

# PHASE I

## Part 1: Meet the Problem

### Problem Overview

Artemis astronauts need efficient lunar rock collection tools! Tasks carried out on Earth become much more difficult under the hostile conditions of the Moon. In the Apollo era, NASA design engineers developed tools based on each mission. Even with Artemis advanced spacesuits, astronauts will need better tools that can achieve the advanced scientific objectives of the Artemis mission. The tool is a system that uses multiple attachments that can be placed on a single handle, enabling use for a variety of purposes. This saves mass and uses less storage space, which is very important for space-based activities. The tool is intended to be used by astronauts on the Moon to efficiently collect lunar rock samples. Time is of the essence when working on the surface of the Moon! Your observations and innovations are vital to advancing NASA's efforts.

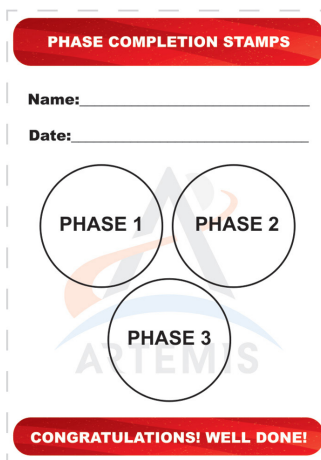
### NASA officials have presented you with the following problem scenario:

Design, build, and test an Apollo era inspired tool to collect rock samples more efficiently. This tool needs to be modified based on the data and observations recorded during a test scenario.

### Getting a Grip on the Moon Role Selection and Preparation

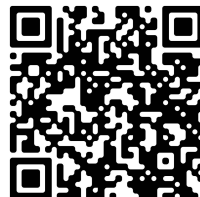
In this activity, you will be working in teams of four to solve a problem. Each member of your team will be taking on a real NASA career role. Below are the instructions for role selection and preparation.

1. Have each team member select a badge from the supply bin.
2. DO NOT trade or change your badge with your team members.
3. Have each person cut out and tape a single Stamp Card to the back of your badge. (Your team will receive your stamp cards from your Mission Directors, see example on the right.)
4. Put on your badges and the included safety glasses.
5. Each team member will now perform the specific tasks of the job listed on their badge during this activity.



Now, closely watch the **Creating Artemis Tools** video and then review the **Job Classification Task Sheet** on page 13 to answer the question on the next page.

[www.youtube.com/watch?v=qv0oTVckrUA](http://www.youtube.com/watch?v=qv0oTVckrUA)



# JOB CLASSIFICATION TASK SHEET

Based on what you heard in the video and information from the Job Classification Task Sheet, what are the individual tasks you are responsible for throughout the phases of this activity?

Have each team member write a response, in pencil, to this question in the space below.

## Tools Engineer

Your Name: \_\_\_\_\_

## Mission Specialist - Geologist

Your Name: \_\_\_\_\_

## Human Factors Engineer

Your Name: \_\_\_\_\_

## Project Manager

Your Name: \_\_\_\_\_

# JOB CLASSIFICATION TASK SHEET

This Task Sheet can be referenced throughout the activity to remind you of your responsibilities.

## Tools Engineer

- Build the lunar rake attachment
- Test the tool and collect tool performance data
- Redesign and build a modified lunar rake attachment
- Test the redesigned tool
- Collect redesign performance data
- Provide final recommendations to NASA for the lunar rake

## Mission Specialist - Geologist

- Build the lunar collection cup attachment
- Test the tool and collect tool performance data
- Redesign and build a modified collection cup attachment
- Test the redesigned tool
- Collect redesign performance data
- Provide final recommendations to NASA for the collection cup

## Human Factors Engineer

- Build the lunar tool handle
- Test the tool and collect tool performance data
- Redesign and build a modified tool handle
- Test the redesigned tool
- Collect redesign performance data
- Provide final recommendations to NASA for the tool handle

## Project Manager

- Build the lunar tongs
- Test the tool and collect tool performance data
- Redesign and build modified lunar tongs.
- Test the redesigned tool
- Collect redesign performance data
- Provide final recommendations to NASA for the lunar tongs
- Assist team members with tool build responsibilities
- Contact Mission Director when each phase is complete to get a red completion sticker

# PHASE I

## Part 2: Explore Knowns and Unknowns

### Building the Getting a Grip on the Moon Tool (overview)

This step is divided into four build components, with each team member performing individual tasks overseen by your Project Manager. During the builds, you will explore knowns and unknowns related to the initial tool **prototype**. For each tool component, you will be given the build instruction pages by your Project Manager to guide you during construction. As you build, consider ways that the tool components and construction method could be improved. Once all the build components have been completed, your team will conduct testing on a simulated lunar surface to help inform potential design modifications. Take care of these pages and your build materials as you work and place the paperwork back in the binder when your task is completed.

### Brief History of Lunar Sample Collection Tools

The pressure suits worn by the Apollo astronauts restricted their **mobility**, particularly their ability to bend over, while on the Moon. For this reason, special tools were designed to allow them to collect rocks and soil for return to Earth. The design of these tools changed somewhat from mission to mission as experience was gained about what worked best. The photographs shown here illustrate the general nature of these tools.



