National Aeronautics and Space Administration

NASA EXPLORATION EXPERIENCE

EDUCATOR GUIDE

NASA Office of STEM Engagement Next Gen STEM

Developed in collaboration with AIAA and Students To Launch. Activity photos provided by Students To Launch.

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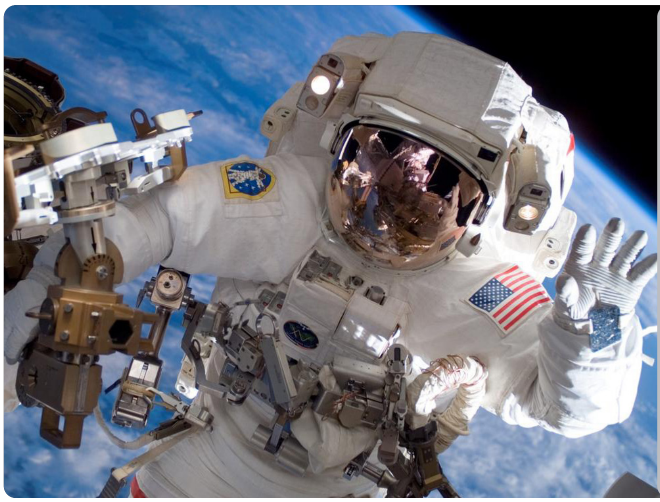
NASA EXPLORATION EXPERIENCE

SPACESUIT GLOVE DEXTERITY and GETTING A GRIP ON THE MOON

EDUCATOR GUIDE



Welcome Mission Directors (informal and formal educators)! This guide contains two hands-on sections. The first section is the Engagement activity. This is a 45-minute activity where participants explore the constraints of **spacesuit** design and test a glove that can be used to perform work on the Moon. The second section is the Experience activity. It is a 3-hour experience which is broken up into three 1-hour phases. During the Experience, participants will create and modify a geological tool to collect rock samples on the lunar surface.

GETTING STARTED

For Mission Directors:

Be sure to read through the entire Educator and Student guides. It is suggested to make copies of the Student guide for the teams and add them to a binder. The groups should read and discuss the safety considerations. These procedures should be strictly followed to ensure a safe activity. You will see that there are Mission Briefings for both the Engagement and the Experience sections. The Mission Briefings help participants activate prior knowledge and provide you with ideas to enhance the activity.

Engagement: Spacesuit Glove Dexterity

In the Engagement activity, participants will consider the constraints of **mobility** and **dexterity** in spacesuit design and extrapolate the spacesuit design's impact on performing work on the Moon and on tool design. Participants will test a multi-layered spacesuit glove's performance.

Connection to NASA

For the Artemis missions, astronauts will visit and work in permanently shadowed regions of the lunar South Pole. Conditions here, especially in the craters, feature some of the lowest temperatures in the solar system – down to -414 degrees Fahrenheit (-248 degrees Celsius). Astronauts will also have to work in an environment where the dust on the lunar surface is sharp, so they must be protected. Gloves help to protect astronauts from the dangerous space environment. What features of the spacesuit glove provide that protection? The first is layering. The gloves are made of between 11-13 layers and are reinforced with silicone, which makes the gloves thicker. Second, gloves are equipped with heaters so that astronauts' fingers are kept warm while still being able to use tools.

Experience: Getting a Grip on the Moon

In the Experience activity, participants will modify a geological tool (referred to herein as tool) to prepare the lunar surface for rock sample collections. For this activity, it is important to understand that the tools needed for the Artemis missions are different from the Apollo missions because the working environment will be much different.

Connection to NASA

Bringing back samples is a major component of the science objectives for Artemis just as it was for the Apollo missions. In the Apollo era, tools were modified for almost every mission, which is why they are not being reused for the Artemis missions. Tools have evolved in response to new knowledge, and the Artemis missions will require a greater number of samples with smaller average weight, so developing new tools is essential. Developing these new tools requires using knowledge from the Apollo era. NASA researched designs used on the lunar surface in the Apollo era, why they were used, which designs were not used, what worked well, which designs changed throughout the mission, and why they changed. Out of this research, new tools are being developed for the Artemis missions.

