops for storage. How many crops can you stack in a designated space?
    - **Mission 3:** Many plants that grow underground are useful for both their roots and their leaves. Use your cosmic claw to separate the crops from the soil. How many crops can you dig out and remove?
2. Have youth alter the design of their cosmic claw as needed.
3. Repeat the process with other members of your team (if applicable).
4. Try another harvest challenge or increase the level of difficulty by adding alien lifeforms or non-edible crops you need to avoid contacting. (Subtract 10 points for any lifeform or non-edible crop harvested.)
    - In your haste to harvest quickly, some non-edible crops and lifeforms got mixed into the same container. Use your cosmic claw to sort items by type and see how many you can get in one minute.
5. Continue optimizing your design and/or rework the design and rebuild the claw.
6. Test each new design to determine which design works better.

Reflection

Giving all participants a chance to reflect on what they have learned is an important part of the experiential learning process. Have all the youth that built and/or tested the claw discuss the following questions with each other (small group sharing). Then, ask one person from each small group to share one of their responses or discussion points.

- **Share:** What changes did you make to your claw as you tinkered with it?
- **Share:** How well did your claw function to perform the task (picking, scooping, raking)?
- **Reflect:** What problems or issues did you observe when using the claw?
- **Reflect:** What were the keys to successfully operating or designing the claw? What would you do differently next time?
- **Apply:** What types of crops do you think can be harvested on Earth using a robotic arm or other mechanical device?
- **Apply:** How does agriculture support space exploration?



Extension/Add-on

Agriculture revolutionized human civilization - because we developed the skills and knowledge to cultivate our own food, we no longer need to travel to find it. We can take the lessons we have learned from Earth and apply them to our future settling of space and other worlds.

Soils: Did you know that 95% of our food is directly or indirectly produced from soil? Soil is one of the most biodiverse habitats on Earth and helps protect against floods and droughts by storing and filtering our water. To learn more about soils, visit these Ag-in-the-Classroom lessons:

- Soil Painting: **agclassroom.org/matrix/lesson/390/**
- Digging into nutrients: **agclassroom.org/matrix/lesson/123/**
- In Search of Essential Nutrients: **agclassroom.org/matrix/lesson/226/**

Hydroponics: By dissolving important nutrients in water and providing certain supports, we can grow plants without soil in a method called hydroponics. Hydroponics is a great option for cultivating plants in space because it functions well in a closed system and requires very few inputs. To learn more, visit these pages and watch the videos:

- Making it Grow interview with Vertical Roots: **fb.watch/5t7nX14w5D/**
- NASA's Growing Plants in Space: **nasa.gov/content/growing-plants-in-space**
- Ag-in-the-Classroom "Martian Food" Video: **agclassroom.org/matrix/resource/495/**

Agricultural Engineering: Did you know that the average U.S. farmer feeds 156 people? By combining fields of study including agriculture, machinery, robotics, food systems, and technology, we can improve the efficiency of food production and environmental sustainability. Check out these resources to learn more:

- Clemson University's Robotic Dairy: **youtube.com/watch?v=ZNN7pMhVVgA**
- Ag-in-the-Classroom Ag Engineering Video: **agclassroom.org/matrix/resource/148/**
- NASA's Design a Lunar Growth Chamber: **nasa.gov/pdf/326866main_Moon_Munchies_Lesson_5_6.pdf**

Next Generation Science Standards

Math and Computational Thinking

- Elementary 3-5: Organize simple data sets to reveal patterns that suggest relationships.
- Middle School 6-8: Create algorithms (a series of ordered steps) to solve a problem.

Engineering Design

- 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.

Life Science

- MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

Physical Science

- 4-PS4-2: Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.
- 5-PS2-1: Support an argument that the gravitational force exerted by Earth on objects is directed down.
- 5-ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

Earth and Space Science

- 3-ESS3-1: Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.
- 5-ESS1-1: Support an argument that the apparent brightness of the sun and stars is due to their relative distances from the Earth.
- 5-ESS3-1: Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
- MS-ESS1-2: Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.
- MS-ESS1-3: Analyze and interpret data to determine scale properties of objects in the solar system.
- MS-ESS2-6: Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.
- MS-ESS3-1: Humans depend on Earth's land, ocean, atmosphere and biosphere for many different resources. Minerals, fresh water and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.
- MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Keep on the Trajectory

Check out all these after-challenge actions to explore more in STEM!

- 4-H at Home offers fun, hands-on educational opportunities for kids and teens to do at home. Explore the wonders of space with easy at home experiments: **4-H.org/about/4-H-at-home/space-exploration/**
- Adventures in Aerospace (shop4h.org) is a 4-H curriculum that connects youth to space through project-based, hands-on learning.
- 4-H Journey to Mars (clemson.edu/4H) is a hands-on learning program that promotes computational thinking skills through kit-based and online activities around a Mars-based theme.
- CS First g.co/csfirst offers an introductory, video-based computer-science curriculum that teaches students foundational skills using Scratch. Guided experiences cover projects like story-telling, games, and more!
- Scratch (scratch.mit.edu) is the world's largest and friendliest creative coding community for youth and educators. Youth can create projects and explore. This platform takes youth from being consumers of technology to creators of it.
- Code.org has a wonderful lineup of easy and fun computer science curriculum and other programs for teachers and students that are age-appropriate.
- ENIGMA (enigma.rutgers.edu) is a NASA project that stands for Evolution of Nanomachines in Geospheres and Microbial Ancestors. It is an educational platform that makes connections between biology, engineering, and geology in hopes of finding habitable worlds and possible life!
- NASA (nasa.gov/stem and steaminnovationlab.org) has many educational programs and resources that engage young people in STEM learning through space exploration and connecting the American public to missions.