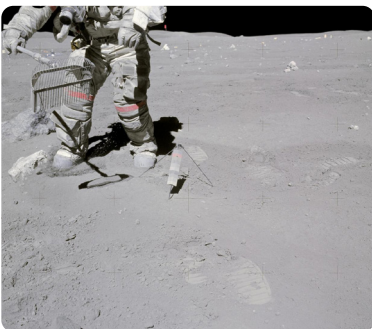
Tongs were used to pick up rock samples. Apollo 12 photograph AS12-47-6932.

Close-up view of a set of tongs, an Apollo Lunar Hand Tool, being used by astronaut Charles Conrad Jr., commander, to pick up lunar samples during the Apollo 12 extravehicular activity. This photograph shows Conrad's legs and a good view of the lunar soil. Credits: NASA



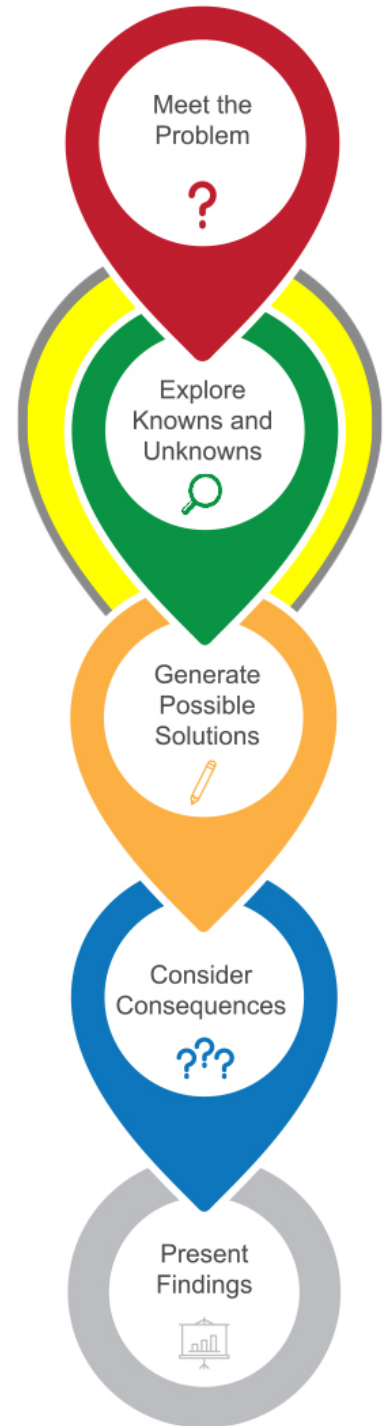
Scoops were used to collect soil samples. Several different scoop designs were used during the Apollo program. A shovel-like trenching tool was also used on one mission. Apollo 17 photograph AS17-146-22371.

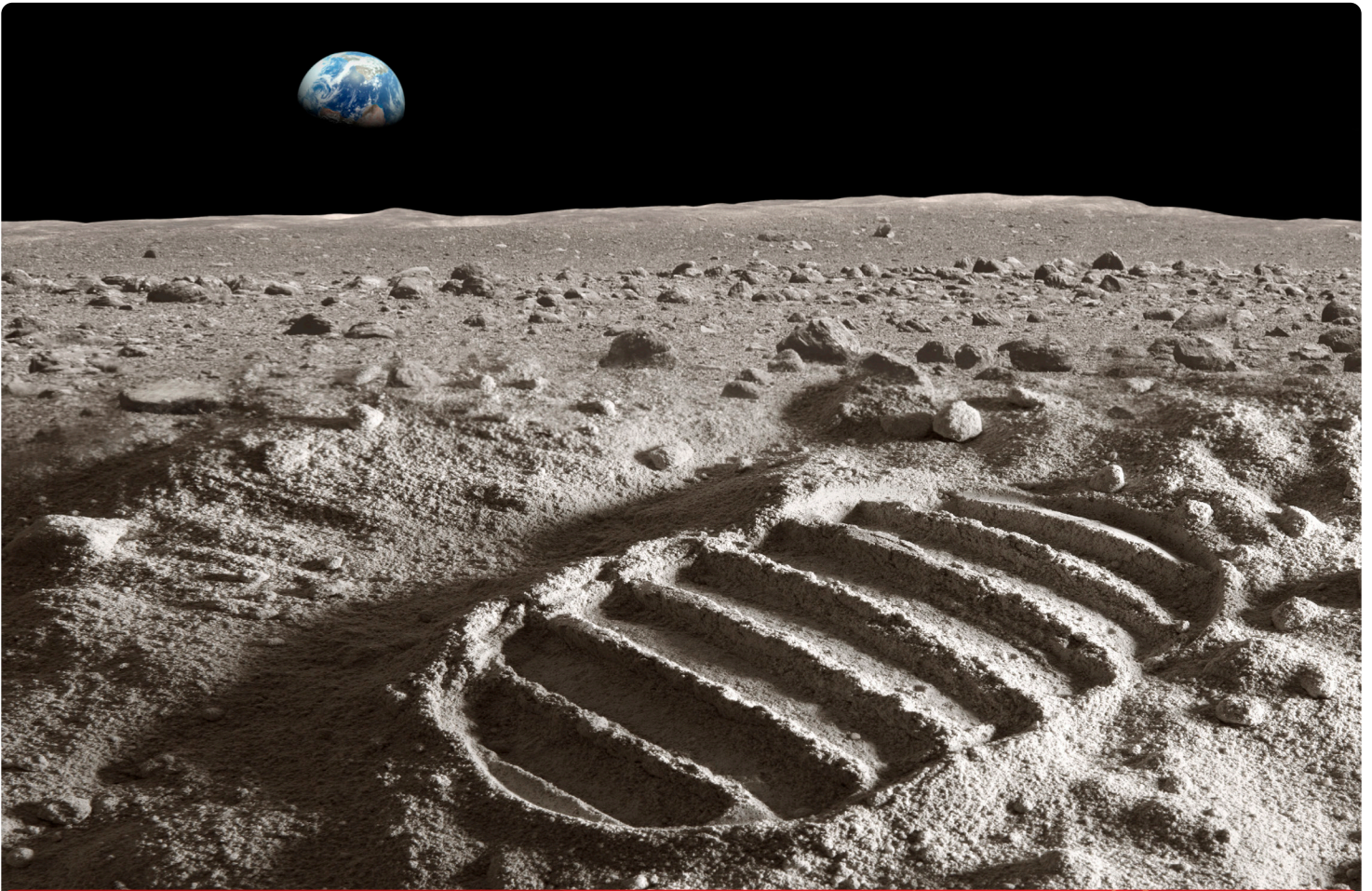
Scientist-astronaut Harrison Schmitt, Apollo 17 lunar module pilot, uses an adjustable sampling scoop to retrieve lunar samples during the second Apollo 17 extravehicular activity (EVA), at Station 5 at the Taurus-Littrow landing site. Credits: NASA