What types of tools will be needed for the Artemis missions? Artemis astronauts will be visiting the South Pole of the Moon, a site that has never been visited by humans. NASA has learned that the site is actually very similar to the Apollo 16 highlands area, where the rocks and **regolith** are not as dark in color as other areas of the Moon. The terrain, created from magma that extruded onto the surface and cooled over time, contains mostly light-colored anorthosite, or calcium-rich, material. What is most challenging about the South Pole is that it is a mostly shadowed area. The Artemis astronauts' suits and tools will need to adapt to the wide swings in temperatures between sunny and shaded areas. The South Pole has permanently shadowed areas containing volatiles — substances that easily evaporate — and NASA wants to research and mine these volatiles. The types of compounds that are frozen into the regolith can cause chemical interactions with tools, so the tools may need a special coating to prevent those chemical reactions. Another important issue regarding volatiles is that as they heat up, they will turn from a solid to a liquid and then to a gas. In some cases, volatiles will get to the gas phase dangerously quickly. Astronauts may need to store these samples in a freezer to protect themselves from potentially harmful compounds. These freezers must be designed to contain the volatile compounds until their return to Earth, where scientists can study them in the safety of a laboratory.

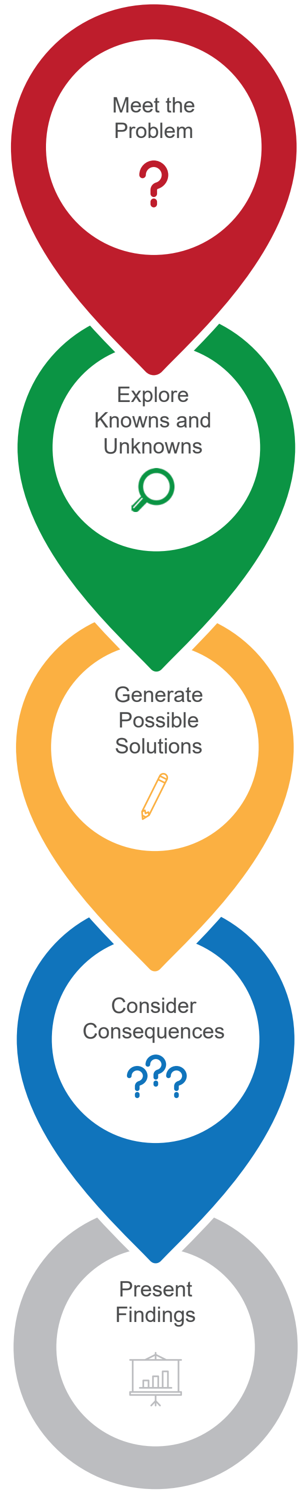
Participants will use the problem-based learning (PBL) framework for the Experience activity. In Phase I, participants will meet the problem and explore the knowns and unknowns by creating a tool such as those used in the Apollo era and testing it. In Phase II, participants will continue to explore knowns and unknowns as they test their tool and collect data. They will also generate possible solutions and consider consequences by modifying the tool so that it is better equipped for the Artemis missions. In Phase III, participants consider the consequences and present their findings.

Watch the video "**NASA Prepares to Explore Moon: Spacesuits, Tools**"

Artist's rendering of the Apollo moon boot print on the surface of the moon. Credits: NASA

PROBLEM-BASED LEARNING PROCESS

NASA astronauts Zena Cardman and Drew Feustel wearing mockup spacesuits after performing an engineering test run before a week of simulated moonwalks. Credits: NASA



- Meet the Problem: Identify the problem, introduce new vocabulary, and discuss previous experiences with the problem
- Explore Knowns and Unknowns: Use resources to explore the knowns and unknowns
- Generate Possible Solutions: Brainstorm possible solutions based on resources and prior experience with the problem
- Consider Consequences: Examine the pros and cons of each solution to determine a viable solution
- Present Findings: Communicate and discuss the process and solutions as a team

Note: For educators looking for more of an engineering design challenge for this activity, check out: **AstroTools Alternate Activity** OR **Robotools (First Woman Camp Experience with instructional video)**

CAMP OVERVIEW

Activities

1. Engagement: Spacesuit Glove Dexterity (45 minutes)
2. Experience: Getting a Grip on the Moon (Phase I, Phase II, and Phase III) (3 hours)

Sample Camp Schedule

8:00 – 8:10 a.m. .... Welcome - Watch "**Artemis I: Launch to Splashdown Highlights**"

8:10 – 8:30 a.m. .... Break (Set-up for Engagement Activity)

8:30 – 9:30 a.m. .... Engagement: Spacesuit Glove Dexterity

Note to Educator: The Engagement activity can be stand-alone or incorporated into the camp day schedule.

