FACILITATOR GUIDE

GALACTIC QUEST

4-H STEM CHALLENGE

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A huge thank you to all the groups of youth and parents for testing and piloting this year's challenge!

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KIT MATERIALS

These materials are included in this kit. If you want to create more, printable materials are also available online at **4-H.org/STEMChallenge**.

Educator Kit Includes:

- Facilitator Guide (1)
- Youth Guides (12)
- Telescope kits (2)
- Set of 12 constellation cards (1)
- Cipher wheels (4)
- Cipher answer sheets (2)
- Astro Adventure boxed game (1)
- Hydraulic claw kits (2)

Family Kit Includes:

- Facilitator Guide (1)
- Youth Guides (2)
- Telescope kit (1)
- Set of 12 constellation cards (1)
- Cipher wheels (2)
- Cipher answer sheets (2)
- Astro Adventure boxed game (1)
- Hydraulic claw kit (1)

WELCOME TO GALACTIC QUEST, THE 2021 4-H STEM CHALLENGE!

If you are new to 4-H, it's important for you to know that our mission is to give ALL youth equal access to opportunity. 4-H is a community for all kids with programs that suit a variety of backgrounds, interests, budgets and schedules. Whether at home, in-school or after-school, in clubs or at camps, 4-H positive youth development programs are available in your local community and welcome children who want to have fun, learn, and grow. Our philosophy is to engage kids in hands-on learning that gives them the chance to make mistakes, learn from each other, and develop important life skills like problem solving, patience, and teamwork. 4-H covers almost any topic imaginable and youth can pursue the topics that interest them most! In general, 4-H projects can be grouped into four main categories or pillar areas: STEM (science, technology, engineering, and math), civic engagement, healthy living, and agriculture. The 4-H STEM Challenge is our signature annual initiative to inspire kids everywhere and spark an interest in STEM through hands-on learning.

This year, National 4-H Council has partnered with Clemson University Cooperative Extension, the United States Space Force, Bayer, and Facebook to create STEM activities that are fun and accessible to young people everywhere. The 2021 Challenge theme of space exploration takes youth on an out-of-this-world adventure and makes connections to the 4-H pillars—STEM, civic engagement, healthy living, and agriculture. The challenge activities allow youth to develop inquiry, observational, and problem-solving skills while they make discoveries and develop their STEM identities.

In this guide, you will learn everything you need to know about facilitating four space-related activities: Stellar Optics, Cipher Space, Astro Adventure, and Cosmic Claw. You do not need prior experience with STEM in order to bring these activities to your youth. Activities have been designed with simplicity and adaptability in mind so that anyone—from teachers to teen leaders to parents—can facilitate them. There is a logical progression to the activities presented in the challenge, but each activity can be conducted independently or in a different order. Each activity contains background information with a script and opening questions, as well as full activity details and reflection questions. **For families wanting to engage with the activities right away or youth working on their own, the Youth Guide can be used as a Quick Start Guide to the challenge.** Galactic Quest is ideal for youth ages 8-14 years to spark an interest in STEM and inspire real-world actions.

4-H STEM Challenge

Although October is officially 4-H STEM Month, youth take part in the 4-H STEM Challenge all year round. With your help, we can spark an interest in STEM for all youth, making hands-on learning accessible to everyone!

Preparation: Get ready to facilitate Galactic Quest by reading through this guide. Focus on the Facilitator Preparation section for a concise overview of how to prepare. For families or youth working on their own, the activity sections in the Youth & QuickStart Guide provide a quick-start way to begin engaging with the activities right away.

Plan: October is 4-H STEM Month and we encourage educators to plan challenge events during this month. An event can be as simple as doing an activity for a class lesson or teaching a few youth at home, or as big as planning a large community event. Re-use or purchase more kits year round to bring STEM to more youth!

Check-in: Visit **4-H.org/STEMChallenge** for the latest updates! This webpage is your resource to help you make the most of the 4-H STEM Challenge, including promotional materials, printable resources, and webinars for adults and teens to better facilitate your event.

Share: Tell your friends and colleagues about the 4-H STEM Challenge, and share on social media using **#4HSTEMChallenge**.

Your feedback helps us improve the 4-H STEM Challenge each year! Once you have completed the Galactic Quest challenge, please take a few moments to fill out this survey about your experience: **4-H.org/STEMChallengeSurvey**.

FACILITATOR PREPARATION

Get comfortable facilitating STEM by familiarizing yourself with this guide and the topics covered in this year's 4-H STEM Challenge. **For families or youth working on their own, the Youth Guide can be used as a Quick Start Guide to begin engaging with the activities right away.**

Checklist:

- ☐ Visit **4-H.org/STEMChallenge** for information, webinars, and training videos for this year's challenge.
- ☐ Select activities that best fit your group, time, and space.
- ☐ Review the vocabulary, materials, and full instructions of the activities you choose, including the basics of the Engineering Design Process on page 31.
- ☐ Print additional Youth Guides or printable resources from **4-H.org/STEMChallenge**.
- ☐ Source any additional materials needed for the activities, including pens and pencils.

Icon Key

Take note of key information in this guide to help you facilitate this STEM challenge. Key information for you, as the facilitator, is presented in the **Facilitator Tips** and **Important Vocabulary** sections. Key information that you can read aloud to the group includes the **Suggested Script** and **4-H Pillar Alignment**.

FACILITATOR TIPS

IMPORTANT VOCABULARY

SUGGESTED SCRIPT

4-H PILLAR ALIGNMENT

Skills Inventory

Skills related to STEM learning help kids to identify with STEM and build their STEM literacy. These skills not only feed science content but influence interest and attitudes towards STEM, which help youth succeed in school and careers. These are some STEM learning skills:

- **Collaboration:** Working effectively together in groups or teams. This is a critical skill for STEM workforce development, which teaches youth how to identify the strengths of their team members and how to work together in order to efficiently complete a task.
- **Creativity:** Looking at and proposing solutions to a problem through multiple approaches, including ones that are "outside the box." Innovation is a product of creativity.
- **Critical Thinking:** Analyzing, evaluating, reflecting, and synthesizing information to propose new ideas and creative solutions. This process helps youth develop into independent, critical thinkers.
- **Engineering Design Process:** Using a cycle of developing, testing, and refining design ideas to solve a problem. Through each step, youth get closer to finding a workable solution to the problem, while using other STEM skills in the process.
- **Inquiry Skills:** Solving problems by asking questions, proposing ideas and testing solutions. This puts youth in the driver's seat.
- **Problem Solving:** Thinking quickly and effectively to solve a problem. This requires youth to use the information they have to create appropriate solutions.
- **Real-World Application:** Taking the skills youth learned in school and applying them to real-world STEM problems. This helps them to connect geometry, data, observation, and other math and science content to real-life scenarios.
- **Resiliency:** Overcoming challenges and being able to persevere through setbacks. In STEM, mistakes and failed attempts are positive experiences, offering opportunities for deeper learning.