Rakes were used to collect small pebbles. The tines on the rake are 1 centimeter apart. The rake was dragged through the soil and then shaken. Small particles fell through the tines and larger particles were trapped in the rake and dumped into a sample bag for return to Earth. Apollo 16 photograph AS16-116-18629.

Astronaut John W. Young collects samples at the North Ray Crater geological site during the mission's third and final Apollo 16 extravehicular activity (EVA). He has a rake in his hand, and the gnomon is near his foot. Credits: NASA





## LET'S GET STARTED!

1. Inform your team's Project Manager (PM) you are ready to receive your build instructions specific to the career on your badge.
2. Locate all the build materials for your tool component from the material bin.
3. Follow your build instructions exactly and in numerical order.
4. If you need help at any point, ask your PM first. They will locate a Mission Director if they are unable to assist you directly.
5. If you find an error in your instructions, please have your PM report it immediately to a Mission Director.
6. When you are finished with the build, inform your PM. Your Project Manager will double check your work for completion and place a blue sticker in the project manager check and approve sheet located at the end of each phase in the student binder.
7. After all team members have successfully completed their Phase I responsibilities, each team member will receive a red sticker of approval on their badge from a Mission Director. This allows your team to move on to Phase II of this Mission.

Above: Artist rendering of the Apollo Moon boot print on the surface of the Moon with the Earth in the distance. Credit: NASA

# MATERIALS NEEDED



Qty	Build Materials per Tool	Qty	Tools
3	Magnets	1	Permanent Marker
1	Test Rake Profile	1	Metric Ruler
1	1 in PVC Pipe	1	Scissors
1	3/4 in PVC Pipe	1	Pencil
1	1 in long Dowel Rod	Qty	Fabrication Lab Station Tools
1	4 in x 6 1/2 in Cardboard	1	Warm Melt Glue Tool
1	Steel Can or Coda Can	1	PVC Cutter
1	Masking Tape	Qty	Lunar Tongs
1	Plastic Mesh	2	Paint Sticks
1	Pool Noodle section (foam grip)	3	Rubber Bands
Several	Blue & Red or Decorative Stickers	1	Dowel Rod
Qty	Templates / Pages		
1	Test Rake Template		



## SAFETY CONSIDERATIONS

**Be sure to follow all safety guidelines from your Mission Director and clean up your work area as you progress.**

- Students should wear safety goggles and cut resistant gloves when working with scissors, PVC cutters, and warm melted glue
- Students should practice safe cutting techniques when using scissors and PVC cutters. Be sure to carefully support the piece being cut. Be careful about where free hand is placed. Avoid moving about the room with scissors or PVC cutters in hand.
- Students should use only the warm melt glue tool at the glue station and adhere to the following precautions:
  - Warm melt glue tool tips can be extremely hot; use caution
  - Do not use the warm melt glue tool in a high traffic area
  - Protect the power cord so it is not loose; it could get caught on something or become a trip hazard
  - Store the warm melt glue tool in holder when the warm melt glue tool is not in use
  - Maintain a clear area with no clutter
  - Do not set the warm melt glue tool on combustible materials, and keep the area clear of combustible materials (loose paper)
  - Use a drip mat under the warm melt glue tool
  - Do not do any overhead work with the warm melt glue tool
  - Do not leave the warm melt glue tool unattended while plugged in and not in use
  - Use protective eyewear and keep loose hair and clothing tied back
- **Students should clean up as they go**
- **Take your time. It's more important to be accurate than to be first!**

Above: A metal table top with the NASA insignia embossed and a pair of gloves and safety goggles setting on the top.

## Phase I – Part 2: Explore Knowns and Unknowns - Tools Engineer

### BUILD THE LUNAR RAKE ATTACHMENT

**STEP 1:** Before you begin, make sure you have all the materials needed in your kit. Be aware that your project team may have made slight changes to the kit. If in doubt, please direct your questions to a Mission Director for support.