9:30 – 10:00 a.m. .... Break

10:00 – 11:00 a.m. .... Experience: Getting a Grip on the Moon Phase I

11:00 a.m. – 12:15 p.m. ..... Lunch/Recess

12:15 – 1:15 p.m. .... Experience: Getting a Grip on the Moon Phase II

1:15 – 1:30 p.m. .... Break

1:30 – 2:30 p.m. .... Experience: Getting a Grip on the Moon Phase III

2:45 – 3:15 p.m. .... Wrap up

3:15 – 3:30 p.m. .... Artemis video – "**Artemis II: Mission Overview**"

On Dec. 13, 1972, scientist-astronaut Harrison H. Schmitt is photographed standing next to a huge, split lunar boulder during the third Apollo 17 extravehicular activity (EVA) at the Taurus-Littrow landing site. Credits: NASA/Gene Cernan

MISSION BRIEFING

Engagement Activity

Engage: Spacesuit Glove Dexterity

Prep Time: 20 minutes

Activity Length: 45 minutes
Summary: NASA is exploring the Moon, Mars, and beyond. One of the challenges for spacewalking is temperature. Temperature on **spacewalks** may vary from as hot as 250 °F (157 °C) in the sunlight to as cold as –250 °F (–157 °C), but in the permanently shadowed region of the lunar South Pole the temperature can reach –414 °F (–248 °C). The spacesuit gloves must be insulated to handle the low temperatures as well as durable enough to handle the sharpness of lunar dust. This means that the gloves must be insulated but also flexible enough to allow the astronaut to grip, turn, and work with a variety of tools.

Watch the Working With Spacesuit Gloves video

www.youtube.com/watch?v=AqaG40I1bh0

Learning Objective: Participants will understand the constraints of spacesuit design.

Outcome: Participants will wear a multi-layered "spacesuit glove" and complete a simple assembly task to better understand issues with dexterity when wearing a spacesuit.

Student roles: The Space Suit Engineer will test the "spacesuit glove" with a dexterity task. The Test Facilitator will use the stopwatch to start and stop the task session and record the number of assemblies completed by the Space Suit Engineer.

Activating Prior Knowledge

- Ask students if they have ever been somewhere cold where they had to wear gloves or a bulky snow suit or heavy jacket. Discuss dexterity with the group. Was it difficult to put on a seatbelt? Bend over? Pick up items?
- Ask students what challenges astronauts might face while wearing bulky spacesuits and thick gloves

Challenge Questions:

- What was the most difficult part of this challenge and what did your team do to overcome the challenge?
- What recommendation could you provide to NASA spacesuit glove designers based on your experience?

MISSION GUIDANCE

GO

- Discuss the challenge and constraints. Time the bolt assembly with and without gloves
- Students work in pairs and allow both students to experience working with the glove layers
- Record data and observations on the table in the student handout

MAYBE

- Share this video with students: "#AskNASA: How Will Astronauts Dig on the Moon?" (5:04)

NO GO

- Timing the bolt assembly only while wearing gloves
- Grouping the students in groups larger than two
- Student not wearing gloves helping other student with bolt assembly

MISSION BRIEFING

Experience Activity

Experience: Getting a Grip on the Moon

Phase I

Watch the Creating Artemis Tools video

www.youtube.com/watch?v=qv0oTVCkrUA

Prep Time: 20 minutes

Activity Length: 60 minutes

Summary: Preparing to explore the surface of the Moon goes well beyond designing and building safe spacecraft and spacesuits. In order to do science on the surface of the Moon, NASA has to ensure that the surface vehicles and suits enable the mobility required and that there are tools to collect rock and soil samples. Several important factors must be considered when developing tools for use in environments other than Earth. One of those factors is environmental conditions. For example, tool designs must account for temperature extremes ranging from –414 °F to 250 °F. Another thing to consider when designing a tool to be used by an astronaut is that wearing a spacesuit is essentially like wearing a balloon, and the astronaut will have to squeeze against that balloon every time they grab something. Human factor concerns include ensuring that tools are easy to use without causing the astronaut pain or difficulty.

Learning Objective: Participants will use the problem-based learning framework and work cooperatively in small teams to create a geological tool to collect rock samples on the lunar surface.
Outcome: Participants will build a geological tool that contains a rake and a specimen collection cup.
Student roles: The Tools Engineer will build the lunar rake attachment. The Project Manager assists team members with tool build responsibilities and builds the lunar tongs. The Human Factors Engineer builds the lunar tool handle. The Mission Specialist (**Geologist**) builds the lunar collection cup attachment.

Activating Prior Knowledge

Ask students:

- What do you think astronauts will do while they are on the Moon?
- What work will they be performing?
- What are they looking for?
- How do you think astronauts will collect and store any samples they find?