Planning Delivery

Galactic Quest is adaptable to a wide range of space, time, and technology constraints. All the activities are "unplugged" and do not require technology equipment to deliver them. The four activities can be enjoyed individually or together, spread out over time or all at once, and in any sequence to best fit your family time, classroom or out-of-school learning environment. We have provided examples of how you might structure your 4-H STEM Challenge with different time allowances.

	STELLAR OPTICS	CIPHER SPACE	ASTRO ADVENTURE	COSMIC CLAW
FULL CHALLENGE	60 minutes	40 minutes	50 minutes	60 minutes
SHORT & SWEET	20 minutes (telescope only) 20 minutes (constellations only)	20 minutes (encryption practice) 20 minutes (relay race)	30 minutes (game only)	30 minutes (build only)
CHALLENGE ADD-ONS	15 minutes	20 minutes	20 minutes	45 minutes

Facilitation Tips

Encourage thinking, sharing, and making connections during these activities. A great strategy to do this is using the K-W-L (Know-Want-Learned) approach. To introduce new topics, anchor youth in their current knowledge, stimulate thought, and track learning, you can focus your questions around what youth **know**, what they **want** to learn, and what they have **learned**. You can ask K-W-L questions out loud to the group, have youth write their answers down independently, or create a graffiti wall with a designated spot for each question. The "Opening Questions" section in each activity has K-W-L questions you can use to begin discussion.

Career Connections

Career connections are included at the end of every activity in the Youth Guide so that youth can explore potential careers related to the topics covered in the respective fields.

ACTIVITY OVERVIEWS

STELLAR OPTICS

In this activity, youth will begin their space adventure by looking at the stars. They will explore principles of light and construct a simple refracting telescope. Using their telescope, youth will learn about common constellations that have influenced human cultures for millennia. Since the distortion of light by moisture and other atmospheric particles hinders our view of celestial bodies here on Earth, youth are introduced to the concept of moving outside of Earth and its atmosphere for further exploration.

STEM Skills:
Inquiry skills, collaboration, real-world application, creativity

4-H Pillar Alignment:
STEM

Full Challenge Time:
60 minutes

Additional Materials:

- Pencils
- Clear cup with water

CIPHER SPACE

This activity introduces concepts of cybersecurity and protecting our assets in space. Youth will use a Caesar cipher wheel to decode a secret message, encrypt and decipher words with their peers, and participate in a group relay race. They will learn about careers in cybersecurity, technology, and space. This activity builds the computational thinking skill of pattern recognition as youth search for patterns to find a solution to the encryption challenges.

STEM Skills:
Computer science, collaboration, real-world application

4-H Pillar Alignment:
STEM/Civic Engagement/Healthy Living

Full Challenge Time:
40 minutes

Additional Materials:

- Pencils
- Paper

ASTRO ADVENTURE

In this board game, youth will attempt to expand their influence on our solar system by collecting resources and adding spacecraft to their fleet. They will learn about the resources needed for space exploration and where they could be found. In addition, youth will explore the implications of space travel on human health in this interplanetary adventure.

STEM Skills:
Inquiry skills, collaboration, real-world application

4-H Pillar Alignment:
STEM/Healthy Living/Civic Engagement

Full Challenge Time:
50 minutes

Additional Materials:

- Shallow container to store resource tokens (optional)

COSMIC CLAW

In this activity, youth will use the Engineering Design Process to design, build, and operate 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 cultivate crops on another world.

STEM Skills:
Inquiry skills, collaboration, real-world application

4-H Pillar Alignment:
STEM/Agriculture/Healthy Living

Full Challenge Time:
60 minutes

Additional Materials:

- Phillips-head screwdriver
- Tape (masking/duct)
- String
- Small container of water
- Wire cutters (optional)
- 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)

STELLAR
OPTICS

STELLAR OPTICS

In this activity, youth will expand their universe by creating a simple refracting telescope to magnify surroundings, investigate the refraction of light, and discover the fascinating world of constellations.

Goals, Objectives and Outcomes

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

- make observations about their surroundings and objects magnified using convex and concave lenses;
- assemble a refracting telescope; and
- use a telescope to view and record constellations.

Full Activity Time (60 minutes)

Introduction: **10 minutes**

Activity: **40 minutes**

Reflection: **10 minutes**

Materials

Telescope kit:

- Objective lens cap
- Convex objective lens
- Aperture ring
- Outer telescope tube
- Focusing ring
- Inner telescope tube
- Connection ring
- Eyepiece washer
- Eyepiece lens
- Eyepiece
- Decorative stickers

One Youth Guide per youth

Not included in the kit:

- Pencil
- Cup of water

IMPORTANT VOCABULARY

- **Design:** To create, execute or construct according to plan.
- **Concave lens:** A lens that is thinner at the middle than on the edges; rays of light that pass through the lens are bent away from each other, i.e. they diverge.
- **Convex lens:** A lens that is thicker at the middle than on the edges; rays of light that pass through the lens are brought closer together, i.e. they converge.
- **Focal length:** The distance between the principal focus and the center of the lens is called the focal point.
- **Focal point:** When parallel rays of light pass through a convex lens, the refracted rays converge at one point called the focal point.
- **Investigate or Analyze:** To carry out research or a study into a subject or discover facts or information.
- **Magnify:** The process of enlarging the apparent size, not the physical size, of something.
- **Refract:** To bend light waves (or other types of waves) as they pass through substances like air, water, prisms, and more.
- **Telescope:** A telescope is an optical device that has the ability to make faraway objects appear much closer.