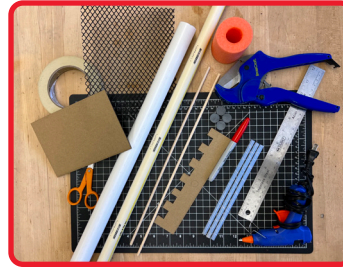
**STEP 2:** Take one of the magnets and label one side of it with an “H” for handle. Take a second magnet and let it attach to the side with the “H.” On the side of the second magnet that touches the “H,” put an “R” for rake. Do the same for a third magnet; on the side that touches the “H” place the letter “C” for cup. Two other team members will be asking for their magnet (the “H” and “C”) so get this step done quickly.

**STEP 3:** Use the magnet to trace a circle above the middle tine of the rake profile. The circle should be centered between the top of the middle tine and the top of the rake profile as shown.

**STEP 4:** Wear safety goggles. At the warm melt glue station, attach the “R” magnet you just marked to the initial test rake profile. The “R” should be visible after gluing on the circle etched location marker. Set it aside.

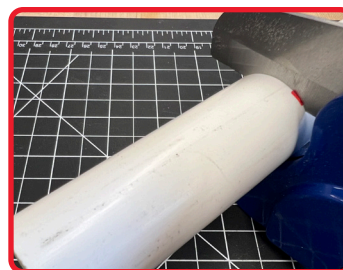
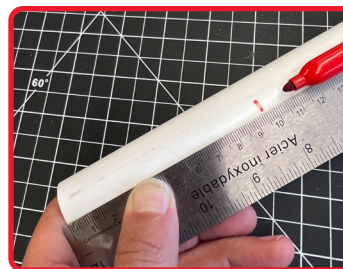
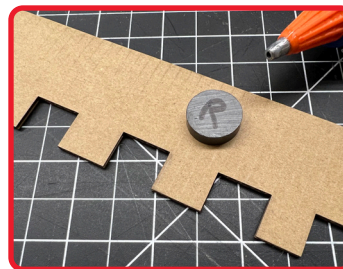
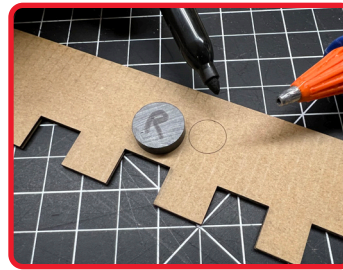
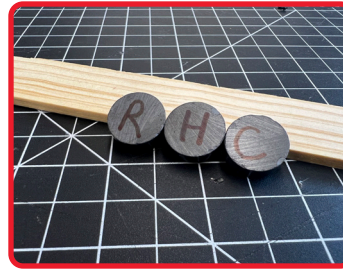
**STEP 5:** Go to the PVC cutting station. Using a ruler and a permanent marker, measure and mark a cut line on the larger 1 in PVC pipe. The distance for the cut line is 9.5 cm (3-¾ in).

**STEP 6:** Wear safety goggles. At the PVC cutting station, carefully use the ratcheting pipe cutter to cut the pipe on the mark you just made. Take your time and focus on how the tool operates.



#### Materials

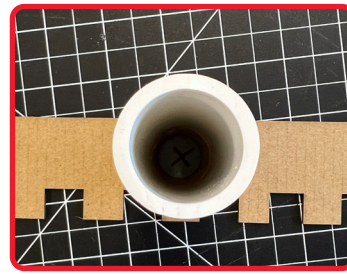
- Magnets
- Test Rake Profile PDF
- 1 in PVC Pipe
- 1 in long Dowel Rod
- Masking Tape
- Permanent Marker
- Metric Ruler
- Scissors





## Phase I – Part 2: Explore Knowns and Unknowns - Tools Engineer (continued)

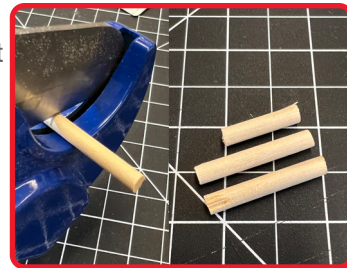
**STEP 7:** At the glue station, attach the tube to the rake profile around magnet as shown. The tube should surround the magnet evenly.



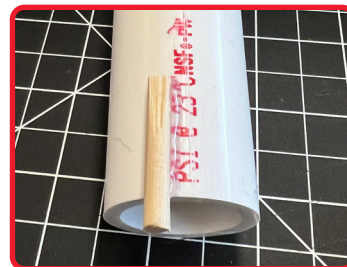
**STEP 8:** Like a welder, lay a “bead” of glue around the tube where it is attached to the rake profile. This will provide extra strength to this attachment point. Set it aside.



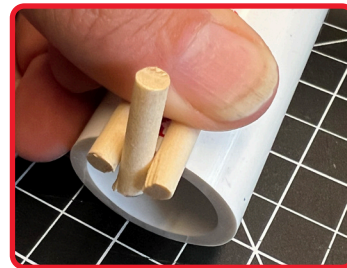
**STEP 9:** Go to the PVC cutting station. Cut two 3 cm (about 1-3/16 in) and one 2 cm (about 13/16 in) pieces of dowel rod. Cut them using the PVC pipe cutting tool.



**STEP 10:** With the rake positioned as in the photo, glue the first 3 cm (about 1-3/16 in) dowel rod to the tube as shown. 2 cm (about 13/16 in) of the dowel rod should be glued to the tube, leaving 1 cm (about 3/8 in) hanging out over the edge.