Challenge Questions:

- What were some difficulties your team faced during the initial design and build process, and how did you overcome them?
- What challenges does your team anticipate in the next phase of the activity, when you begin to test the tool?
- Do you think wearing the gloves will cause any difficulty, or has your team already considered the use of gloves with your new tools?

MISSION BRIEFING

Experience Activity

Experience: Getting a Grip on the Moon

Phase II

Prep Time: 20 minutes

Activity Length: 60 minutes

Summary: Since tool design for the Artemis missions involves consideration of the different environment factors on the lunar South Pole, testing and improving the design is essential. Prototyping early and often to get feedback from the crew will be a necessary step. Testing while wearing gloves in an analog environment like the Johnson Space Center rock yard creates a baseline for the Artemis tools' performance, and this helps scientists and engineers understand how the tool will eventually function on the lunar surface.

Learning Objective: Participants will use the problem-based learning framework to test and redesign their modified tool.
Outcome: Participants test and redesign their tool to collect rock samples.
Student roles: The Tools Engineer, Project Manager, Human Factors Engineer, and Mission Specialist (Geologist) will complete testing of the tool and provide feedback to the team.

Challenge Questions:

- What were some difficulties your team faced during the initial design and build process, and how did you overcome them?
- Were you surprised by the performance of your tool? Explain.
- How were you able to improve your tool during the redesign phase? What design changes did you make, and how did they improve your tool's performance?

MISSION BRIEFING

Experience Activity

Experience: Getting a Grip on the Moon

Phase III

Prep Time: 20 minutes

Activity Length: 60 minutes

Summary: NASA established the foundation for the Axiom Extravehicular Mobility Unit (AxEMU) with the agency's Exploration Mobility Unit (xEMU) **prototype** development efforts that advanced spacesuit designs for multiple destinations. Axiom Space used the experience, expertise, and data behind the xEMU as a basis for AxEMU design and development, including advancements in technology, training, astronaut feedback on comfort and maneuverability, and compatibility with other NASA systems.

Learning Objective: Participants will test the redesign of their tool and present the pros and cons of their design.

Outcome: Participants will test their improved design from Phase II and present their designs along with their reflections to the group.

Student roles: The Tools Engineer will test the redesigned lunar rake attachment. The Project Manager will test the redesigned lunar tongs. The Human Factors Engineer will test the redesigned lunar tool handle. The Mission Specialist (Geologist) will test the redesigned lunar collection cup attachment. All testers will summarize and present their findings to the group.

Challenge Questions:

- What were some difficulties your team faced during the initial design and build process, and how did you overcome them?
- Were you surprised by the performance of your tool? Explain.
- How were you able to improve your tool during the redesign phase?
- What design changes did you make, and how did they improve your tool's performance?

CULTURALLY RESPONSIVE EDUCATION (CRE)
Strategies Tip Sheet

Section Title (page #)	CRE Strategy	CRE Tips
Mission Briefing Activating Prior Knowledge	Making Cultural Connections	• Pose questions to activate prior knowledge and/or make connections to real-life applications • Use of multimedia resources such as videos
Preparation Job Classification Task Sheet	Power and Participation	• This activity provides the opportunity for active participation of all students • Sharing responses in small groups and with the entire class • Team roles assigned to encourage all students to participate
Mission Briefing Activating Prior Knowledge Glossary	Language and Communications	• Activate prior knowledge on terms used in the lesson and have students offer a definition or understanding of the terms (dexterity, geologist, mobility, prediction, prototype, regolith, spacesuit, spacewalk)
Preparation Job Classification Task Sheet	Power and Participation	• Students will participate in a think/pair share to answer Challenge Questions • Use team roles: tools engineer, program manager, mission specialist (geologist), human factors engineer
Procedure	High Expectations	• Students will use inquiry and critical thinking to collaborate in groups to make quantitative and qualitative observations
Connection to NASA	High Expectations	• Students will learn about the connection to NASA and determine how it relates to their lives

Job Classification Task Sheet

This Task Sheet can be referenced throughout the activity to remind students of their responsibilities. Each member of the team will have the opportunity to take on the role of a Space Suit Engineer and a Test Facilitator.

