Lunar Flagpole Device for Microgravity Challenge
Astro Anchors

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Concept Video Pitch

Unlisted YouTube link will go here

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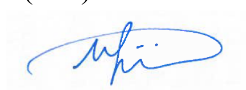

Faculty Advisor Signature

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I. Technical Section

A. Abstract

This project aims to design a flagpole and an anchor capable of being put together by an astronaut on the moon. The proposed flagpole design will consist of various pole segments, couplers, and an anchoring system for stability. The pole segments will be attached to each other using the same coupler design. Due to this, the assembly will have a repetitive nature that will aid in the speed of both learning how to deploy the flag and actually deploying it. The anchoring system is comprised of two main sections: an auger bit and a baseplate. The auger bit in the anchoring system helps to secure the flag axially. When an axial load is applied to the top of the flagpole, the flights on the auger will exert an opposite force, holding the flag firmly in place. Additionally, the baseplate will help reinforce against lateral motion of the flag to prevent it from tipping. The baseplate itself is aided by four long pipes that will help to stabilize the flag. The baseplate will act to create a counter moment to any lateral forces. This baseplate is free to spin on the pole while not being able to move axially. This will allow for the torque applied on the flagpole to drive the baseplate into the ground. This flagpole design will be beneficial to NASA as it will allow for quick, easy, and reliable deployment of the flagpole while on the Moon.

B. Design Description

1. Proposed Design:

The proposed design for the lunar flag utilizes an auger bit anchoring system with a modular pole build, shown in Figure 1. The anchoring system consists of an auger bit and a baseplate, as shown in the figure. The auger is designed such that it prevents against axial motion of the pole. The auger will also aid in driving the flagpole anchoring system into the ground. Furthermore, the baseplate is designed such that it prevents the flagpole from falling over in the application of a lateral force. With the auger and base plate assembled together, the flagpole is able to resist 10-pound vertical and horizontal forces when applied at the top of the flagpole.

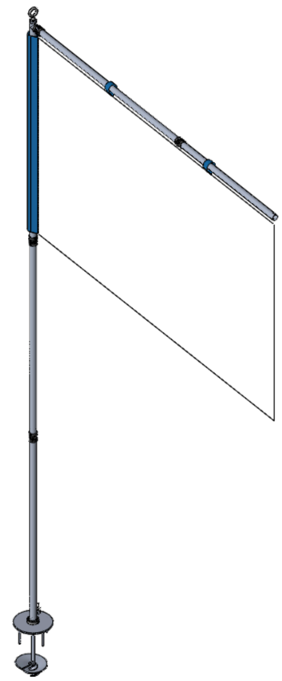

Figure 1. Lunar Flagpole Device

Figure 2 displays the disassembled lunar flag within the required storage space of 48 inches by 12 inches by 8 inches. A drawing of the lunar flag with overall dimensions is shown in Appendix ___.

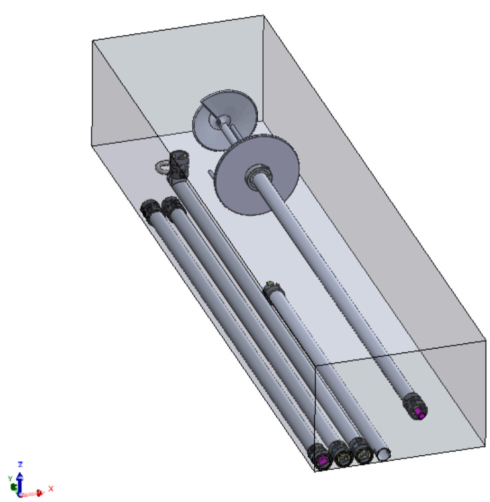

Figure 2. Disassembled Flagpole Device Stowed within 48 inches by 12 inches by 8 inches

The flagpole itself is made up of three main vertical pole segments. The pole of each segment has an outer diameter of 1 inch and a wall thickness of 0.05 inches while being made of 6061-T6 aluminum. According to FEA, with results shown in Figure 3, these dimensions will allow for full loading of the flag without yield.

Figure 3. FEA Results of Critical Location on Aluminum Pipe

The bottom pole segment is connected to the anchoring system using two 8-32 x ⅜ inch NF bolts at the base of the pole. These same bolts will be used in any locations where bolts are indicated to be used. This will be a permanent fixture and will not be assembled by the user. This connection is shown later in Figure 7.

At the other end of the bottom pole segment, there are two main components. One of these components is a coupling mechanism to connect to the next pole segment. This coupler, shown in Figure 4, is connected to the pole using bolts. The coupler itself is ABS which will be 3D printed and a small fin that is made of 3003 aluminum.