**STEP 11:** Repeat the last step with the other 3 cm (about 1-3/16 in) dowel rod. Position it exactly the width of the 2 cm (about 13/16 in) dowel rod away from the first.



**STEP 12:** Congratulations! Your finished rake head should look like this. Set it aside for testing in Phase II.



## Phase I – Part 2: Explore Knowns and Unknowns - Mission Specialist - Geologist

### BUILD THE COLLECTION CUP

**STEP 1:** Before you begin, make sure you have all the materials needed in your kit. Be aware that your project team may have made slight changes to the kit. If in doubt, please direct your questions to a Mission Director for support.



#### Materials

- Soda Can
- Masking Tape
- PVC Pipe
- Magnet
- Mesh
- Dowel Rod
- Permanent Marker
- 4 in x 6-1/2 in Cardboard

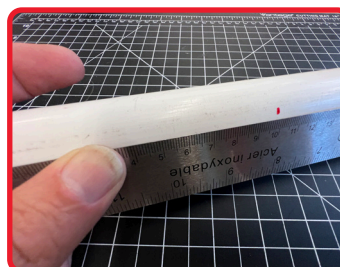
**STEP 2:** Take the 11 cm (about 4-5/16 in) x 16.5 cm (about 6-1/2 in) piece of cardboard and roll it gently around the steel can or soda can so that you can connect the sides, making a cylinder.



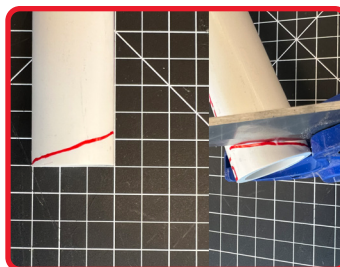
**STEP 3:** Tape the cardboard together so that it stays as a cylinder.



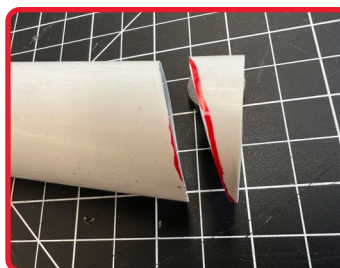
**STEP 4:** Go to the PVC cut station. Cut a piece of 1 in (larger) PVC to 10 cm (about 3-15/16 in) at the PVC cutting station.



**STEP 5:** Using the same tool, mark and very carefully make a 45-degree angle cut on one end of the tube as shown.



**STEP 6:** Your cut tube should look like this.

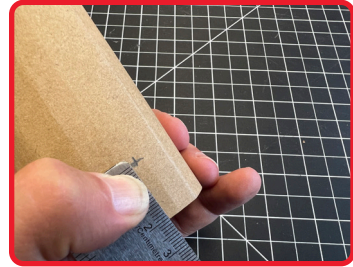


## Phase I – Part 2: Explore Knowns and Unknowns - Mission Specialist - Geologist (continued)

**STEP 7:** Ask your team member building the rake tool to give you the magnet with a letter “C” written on it.



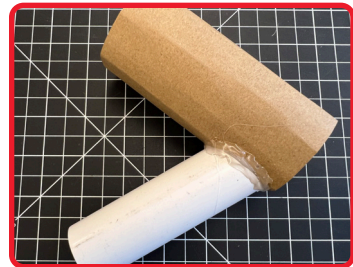
**STEP 8:** At the glue table, measure about 2 cm (about 13/16 in) up from the bottom edge of your cardboard tube and make a mark to glue the magnet labeled with the letter “C.”



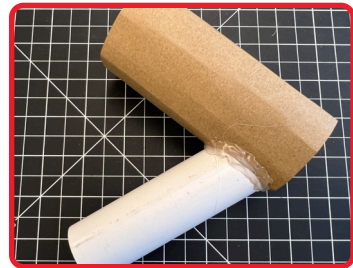
**STEP 9:** Glue the magnet on the cardboard cylinder with the “C” being visible.



**STEP 10:** Center the 45-degree angle cut end of the PVC around the “C” magnet and glue into position as shown.



**STEP 11:** Like a welder, lay a “bead” of glue around the base of the PVC where it meets the cardboard for extra strength.



**STEP 12:** Go to the PVC cutting station. Cut two 3 cm (about 1-3/16 in) and one 2 cm (about 13/16 in) pieces of dowel rod. Cut them using the PVC pipe cutting tool used earlier.

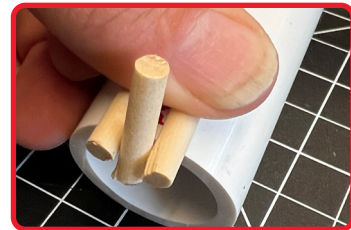


## Phase I – Part 2: Explore Knowns and Unknowns - Mission Specialist - Geologist (continued)

**STEP 13:** With the collection cup positioned as in the photo, glue the first 3 cm (about 1-3/16 in) dowel rod to the tube as shown. 2 cm (about 13/16 in) of the dowel rod should be glued to the tube, leaving 1 cm (about 3/8 in) hanging out over the edge.