Space Suit Engineer

- Try on the spacesuit gloves
- Provide feedback on the fit and comfort of the spacesuit gloves
- Complete as many bolt, washer, and wing nut assemblies in 1 minute without spacesuit gloves as possible
- Complete as many bolt, washer, and wing nut assemblies in 1 minute with spacesuit gloves as possible

Test Facilitator

- Use a stopwatch to start and stop the 1-minute (60-second) test trial
- Record the number of bolt, washer, and wing nut assemblies completed by the Space Suit Engineer without wearing the spacesuit gloves
- Record the number of bolt, washer, and wing nut assemblies completed by the Space Suit Engineer while wearing the spacesuit gloves

Materials Needed

Qty	Testing Materials	Qty	Templates / Pages
20	3/8 in x 1 in bolts	1	Spacesuit glove Dexterity Data Recording Sheet
20	3/8 in wing nuts		
20	3/8 in flat washers	**Qty**	**Tools**
1	Pair of nitrile (non-Latex) coated gloves	1	Stopwatch
1	Pair of nitrile exam gloves		
1	Pair of cotton or polypropylene liner gloves (cut-resistant gloves)		

Safety Considerations

- Students should clean up as they go
- Ensure all hardware stays on the work surface and does not roll onto the floor where it could become a slip/trip issue if stepped on. Use a plastic container/dish to store all small hardware so it does roll away and onto floor.

Refer to Steps in Student Guide to prepare for Classroom Implementation

- Practice Hardware Assembly
- Try on the Spacesuit Gloves
- Testing Procedure

SPACESUIT GLOVE DEXTERITY DATA RECORDING SHEET

Directions: Use this data recording sheet to record your observations, predictions, and test data.

PART 1: BEFORE YOU START: MAKE A PREDICTION!

Prediction Table

Team Member Name	# of Hardware Assemblies ***without*** spacesuit gloves in 1 minute	# of Hardware Assemblies ***with*** spacesuit gloves in 1 minute
Name:		
Name:		

PART 2: TEST YOUR DEXTERITY

Test Data Table

Team Member Name	# of Hardware Assemblies ***without*** spacesuit gloves in 1 minute	# of Hardware Assemblies ***with*** spacesuit gloves in 1 minute
Name:		
Name:		

PART 3: TEST YOUR DEXTERITY

Test Data Table

Team Member Name	Notes and observations about spacesuit gloves comfort and fit and how they influence hand movement	
Name:	Comfort / Fit	Influence on Hand Movement
Name:	Comfort / Fit	Influence on Hand Movement

Describe your data: How did your **prediction** compare to your actual test results? Does wearing spacesuit gloves influence your dexterity? Back up your response with data from this activity.

You are a NASA engineer that has been asked to improve spacesuit gloves design.
Describe three modifications, improvements, or changes you would implement.

1.

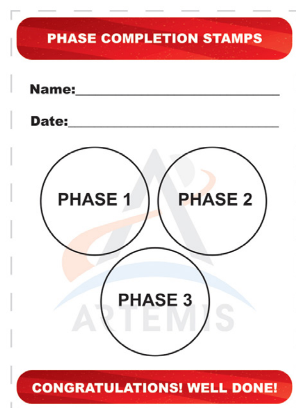
2.

3.

Getting a Grip on the Moon Role Selection and Preparation

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

1. Have have each team member select a badge from the supply bin.
2. Students SHOULD NOT trade or change your badge with team members.
3. Have each person cut out and tape a single Stamp Card to the back of their badge. (See example to right.)
4. Put on 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.
6. Play the introductory video from Explorer Josh for the students. Have the students review the Job Classification Task Sheet on page 14 of the Student guide (page 16 of this Educator guide) to answer the provided questions.



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 red completion sticker

BADGES AND STAMP CARDS

NASA
EXPLORATION
EXPERIENCE

ARTEMIS

Tools Engineer

PHASE COMPLETION STAMPS

Name:__________________________

Date:___________________________

PHASE 1 PHASE 2 PHASE 3

CONGRATULATIONS! WELL DONE!

NASA
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EXPERIENCE

ARTEMIS

Mission Specialist - Geologist

PHASE COMPLETION STAMPS

Name:__________________________

Date:___________________________

PHASE 1 PHASE 2 PHASE 3

CONGRATULATIONS! WELL DONE!

NASA
EXPLORATION
EXPERIENCE

ARTEMIS

Human Factors Engineer

PHASE COMPLETION STAMPS

Name:__________________________

Date:___________________________

PHASE 1 PHASE 2 PHASE 3

CONGRATULATIONS! WELL DONE!