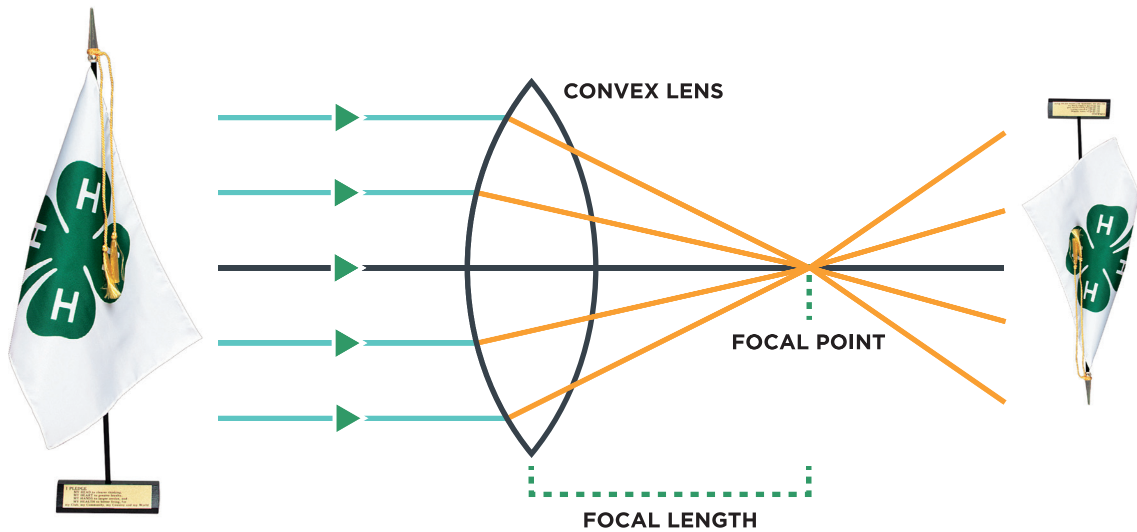
Decoding the Lenses

Lenses are specially shaped pieces of glass or transparent plastic that bend the light travelling through them.

Lenses which are thicker in the middle than the edges are called **convex lenses**. Lenses which are thinner in the middle than at the edges are called **concave lenses** (they cave in!). They both bend light as it passes through them.

Convex lenses **converge** light that passes through them. Converge—when two or more things come together to form a new whole; to tend or move toward one point or another; to come together.

Concave lenses **diverge** light that passes through them. Diverge—to move or extend in different directions; to move apart.



The above figure shows how a convex lens refracts light to bend the light inward, converging to a single focal point and then back out again. An image seen through a convex lens beyond the focal point will be upside down.

Overall Steps

1. Gather all materials to use for the telescope activity.
2. Break the group into teams of 2-4. They may also work individually.
3. Read the Suggested Script section out loud to the group.
4. Engage the group by asking the Opening Questions.
5. Facilitate the Experience.
6. Facilitate the Reflection at the end of the activity.

TIPS FOR ENGAGEMENT

1. Before youth start assembling their telescope, have them make observations about the components of the kit and predict how they might work together.
2. Younger youth may need more step-by-step instructions on the assembly, whereas older youth may be able to assemble and test their telescopes with little instruction.
3. Although the telescope comes as a complete kit, let youth think about and make suggestions on how they could make adjustments to its design.
4. In working with larger groups, you can engage more youth at one time by allowing some youth to make observations with lenses while others are exploring constellations at close range using the telescope tubes (no lenses).

SUGGESTED SCRIPT

For thousands of years, humans have looked to the stars and wondered what was up there. Many cultures across the globe have their own traditions and histories related to stars and constellations. Constellations are groups of stars or celestial objects that form recognizable patterns and are easily seen from Earth. Humans have navigated and explored using constellations and their associated stars. Did you know that even astronauts on the Apollo missions used Altair, one of the brightest stars in the Aquila constellation, to find their way to the Moon?

For as long as we have been looking at the night sky, we have wanted to know more about stars and space. Astronomy is the scientific study of everything beyond Earth's atmosphere, including celestial bodies. Telescopes are a tool that astronomers use to get a better look, as this optical device has the ability to make faraway objects appear much closer. Telescopes collect light from a distant object and bring that light to a focus, where a second device magnifies the image and brings it to your eye. Galileo turned his telescope towards the heavens in 1610 and expanded what we knew about the universe far beyond what could be seen with the naked eye. Scientists learned that Saturn had rings and Jupiter had moons. A new age of discovery had begun! Edwin Hubble used the largest telescope of his day, in the 1920s, to discover galaxies beyond our own. However, the same physics principle that allows telescopes to work, called refraction, is also the same reason that telescopes on Earth struggle to see clearly. Earth's atmosphere is full of moisture and other molecules that refract the light waves and disrupt the images we are trying to see with telescopes. So, in order to see objects more clearly, we need to use telescopes outside of Earth's atmosphere.

In 1990, the Hubble Space Telescope, named for Edwin Hubble, was the first major optical telescope to be placed in space. Unfortunately, a microscopic flaw in the manufacturing of a mirror (a flaw less than 1/50th the thickness of a human hair) rendered the first images of the telescope virtually useless. They were very blurry and needed computer modeling to restore some clarity. A repair in 1993 corrected the issue (kind of like putting on a pair of glasses!), and the Hubble Space Telescope has been one of the most productive pieces of scientific equipment ever built. It has shown us weather on other planets, planets orbiting other stars, and stars being formed inside nebulas. Now, NASA's James Webb Space Telescope is an orbiting infrared observatory that will complement and extend the discoveries of the Hubble Space Telescope. It has a target launch of October 31, 2021.

Opening Questions

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

1. What do you know about looking at the stars?
2. What do you want to know about how we view things in space?
3. What have you learned about telescopes today? (This question can be repeated at the end of the activity too.)

Experience - Detailed Instructions

Optical Illusion

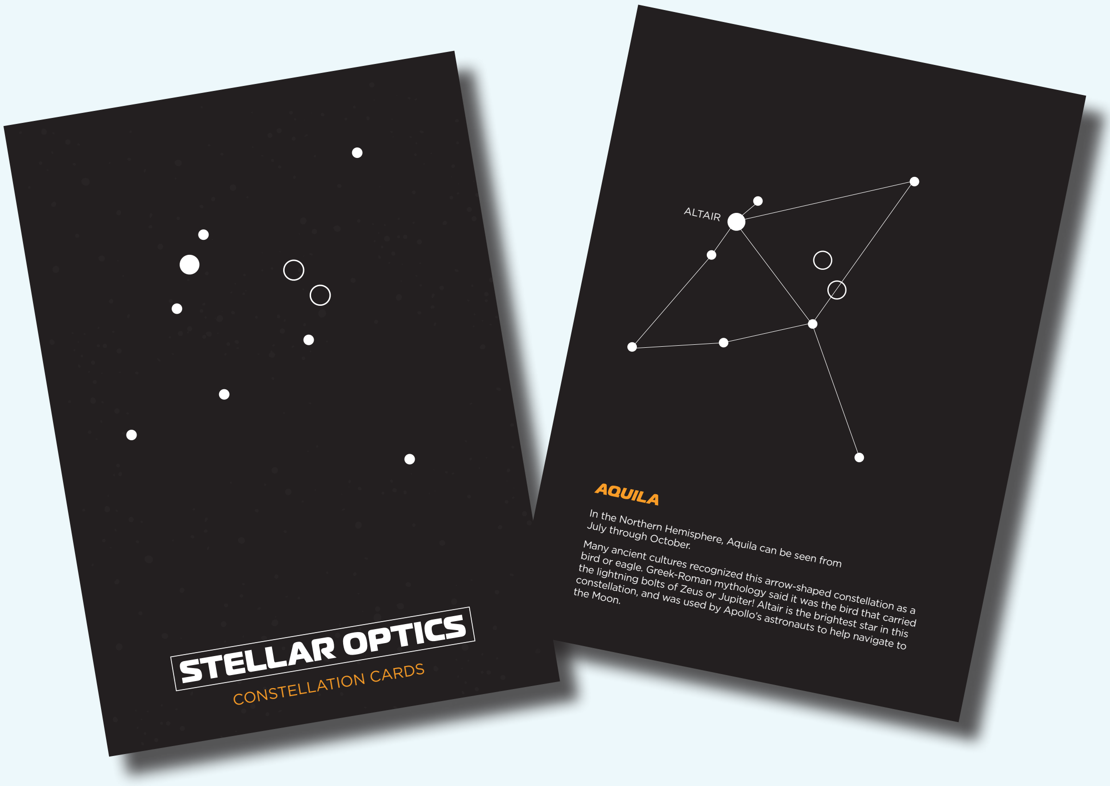
1. Fill a clear cup about halfway with water and stick a pencil in the water.
2. Have youth observe what they notice. Does the pencil maintain its original appearance from top to bottom? Does the pencil look the same from all angles?
3. The pencil is not changed, but it appears broken, enlarged, and/or curved in the water. Light waves traveling through the cup of water are bent and distorted due to refraction.