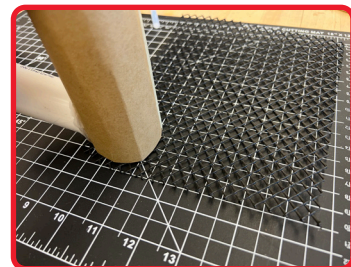
**STEP 14:** Repeat gluing the other 3 cm (about 1-3/16 in) dowel rod next to the first using the 2 cm (about 13/16 in) dowel rod to position it one dowel rod width away from the first. Let cool.



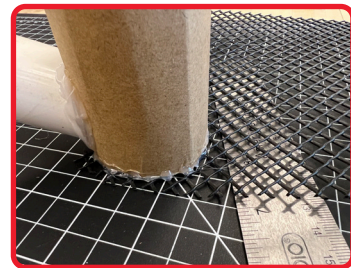
**STEP 15:** It should look like this.



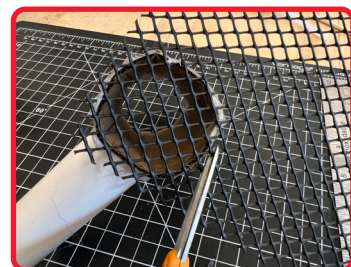
**STEP 16:** Place plastic mesh on the glue mat as shown; then place your collection cup in the corner of the mesh.



**STEP 17:** Lightly glue the mesh to the bottom of the collection cup. Do not use too much glue right now. You do not want to glue everything to the mat! If it does stick slightly, slide your ruler under the mesh to loosen it.

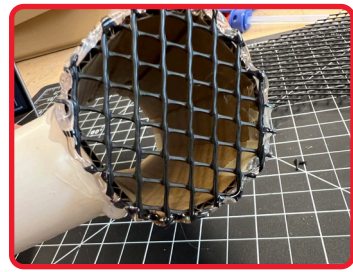


**STEP 18:** Using scissors, carefully trim the mesh to the perimeter of the collection cup.



## Phase I – Part 2: Explore Knowns and Unknowns - Mission Specialist - Geologist (continued)

**STEP 19:** Reinforce the mesh connection to the cup with a continual bead of glue around the cup's perimeter.



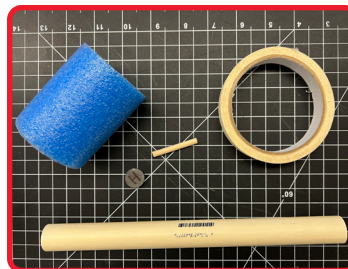
**STEP 20:** Congratulations! Your finished collection cup should look like this! Set it aside for testing in Phase II.



## Phase I – Part 2: Exploring Knowns and Unknowns - Human Factors Engineer

### BUILD THE TOOL HANDLE (FOLLOW THE INSTRUCTIONS IN ORDER)

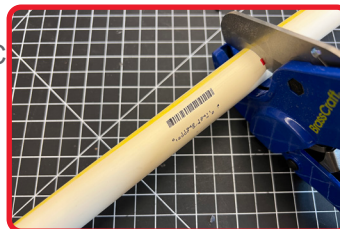
**STEP 1:** Before you begin, make sure you have all the materials needed in your kit. Be aware that your project team may have made slight changes to the kit. If in doubt, please direct your questions to a Mission Director for support.



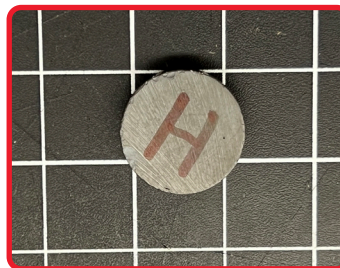
#### Materials

- Pool Noodle section
- Magnet
- Masking Tape
- Dowel Rod
- PVC Pipe

**STEP 2:** At the PVC cutting station, measure and cut a 36 cm (about 14 3/16 in) piece of the 3/4 in (smaller) PVC using the PVC cutting tool.



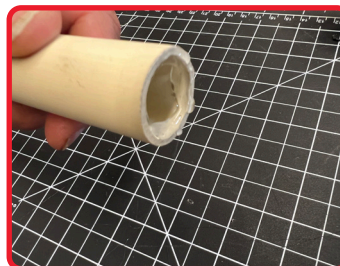
**STEP 3:** Ask your team member building the rake tool to give you the magnet with a letter “H” written on it.



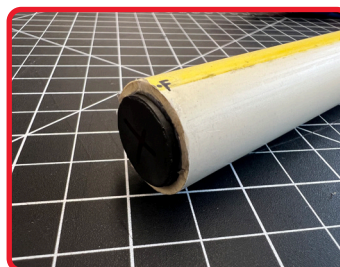
**STEP 4:** Take the magnet with an “H” and place it into the end of the PVC pipe you just cut. Before you glue it into position, make sure the magnet fits properly in the end of the tube. This is called ‘dry fitting’.



**STEP 5:** At the glue table, apply glue to the interior wall of the tube and let the glue slightly harden.



**STEP 6:** Press the magnet into the hole with the “H” facing outwards as shown. Leave the face of the magnet just very slightly protruding out the end of the tube as shown.



**STEP 7: STOP!!!** Assist the rake and collection cup tasks since you need both to move forward from here! When the rake and cup are completed, proceed to the next step.



**STEP 8:** Insert the handle with the magnet end into each of the two tools. Mark the location nearest the large tube between the two dowel rods with a pencil or marker for each tool.