NASA
EXPLORATION
EXPERIENCE

ARTEMIS

Project Manager

PHASE COMPLETION STAMPS

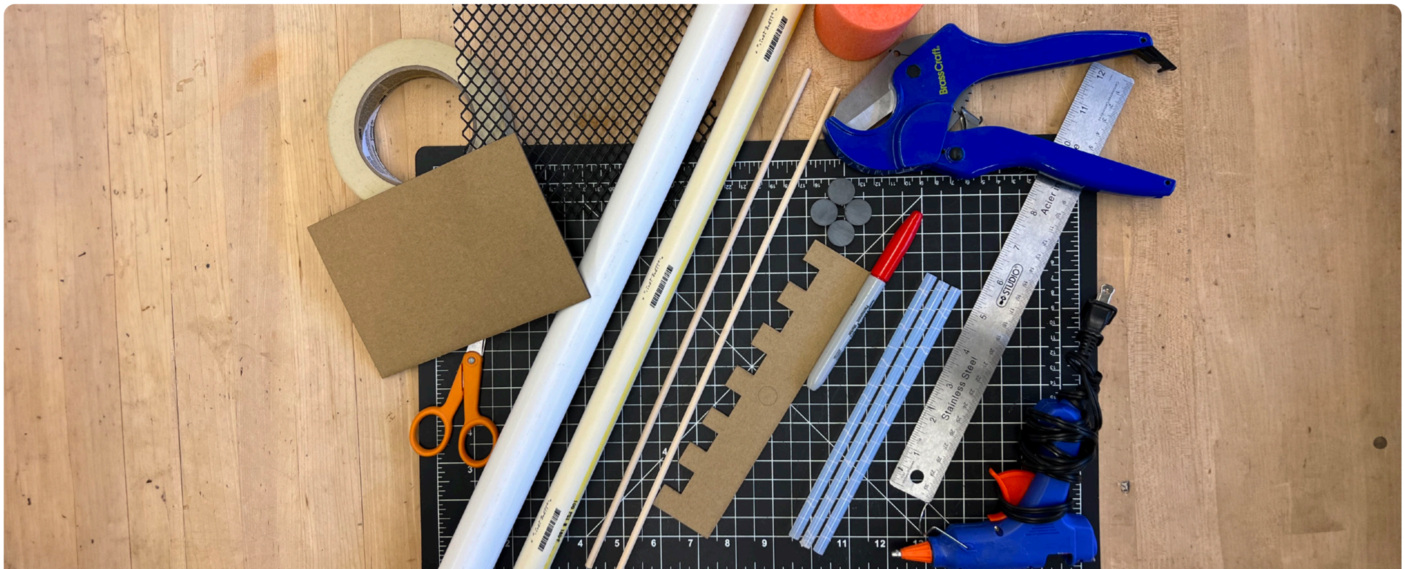
Name:__________________________

Date:___________________________

PHASE 1 PHASE 2 PHASE 3

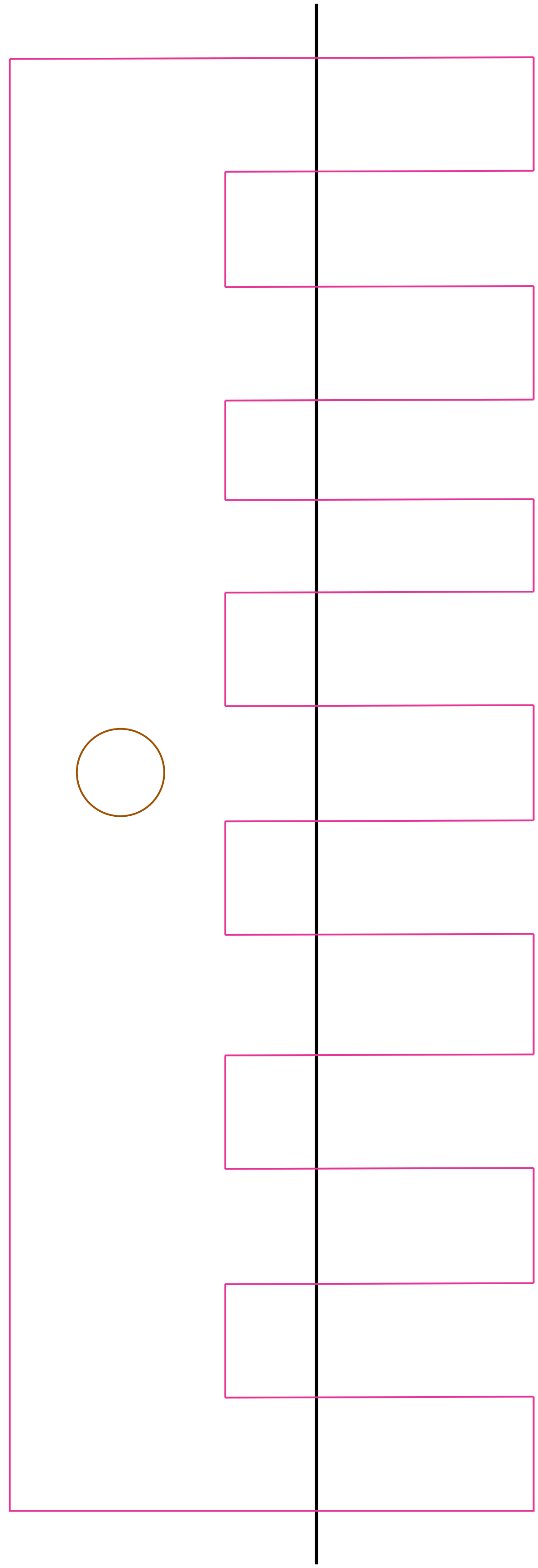
CONGRATULATIONS! WELL DONE!