Telescope (Kit)

1. Have youth look at both lenses in the kit and make observations about them. How do objects look when they attempt to look through the lenses? Change the distance from the lens and the object, as well as the distance between the lens and their eye. Do both lenses behave the same? Do not rush this step.
2. Have youth look at all the components of the telescope kit and lay them out on a surface.
3. Assemble the telescope according to the instructions in the Youth Guide and diagram below. (Younger youth may need detailed instructions, whereas older youth can be challenged to predict how the telescope should be assembled.)
4. Have youth test their assembled telescope. An ideal distance for testing is from about 50 feet. The focus of the telescope is adjusted by sliding the telescope tubes that bring the lenses closer and farther away. (WARNING: Never look at the sun with a telescope, binoculars, or your naked eye. It can lead to serious injury and permanently damage vision.)
5. Have youth reflect on how the telescope operates. Images will appear upside down and the directional movement may seem counterintuitive for the user.

Constellations

1. Place constellation cards at a distance where they can be viewed by the telescope (about 50 feet works best).
2. Youth will use the telescope to view the star cards from a distance. (For smaller spaces, youth can use the inner or outer telescope tubes without lenses to view the constellation cards at close range.)
3. Youth will record the pattern of key stars they can see through the telescope in their guides and review facts about their constellation.



Reflection

Giving all participants a chance to reflect on what they have learned is an important part of the experiential learning process. Have small groups or pairs share with the whole group.

- **Share:** What happened when you used your telescope?
- **Share:** What did you learn about your constellation(s)?
- **Reflect:** What were the keys to successfully seeing your constellation(s) through the telescope?
- **Reflect:** What would you change about this activity in the future?
- **Apply:** What are some other benefits of using telescopes?
- **Apply:** Where else can the principle of refraction be applied (or observed)?

Extension/Add-on

1. Take the stargazing outside! Use star charts or stargazing apps to continue the exploration of constellations in the night sky. NASA's starfinder activity has printable resources based on the month of the year. (**spaceplace.nasa.gov/starfinder/en/**)
2. Most of the widely known constellations in the night sky are based on Greek and Roman mythology. Have youth research more constellations, especially those of other cultures and ancient civilizations.
3. Measure the focal length of each lens. Place a light at the same elevation in the room as the lens, then place a lens between the light and a vertical piece of paper. Slowly move the lens closer and closer to the piece of paper until a miniature projection of the light comes into focus on the piece of paper. The distance between the piece of paper and the lens at this point is the focal length. (Focal length will be less than an inch for the small eyepiece lens and between 1-2 inches for the objective lens. The focal length is determined by the curvature and thickness of the lens instead of the diameter or size of the lens.)

CIPHER SPACE

CIPHER SPACE

In this computer science activity, youth will explore the terms encryption, decipher, and cybersecurity as they consider how data is shared and why it needs to be secure. Participants will use a Caesar cipher wheel to decode a secret message, encrypt, and decipher words with their peers, and participate in a group relay race. This activity encourages the use of the computational thinking skill of pattern recognition as youth search for patterns to find a solution to the encryption challenges.

Goals, Objectives and Outcomes

By the end of this activity, youth will be able to:

- understand the terms cybersecurity, encryption, and decipher as they apply to computer science;
- use ciphers to encrypt and decipher messages; and
- understand the importance of cybersecurity on Earth and in space.

Full Activity Time (40 minutes)

Introduction: **5 minutes**

Activity: **25 minutes**

Reflection: **10 minutes**

Materials

Cipher wheel

Cipher answer sheet

One Youth Guide per youth

Not included in the kit:

- Dry erase marker (optional)

IMPORTANT VOCABULARY

- **Cipher:** The generic term for a technique or algorithm that performs encryption.
- **Cipher key:** A number, or in some cases a string of characters, that correlates to the solution of an encrypted message. In a Caesar cipher, the number corresponds to the number of letters of the alphabet that a message is shifted.
- **Cybersecurity:** The use of technologies and strategies to protect computer systems and their electronic data from unauthorized access, damage, disruption, and theft.
- **Encode:** To convert information or an instruction into a particular form.
- **Encryption:** The process of taking a normal message and scrambling it into a highly complex code which can only be unscrambled by “authorized” people.
- **Data:** Information stored by a computer, for example, files, emails, apps, video games, songs, and pictures.
- **Decipher:** To take a secret message and reproduce the original plain text; to reverse encryption.

Overall Steps

1. Gather all materials for the cipher activity.
2. Read the initial Suggested Script out loud to the group.
3. Engage the group by asking the Opening Questions.
4. Facilitate the initial Experience with small groups or have them work individually.
5. Divide the entire group in half, read the second Suggested Script and premise out loud to the group, and facilitate the relay Experience.
6. Facilitate the Reflection at the end of the activity.