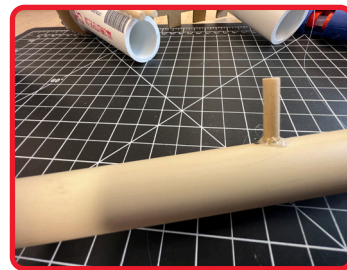
**STEP 9:** Your two marks should be within 1 cm (about 3/8 in) of each other. If they are beyond 1 cm (about 3/8 in) apart, ask your Mission Director to change the length of your dowel rods so that the indexing system will work.



**STEP 10:** On the mark furthest back from the magnet, glue a 2 cm (about 13/16 in) long dowel rod perpendicular to the tube as shown. Both the RAKE and CUP tasks have a 2 cm (about 13/16 in) cut dowel rod you can use.



**STEP 11:** Put a small bead of glue around the base of the dowel rod for added strength. Let cool.

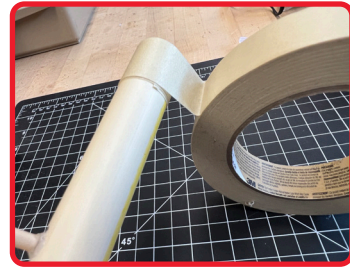


**STEP 12:** When glue has cooled, insert the handle into each tool to confirm it locks in place and does not allow the handle to spin.

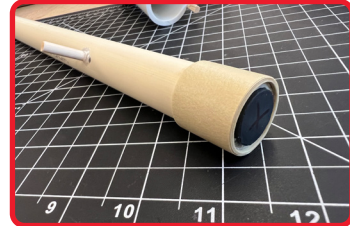


## Phase I – Part 2: Exploring Knowns and Unknowns - Human Factors Engineer (continued)

**STEP 13:** The handle should have a loose fit in the larger PVC pipe on the tools. We will eliminate this “play” by making two bushings from masking tape.



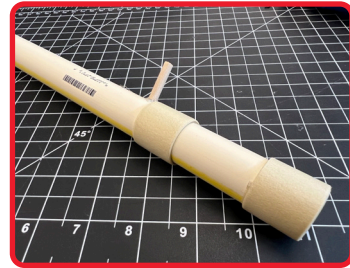
**STEP 14:** Wrap a few layers of masking tape onto the end of the tube near the magnet and near the indexing dowel rod as shown.



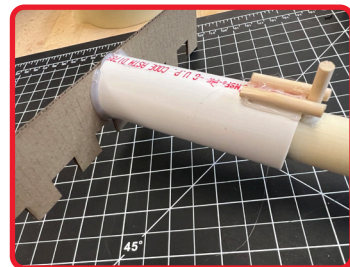
**STEP 15:** Continue to wrap masking tape until you have filled the gap between the two pieces of PVC as shown. If it is too snug or does not fit, remove some of the tape.



**STEP 16:** Make another masking tape bushing lined up with the base of the dowel rod, similar to the other bushing you made in STEP 4 to STEP 15.



**STEP 17:** Check to make sure that the magnet on the handle has a secure hold on the rake attachment.



**STEP 18:** For the last step in handle construction, lightly glue the foam grip approximately 5 cm (about 2 in) up from the end of the handle as shown.



**Congratulations! You're done!**

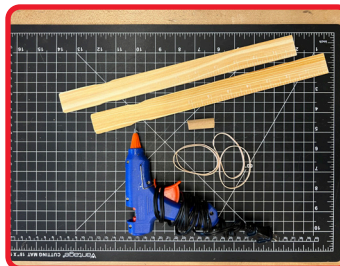
Inform your PM of your completed work to get it signed off.



## Phase I – Part 2: Explore Knowns and Unknowns - Project Manager

### BUILD THE LUNAR TONGS; CHECK AND APPROVE TEAM'S PHASE I TASKS

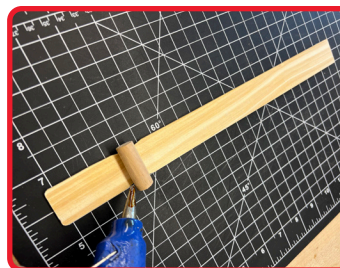
**STEP 1:** Acquire all necessary materials for the lunar tongs build.



#### Materials

- 2 Paint Sticks
- 3 Rubber Bands
- Dowel Rod

**STEP 2:** Measure over 4 cm (about 1-9/16 in) on one of the paint stir sticks and glue the dowel rod as shown. Run a bead of glue on both sides of the dowel rod with the warm melt glue tool just like a welder.



**STEP 3:** Place another paint stir stick on top of the glued dowel rod so that it aligns at the ends as shown.



**STEP 4:** Wrap a rubber band over the stir sticks and dowel rod as shown so that the rubber band holds the tongs in an open position.



**STEP 5:** Here is another view of the rubber band wrapped around the dowel.

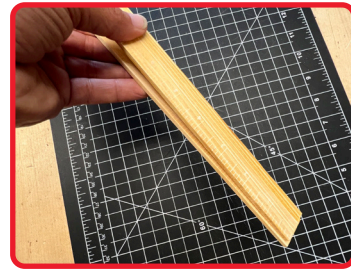


**STEP 6:** Your completed lunar tongs should look like this. You can wrap another rubber band on the end of the tongs to increase stability.