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
Qty	**Templates / Pages**		
1	Test Rake Template		

Rake Template



Rake Template Laser Cut Settings

These are the settings for a Glowforge laser utilizing the drawing from page 17. Your laser machine settings for 2 mm cardboard may be different. The single long cut line on the diagram is to make the tangs of the rake less effective by making them shorter. If you prefer longer rake tines ignore that cut step. You may also ignore using the laser and can use the diagram from page 17 as a template to trace and cut with scissors or razor tool.

Glowforge® print settings

Design id: 7BG1AYAL4BUXJY7LNMPKC9QAIPUUA

Timestamp: Tue Oct 03 2023 13:02:21 GMT-0700 (Pacific Daylight Time) Version: 1.0

Step 0: #000000 Cut::Manual

Step 0: #000000 Speed=314

Step 0: #000000 Precision Power=full

Step 0: #000000 # of Passes=1

Step 1: #9e5000 Score::Draft

Step 2: #e53595 Cut::Manual

Step 2: #e53595 Speed=328

Step 2: #e53595 Precision Power=full

Step 2: #e53595 # of Passes=1

PREPARING THE EXPERIENCE ROOM

- Tables with even numbers of students (partner students together for assembly task and groups of 4 for the Experience activity)
- Projector screen/TV for Explorer Josh video
- Place to set up child's pool with "lunar regolith" and red tape and entry barrier (for the Experience activity)

SAFETY CONSIDERATIONS

- 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. Be sure to carefully support the piece being cut. Be careful about where their free hand is placed.
- Students should use the warm melt glue tool only at the glue station and follow these 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 tripping hazard
  - Store the warm melt glue tool in holder when 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 it unattended while plugged in and not in use
  - Use protective eyewear and keep loose hair and clothing tied back

PHASE I STICKER SHEETS

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

Blue Sticker

Phase II Baseline Test: Tools Engineer

- Complete testing of tool
- Provide tool feedback to team in stand-up presentation
- Complete TFF Side 1
- Complete TFF Side 2 focusing on lunar rake feedback
- Redesign and rebuild tool

Blue Sticker

Phase II Baseline Test: Mission Specialist - Geologist

- Complete testing of tool
- Provide tool feedback to team in stand-up presentation
- Complete TFF Side 1
- Complete TFF Side 2 focusing on collection cup feedback
- Redesign and rebuild tool

Blue Sticker

Phase II Baseline Test: Human Factors Engineer

- Complete testing of tool
- Provide tool feedback to team in stand-up presentation
- Complete TFF Side 1
- Complete TFF Side 2 focusing on handle feedback
- Redesign and rebuild tool

Red Sticker

Phase II Baseline Test: Project Manager

- Complete testing of tool and provide tool feedback to team in Standup presentation
- Complete TFF Side 1 & Side 2 focusing on lunar tongs feedback
- 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
- Redesign and rebuild tool

PHASE III STICKER SHEETS

Blue Sticker

Phase III Retest: Tools Engineer

- Test your redesigned rake attachment
- Record your data in your Phase III TFF
- Summarize and present your findings to the group

Blue Sticker

Phase III Retest: Mission Specialist - Geologist

- Test your redesigned collection cup
- Record your data in your Phase III TFF
- Summarize and present your findings to the group

Blue Sticker

Phase III Retest: Human Factors Engineer

- Test your redesigned handle attachment
- Record your data in your Phase III TFF
- Summarize and present your findings to the group

Red Sticker

Phase III Retest: Project Manager

- Test your redesigned lunar tongs
- Record your data in your Phase III TFF
- Summarize and present your findings to the group. Check and approve team tasks. Apply blue sticker to this sheet as team members complete their tasks.
- Contact a Mission Director when each phase component is complete to get the red sticker

GLOSSARY

Dexterity – Skill and ease in performing tasks, especially with the hands.