TIPS FOR ENGAGEMENT

1. Before deciphering a whole word, demonstrate the use of the cipher wheel with younger youth with single-letter examples; whereas older youth may be able to use the cipher wheel with little instruction.
2. Allowing youth to work together in pairs or small groups enables them to more comfortably ask questions and troubleshoot use of the cipher wheel.
3. For individuals who may feel intimidated by the pressure of deciphering code in the relay activity, adjust the rules of the race to allow individuals to bring the encrypted code back to their group. Solving each step can be a team effort.
4. Allow youth to brainstorm other games that would simulate cybersecurity or involve data protection.

SUGGESTED SCRIPT

We use computers and the internet in many different ways in everyday life. Our society depends on computers for banking, communication, entertainment, education and even space exploration! Much of this technology is supported by a vast network of satellites currently orbiting our planet. Think of some of the ways you use the internet—online shopping, research for school, managing a bank account, downloading videos, streaming music, and more. Now think of the information you or your family members have typed into a computer, tablet or smartphone lately—login information, passwords, addresses, phone numbers, birthdays and other identifying information. As we use technology to communicate over the internet, it is important that we maintain privacy and control over who can access our private information. Private information in the wrong hands can have serious, negative consequences!

Long before computers were invented, people were sending private messages using their own secret systems of communication. Encryption is a way to hide a message in plain sight. One of the earliest known uses of encryption is the Caesar Cipher Wheel, which dates back to 100 A.D. and was named after Julius Caesar. Caesar used this type of encryption to send secure messages to military officials. Today, we use similar modes of encryption to keep vast amounts of personal and confidential information safe as it travels the internet with the support of satellites.

Opening Questions

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

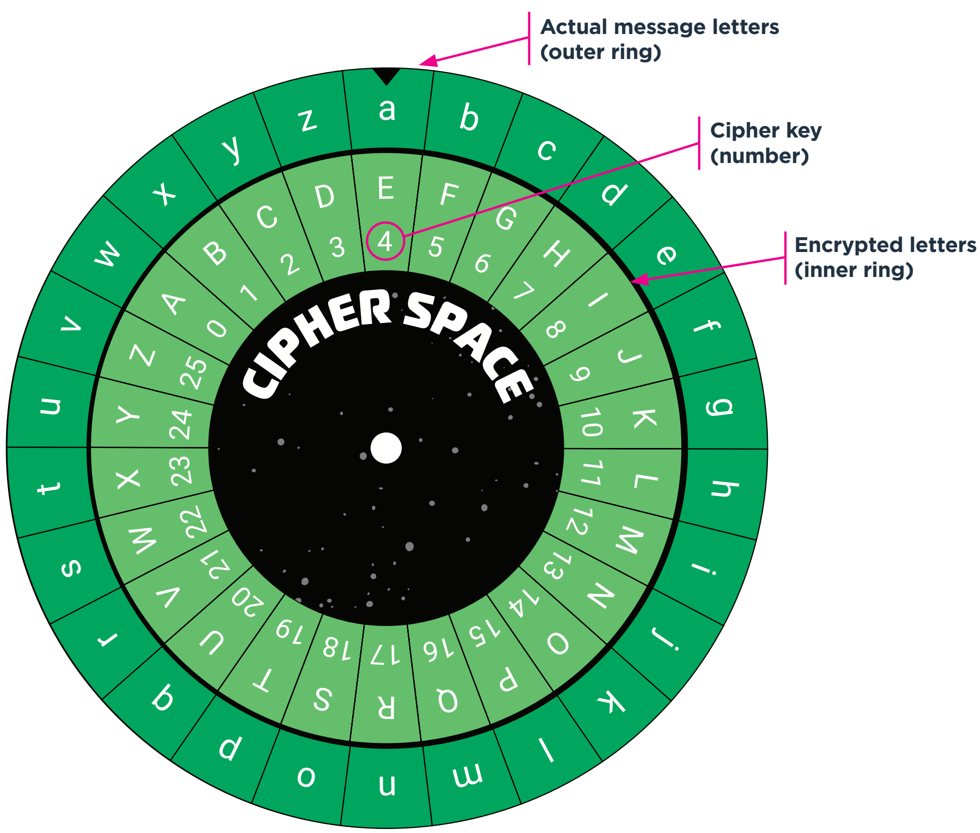
1. What do you know about cybersecurity?
2. What do you want to know about encryption?
3. What did you learn about ciphers? (This question can be repeated at the end of the activity too.)

Experience -
Detailed Instructions

Using the Cipher

1. The cipher wheel has an inner circle on top that should move relative to the base.
2. In a Caesar cipher, every letter in the alphabet is shifted a certain number of spaces over. The number of spaces the letters are shifted is called the “key.” If you know the cipher key, then you can break the code to read the message.
    - The outer base serves as the letters of the actual message. The inner wheel letters correspond with the encrypted code.
    - With a key of “0,” the “0” and “A” on the inner wheel line up with the letter “a” on the outer base and there is no encryption. “A” in the code is equal to “a” in the actual message.
    - With a cipher key of “4,” shift the inner circle so that “4” and “E” line up with “a.” “E” is the encrypted letter and “a” the deciphered letter. At this setting, an encrypted “L” would be deciphered to the actual letter of “h.” “LIEZ” is deciphered to “head.”
3. Have youth complete the practice steps in their guide for deciphering their code, finding the cipher key, and encrypting the code.

    Solutions for Youth Guide practice steps:
    Decipher the Code: OMZVOT
    Encrypt the Code: CYBERSECURITY
    Find the Cipher Key: 6
4. Now that youth should feel more comfortable using their cipher wheels, have them encrypt three words related to space and write them in the space provided in the Youth Guide.
5. Have youth trade messages with a partner and try to decipher them.



SUGGESTED SCRIPT

The first satellite was launched into space in 1957 and was used for radio transmissions. Although space may seem like a big place, the area where satellites orbit is starting to get a bit crowded. Over 9,000 satellites from 40 different countries have launched into space, with 57,000 more projected in the future. In 2020, there were roughly 2,500–2,600 active satellites orbiting Earth. That is a lot to keep track of to avoid collisions and other threats! For this reason, the United States stood up its first new branch of the Armed Forces in more than 70 years—the U.S. Space Force. The Space Force has been in development for decades and started as Air Force Space Command in 1982. Its mission is to protect U.S. and allied interests and assets in space. This particularly applies to satellites that affect our way of life. The Space Force has to stay ahead of current and future threats that are posed to satellites, keeping them from physical harm or cybersecurity threats caused by accidents or on purpose.

For this next activity, imagine a satellite is about to collide with an object in space and hackers have disabled the primary communication channel you have with the satellite. You and your teammates will race to gather the proper information to send a new encrypted message to your satellite and override the hacker's instructions in order to save the satellite!