## Phase I – Part 2: Explore Knowns and Unknowns - Project Manager (continued)

**STEP 7:** Pinch down on the tongs to grip lunar rocks that you want to pick up.



**STEP 8:** Assist your team members as needed until all components are complete.



**STEP 9:** Check and approve team member Phase I tasks. Place blue stickers on the Phase I task sheet as tasks are completed.

**STEP 10:** Contact a Mission Director for final approval and a red sticker for Phase I badge.

### **Congratulations!**

Your Team's Lunar Getting a Grip on the Moon Kit  
is now ready for testing!



**Blue  
Sticker**

**Phase I Build: Tools Engineer**

- Build the lunar rake attachment



**Blue  
Sticker**

**Phase I Build: Mission Specialist - Geologist**

- Build the lunar collection cup attachment



**Blue  
Sticker**

**Phase I Build: Human Factors Engineer**

- Build the lunar tool handle

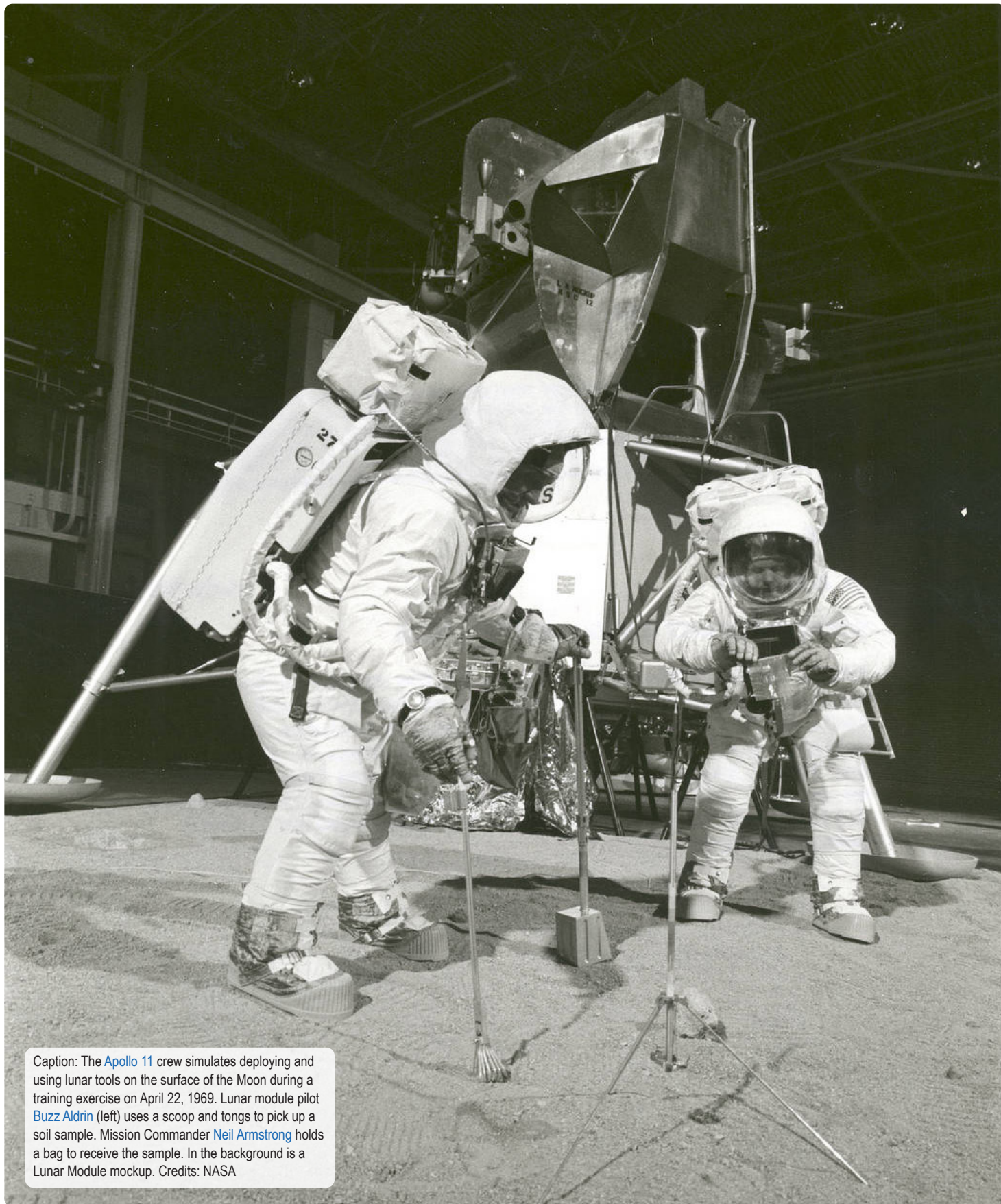


**Red  
Sticker**

**Phase I Build: Project Manager**

- Build the lunar tongs
- Assist team members with tool build responsibilities
- Check and approve team tasks. Apply blue sticker to this sheet as team members complete their tasks.
- Contact Mission Director when each phase component is complete to get red sticker

**Congratulations!!! You are now ready to conduct initial tool testing in Phase III!**



Caption: The [Apollo 11](#) crew simulates deploying and using lunar tools on the surface of the Moon during a training exercise on April 22, 1969. Lunar module pilot [Buzz Aldrin](#) (left) uses a scoop and tongs to pick up a soil sample. Mission Commander [Neil Armstrong](#) holds a bag to receive the sample. In the background is a Lunar Module mockup. Credits: NASA