Geologist – An expert in (or student of) geology, which is the study of planetary bodies' processes and structures.

Mobility – The ability to move or be moved freely and easily.

Prediction – The act of attempting to tell beforehand what will happen.

Prototype – An engineering unit that is built to address all critical scaling issues and operated in a relevant environment to demonstrate performance in the actual operational environment and platform (ground, airborne, or space).

Regolith – A layer of loose, unconsolidated rock, mineral, and glass fragments covering solid rock (e.g., on the lunar surface).

Spacesuit – A self-contained living environment for pilots and astronauts that consists of everything needed for short-term survival, including breathing oxygen, the pressure exerted on the body, and a heating and cooling system.

Spacewalk – Any human activity in space that takes place outside a vehicle. A spacewalk is also called an extravehicular activity (EVA)

SIDE 1: PHASE II Tool Feedback Form (TFF)

NUMBER OF ROCKS COLLECTED:

Student Names: ______________________ **Team Name:** ______________________

Date: ______________________ **Test Site Number:** ______________________

Lunar Rake (5 is best)

A. Performance: Efficiently find rocks hidden in sand.

1 2 3 4 5

B. Performance: Ease of use with spacesuit gloves.

1 2 3 4 5

General Notes

What went well?

What could be improved?

Collection Cup (5 is best)

A. Performance: Efficiently scoop rocks into bucket.

1 2 3 4 5

B. Performance: Placing in bucket.

1 2 3 4 5

General Notes

What went well?

What could be improved?

Tool Handle (5 is best)

A. Performance: Stability and connection to tool attachments.

1 2 3 4 5

B. Performance: Placing in bucket.

1 2 3 4 5

General Notes

What went well?

What could be improved?

Lunar Tongs (5 is best)

A. Performance: Grip and pickup rocks and place in collection bucket.

1 2 3 4 5

B. Performance: Clearing fine debris.

1 2 3 4 5

General Notes

What went well?

What could be improved?

SIDE 2: PHASE II Tool Feedback Form (TFF)

Your Tool Component (Circle one): Handle Rake Collection Cup Tongs

A. Provide feedback to your team members about their individual tool's performance during testing.
B. Collect feedback from each of your team members about your tool's performance during testing.

Performance Data for Your Tool component.

Role	Performance Score: A	Performance Score: B
Tools Engineer		
Mission Specialist - Geologist		
Human Factors Engineer		
Project Manager		

PRO TIP:
Make sure you are getting scores for **YOUR TOOL** from your team members!

C. Write down any other comments from team members related to your tool's performance during testing in the space below. **YOU WILL USE THESE NOTES TO CREATE A DESIGN FOR AN IMPROVED VERSION OF YOUR TOOL IN STEP 2!**

SIDE 1: PHASE III Tool Feedback Form (TFF)

NUMBER OF ROCKS COLLECTED:

Student Names: ____________________ **Team Name:** ____________________

Date: ____________________ **Test Site Number:** ____________________

Lunar Rake (5 is best)

A. Performance: Efficiently find rocks hidden in sand.

1 2 3 4 5

B. Performance: Ease of use with spacesuit gloves.

1 2 3 4 5

General Notes

What went well?

What could be improved?

Collection Cup (5 is best)

A. Performance: Efficiently scoop rocks into bucket.

1 2 3 4 5

B. Performance: Placing in bucket.

1 2 3 4 5

General Notes

What went well?

What could be improved?

Tool Handle (5 is best)

A. Performance: Stability and connection to tool attachments.

1 2 3 4 5

B. Performance: Placing in bucket.

1 2 3 4 5

General Notes

What went well?

What could be improved?

Lunar Tongs (5 is best)

A. Performance: Grip and pickup rocks and place in collection bucket.

1 2 3 4 5

B. Performance: Clearing fine debris.

1 2 3 4 5

General Notes

What went well?

What could be improved?

SIDE 2: PHASE III Tool Feedback Form (TFF)

Your Tool Component (Circle one): Handle Rake Collection Cup Tongs

A. Provide feedback to your team members about their individual tool's performance during testing.
B. Collect feedback from each of your team members about your tool's performance during testing.

Performance Data for Your Tool component.

Role	Performance Score: A	Performance Score: B
Tools Engineer		
Mission Specialist - Geologist		
Human Factors Engineer		
Project Manager		

PRO TIP:
Make sure you are getting scores for **YOUR TOOL** from your team members!

C. Write down any other comments from team members related to your tool's performance during testing in the space below.

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