Experience - Detailed Instructions

Save The Satellite

1. Set up a space for a relay race: If playing solo or one-on-one, skip to number 2.
    - Place a table or surface for each team at the far end
    - On each table, place the cipher wheel, pencil, and cipher answer sheet. (If outdoors, use tape to secure the answer sheet to the table.)
    - Each team will need pencil or marker to record their answers.
2. Divide the youth into two teams. If playing solo or one-on-one youth can use a stopwatch or app to see how long it takes to complete the decoding challenges and determine a winner based on time.
3. Explain the premise of the relay and rules:
    - At the start of the race, each team member will race down to the far end (one person at a time), decipher the first letter on the answer key using the cipher wheel, record the deciphered letter, and race back to the line. The next person will take their turn as soon as the first person returns.
    - There are no spaces between words in the encrypted text or the solution space. Youth can draw a line between words to more easily read the phrase.
    - If a team member discovers a mistake in the deciphered message, they can use their turn to "debug" the code.
    - If a team member cannot solve their step in the code, they can put a slash in their solution square and run back to the line. Team members will have a chance to go back and "debug" the code after the rest of the spaces have been filled in.
4. The first team to completely solve their message (all spaces in the solution are completed with the correct letters) and shout it out loud wins!

Solutions to Answer Sheets in the Relay Race

RACE #1: SPACEDOMAIN

RACE #2: ALWAYSABOVE

RACE #3: DEFENDINGTHESPACEDOMAIN

RACE #4: GUARDINSAREALWAYSABOVE

Reflection

Giving all participants a chance to reflect on what they have learned is an important part of the experiential learning process. Have youth answer the following questions with a partner (pair sharing).

- **Share:** What were the most and least difficult parts of deciphering for you?
- **Share:** How does this activity relate to cybersecurity?
- **Reflect:** What were some strategies you used to make deciphering faster or easier?
- **Reflect:** What did you observe others doing that might affect how you would use encryption in the future?
- **Apply:** What are some ways you could share your cipher knowledge with others?
- **Apply:** Where else can the principle of encryption be applied in real life?

Extension/Add-on

1. Have youth make up their own game to reinforce the learning concepts in this activity.
2. To further explore the use and function of encryption, explore additional computer science activities with Code.org (Hour of Code: Simple Encryption) and Google CS First (Send a Secret Message).
3. For more information on modern encryption, view this video from Code.org: **youtube.com/watch?v=ZghMPWGXexs**
4. Check out the Career Connections in the Youth Guide and have youth research other educational and career opportunities within the field of computer science and cybersecurity!

ASTRO ADVENTURE

ASTRO ADVENTURE

In this activity, youth will strive to collect valuable resources to sustain and further space exploration in our solar system. This interactive board game will allow youth to learn about known resources in our solar system, understand the implications of space travel on human health, and explore our collective civic responsibility towards resources and trade in an extraterrestrial economy. With a little bit of luck and a bit of strategy, in this game youth will expand their presence in our solar system and play to win the Astro Adventure.

Goals, Objectives and Outcomes

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

- understand health implications associated with space travel;
- describe known resources in our solar system and where to find them;
- appreciate issues of scarcity and civic responsibility; and
- find the best strategy to win the game.

Full Activity Time (50 minutes)

Introduction: **10 minutes**

Activity: **30 minutes**

Reflection: **10 minutes**

Materials

Astro Adventure game:

- Gameboard
- 4 pawns per player
- Resource tokens (25 per color)
- Deck of situation cards (52 cards)
- 2 dice

One Youth Guide per youth

IMPORTANT VOCABULARY

- **Carbon:** An element that is the basic building block for plant life.
- **Fuel:** A substance used as an energy source to propel a spacecraft. Common fuels include hydrogen, oxygen, alcohols (C_2H_6O), and methane (CH_4).
- **Mineral:** A substance that is formed naturally by geologic processes. They are solid, inorganic, and can have a crystal structure. Rare minerals and metals have high value on Earth and are also used in manufacturing for space exploration. Gold, platinum, titanium, nickel, and aluminum are metals commonly used in instruments like satellites, telescopes, and rockets.
- **Probability:** The chance or likelihood of something happening. The higher the probability, the more likely an event will occur.
- **Resource:** Something that can be used for a particular purpose to satisfy human needs.
- **Scarcity:** Describes a limited number of available resources; a situation where there is not enough to go around.
- **Water:** A molecule made of hydrogen and oxygen that is the basis of the fluids of living organisms.

Overall Steps

1. Read the Suggested Script section out loud to the group.
2. Engage the group by asking the Opening Questions.
3. Set up the game and review the instructions and rules as a group.
4. Play the game!
5. Facilitate the Reflection section when the game is over or time runs out.

TIPS FOR ENGAGEMENT

1. Written rules are helpful as a baseline, but players learn best by playing the actual game and seeing the rules modeled by others.
2. If you have more youth than available positions in the game, you can let pairs of youth work together in teams and/or assign additional roles such as the "resource bank" (a person that hands out resources to the appropriate players during each turn) and the "situation card reader" (a person who reads the situation cards when seven is rolled).
3. Experienced players can team up with novice players to help them learn the game before they adventure on their own.
4. If a rule appears unclear, players may discuss it and come to a group consensus on how they interpret the game to be played. Ideally, this occurs in advance of any gameplay to not advantage or disadvantage any particular player.
5. If a player cannot complete a physical activity as written on the card, they may come up with an alternative.

SUGGESTED SCRIPT

Space is an extraterrestrial frontier. Humans are pushing the boundaries of knowledge and understanding with our exploration of places beyond Earth's atmosphere. Advanced telescopes cruise across the galaxy and send back breathtaking images. Rovers explore the surface of Mars. The Moon has been the site of our first footsteps away from planet Earth and will serve as the testing ground for future missions to far-off places. This is a generally accepted pattern of our approach to space exploration:

Step 1: We see where we want to explore with a telescope and send an orbiter to gather more information.

Step 2: We send a lander and/or rover to the surface to send back more detailed information.

Step 3: We send humans to the surface!

Step 4: Ultimately, this step would be to establish a spaceport to support human life. Unfortunately, this process is extremely expensive and the concept of taking materials from Earth every time they are needed is also very time consuming. In this game, we will explore alternatives to exhausting Earth's resources to support space exploration.

For the first time in human history, extraterrestrial resources are within our reach! In addition to navigating through space, we will also have to navigate important issues of trade and ownership in an out-of-this-world economy. The United Nations now recognizes 90 space-faring nations. The Outer Space Treaty of 1967 specifically says that exploration and the use of space should be used to benefit all people and be peaceful in nature.

Opening Questions

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

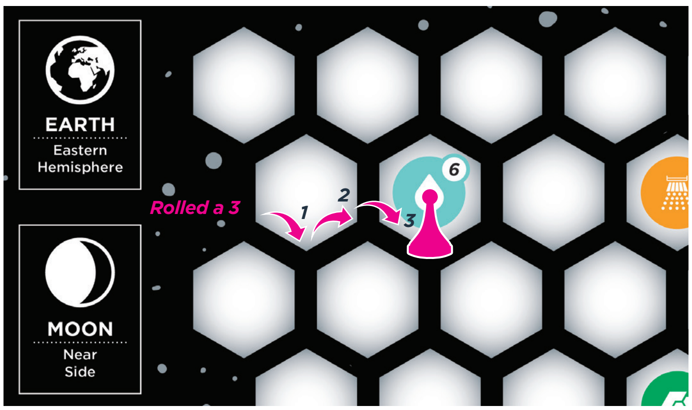
1. What do you know about resources on other worlds?
2. What do you want to know about the effects of space travel on the human body?
3. What did you learn about rules in space? (This question can be repeated at the end of the activity too.)

Experience - Detailed Instructions

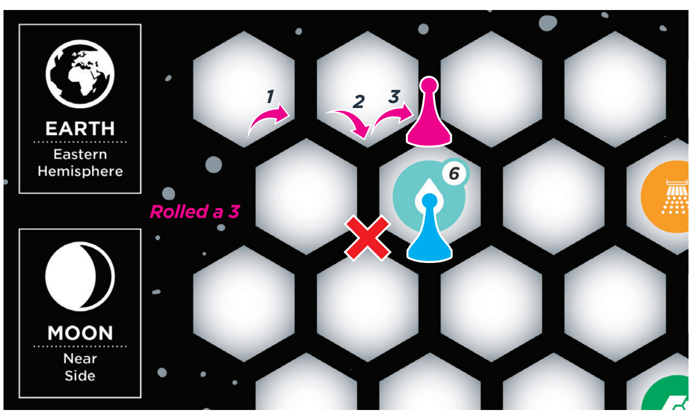
General rules of the game

- On a player's turn they move their pawn along segments of lines between the hexagons and come to rest where the lines of each hexagon intersect. Each line segment counts as one move indicated by the dice. If a five is rolled, a player can move their pawn five intersections or places.
- A pawn cannot pass through an intersection where there is another pawn.
- A pawn cannot end its move on a place right next to another pawn. There has to be at least one intersection or place between every pawn when they are at rest.

Example when ***unobstructed*** by other players:



Example when ***obstructed*** by other players:



Example turn once all players have at least one pawn on the board.

- If [anyone] rolls a 4, and would collect 1 green resource (carbon) each because they have 2 pawns adjacent to a green world with the number 4.
- If [anyone] rolls a 5, then would collect 2 green resources (carbon) each because they have 2 pawns adjacent to a green world with the number 5 AND would collect 1 gray resource (rare mineral) because they are adjacent to a gray world.
- If [anyone] rolls an 8, ONLY can collect a resource because they are the only pawn adjacent to a world with the number 8.
- If a 7 is rolled, no resources are collected and a situation card is drawn.

Getting Started

1. Roll the dice to see who goes first and establish a playing order that will be used the entire game.
2. Each player will place a pawn on the left side of the gameboard at a starting point of their choosing—Earth eastern hemisphere, Moon near side, ISS, Moon far side, Earth western hemisphere.
3. With the hexagonal lines serving as various paths, a player can move with the intersections of those lines serving as locations that player pawns can stop. Each player will roll the dice, choose their own path, and move the indicated number of intersections. (See rules for how pawns can be positioned on the board.)
4. Once all players place their first pawn into the playing field, the Astro Adventure can begin.

Play Astro Adventure

5. **Roll Dice:** The first player in order will roll the dice.
   - If a 2-6 or 8-12 is rolled, ***all*** players who have a pawn next to a world with that number will collect one resource of the corresponding color.
   - If the number 7 is rolled, the player will draw a situation card, read it aloud, and follow the instructions. They will keep the card for the rest of the game. (If a player does not have the resources to follow the action on a situation card, they will perform no action.)
6. **Collect resources & carry out actions**: Next, while it is still their turn, they can choose to take any or all of the following actions:
   - Add a new pawn to the left side of the game board by trading four different resources (one of each type—water, carbon, propellent, and rare minerals) with Earth.
   - Trade resources with Earth at a 4:1 ratio. (They must have four of a single kind of resource to trade for one of the desired resources.)
   - **Initiate trades with other players!** (Both players involved in a trade must agree on the terms.) Alliances can also be formed between players.
7. **Move Pawn:** This ends the first player's turn unless they rolled a 2-6 or 8-12, in which case they have the option to move a pawn, even one just added to the game board, the number of places indicated on the dice.
8. The first player that gets all four of their pawns on the board and shouts "Blast Off" wins the Astro Adventure!

Play for Points

Another way to determine the winner for Astro Adventure is having the most points when a player gets all four of their pawns on the board or when time is up! This is a great method if you only have a limited amount of time to play, or if older youth want to play Astro Adventure with a different game strategy. All players will total their points using the table on the right when the game is over. **The player with the most points wins the Astro Adventure!**

ITEM	POINTS FOR EACH ITEM
Water Resource	1
Carbon Resource	2
Propellent Resource	3
Rare Minerals Resource	4
Situation Card	2
Pawn	11

Associated with game strategy, have youth explore probabilities associated with dice rolling. There are two options to assist with this process and record data in their Youth Guide:

1. Small groups of youth roll the dice as many times as they can for one minute and tally the numbers that are shown on the two dice, or
2. Youth could tally the numbers that are rolled during their respective games.

Once the numbers are tallied, you can combine the total of the observations for all groups and compare it to the theoretical probabilities associated with rolling each number.

NUMBER ROLLED	THEORETICAL PROBABILITY
2	2.78%
3	5.56%
4	8.33%
5	11.11%
6	13.89%
7	16.67%
8	13.89%
9	11.11%
10	8.33%
11	5.56%
12	2.78%

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 who played the board game discuss the following questions with each other (small group sharing). Then, ask for one person from each small group to share one of their responses or discussion points.

- **Share:** Was it easy to collect resources? What number was rolled most often?
- **Share:** What decisions did you make during the game that could have affected the outcome?
- **Reflect:** What did you learn about staying healthy in space?
- **Reflect:** How would the process of collecting resources change if all of the players worked together?
- **Apply:** Trading resources was important to winning the game. How do countries trade resources with each other? What are some valuable resources you can think of?
- **Apply:** What resources are important to space exploration? What role does scarcity of resources play on Earth and elsewhere?

Extension/Add-on

Take Astro Adventure a step further by researching resources in space and methods to harvest them. Have youth explore the following questions:

- What resources could be collected from space and how valuable would they be on Earth?
- The Outer Space Treaty of 1966 has paved the way for modern space programs. Today, China, Russia, Japan, and European countries are all major contributors to space technology. Youth can research these countries and explore the ways that they are cooperating here: **unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html**
- What treaties or other protections would you recommend for future space exploration?

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

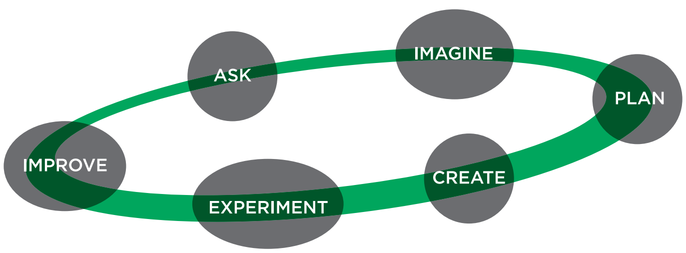
- Phillips-head screwdriver
- Masking or duct tape
- String
- Small container of water
- Items for the end of claw (small cups, plastic utensils, bottle caps, suction cups, etc.)
- Items to pick up (small candy,small balls, rice, sand, etc.)
- Starting location (bin or designated area)
- Ending location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

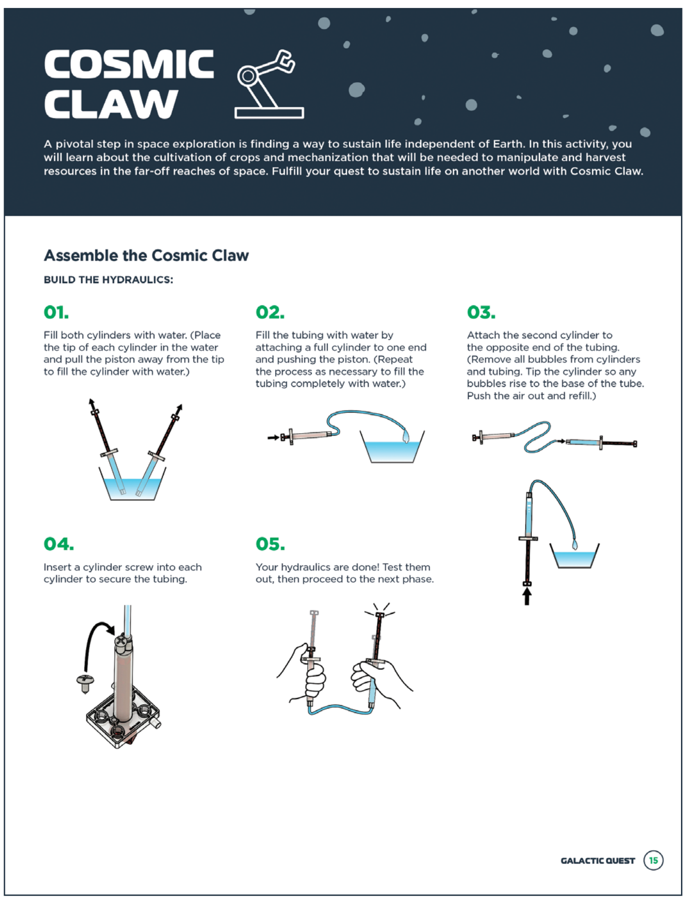
Ask the group the following questions to anchor them in the learning experience and stimulate wondering:

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.)

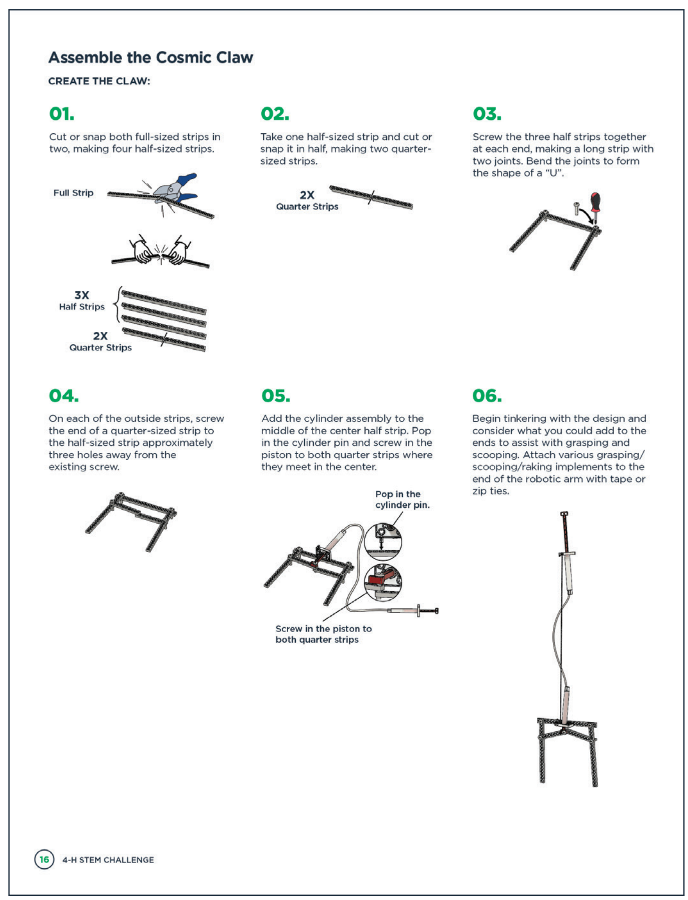
04. Insert a cylinder screw into each cylinder to secure the tubing.

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

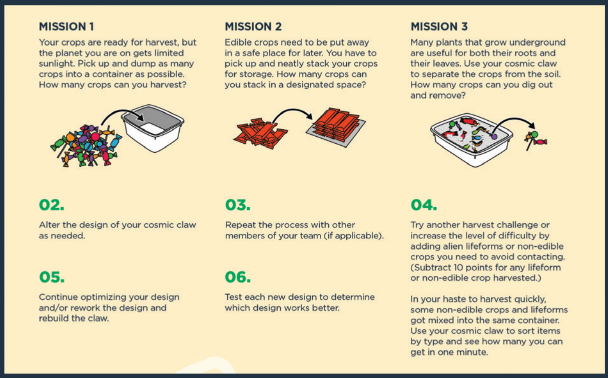
Harvest Challenge

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.

4-H STEM Challenge

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In 4-H, we believe in the power of young people. We see that every child has valuable strengths and real influence to improve the world around us. We are America's largest youth development organization—empowering nearly six million young people across the U.S. with the skills to lead for a lifetime.

Learn more online at **4-H.org/STEMChallenge.**