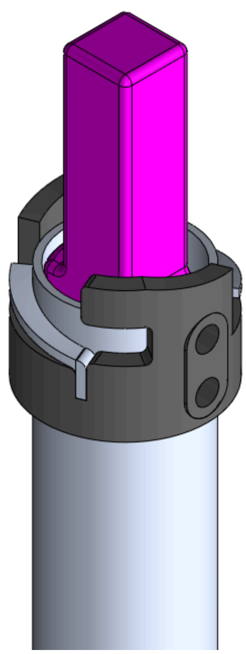

Figure 4. Coupling Mechanism with Square Extrusion for Torque Application

For each flagpole connection interface, the same coupler mechanism is used, so any mention of a coupler will refer back to this design. This coupler design works by first aligning the tab on one coupler with the opening of the other coupler. Then, they are pushed together while compressing the aluminum fin slightly. Once compressed enough, the poles will be able to be twisted together. The two fins on each side of the connection will exert opposite forces on the coupler, allowing for a friction-based lock. This locking mechanism design allows for easy disassembly. The lock is in place to prevent unintentional loosening of the joints of the flagpole to due small torques from vibrations or movement of the device.

On this same bottom pole segment, there is a square extrusion on the top side of the pole, also shown in Figure 4. This component and the coupler will be bolted together. The square extrusion serves as the point on which the driving torque will be applied. The center pole has a matching square cut out, shown in Figure 5, that will connect with the extrusion on the bottom pole segment. Twisting the middle pole segment once attached to the extrusion will be the method of torque application to drive the auger into the ground.

Figure 5. Square Cut-Out on Pole Segment

This middle segment of the pole has the same coupler as previously described on each end of it. Other than that and the square cut-out, no other modifications are to be made to this pole segment style. During assembly, this segment will be used as a tool to aid in applying torque to the auger bit. When fully assembled, this segment will be used only to increase the height of the flagpole.

The top segment of the pole has two different ends. On one end is the same coupler as previously described. This end will connect to the middle pole segment. The opposite end has an eyebolt for applying the required forces as well as a coupler at a 90 degree angle. This end is shown in Figure 6.

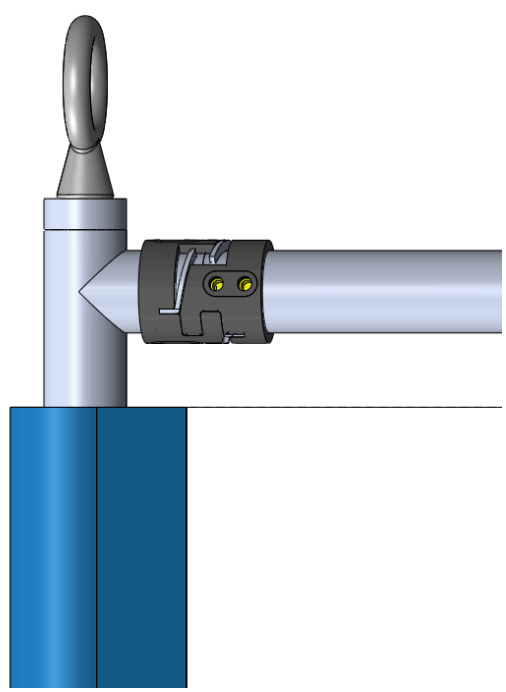

Figure 6. Top of Flagpole with 90 Degree Coupler and Eyebolt

The eyebolt on the pole is made of steel and will be the point of application for the axial and lateral forces during testing. This will be connected to the pole via a threaded end cap. This end cap will be made of the same aluminum as the pole and will be MIG welded to the pole. The pipe and coupler that is shown at the 90-degree angle will be used to secure other pipes that hold the flag itself upright. This pipe segment will be MIG welded to the top segment of the flagpole.

Attached to the 90-degree coupler will be a pole segment for the flag to deploy on. This segment is identical to the middle segment previously described which contains the square cut-out. This segment is identical so that the user can grab either of these two pole pieces without having to ensure they are using the correct one. If this square cut-out was removed, these two pole pieces may get mixed up during assembly. This would cost additional time. Having the pieces be identical allows the user to grab either segment. All other pole segments are different enough to where this should not be an issue. This will save time in the assembly of the flagpole, helping to keep the total assembly time to under ten minutes.

The final pole segment is the only segment that is less than 3 feet long. This segment is connected to the end of the first horizontal pipe segment, as shown in Figure 1 using the same coupler as all other connections.

To stabilize these pole segments, an anchoring system was designed. This design consists of the auger bit and the base plate. This is shown in Figure 7.

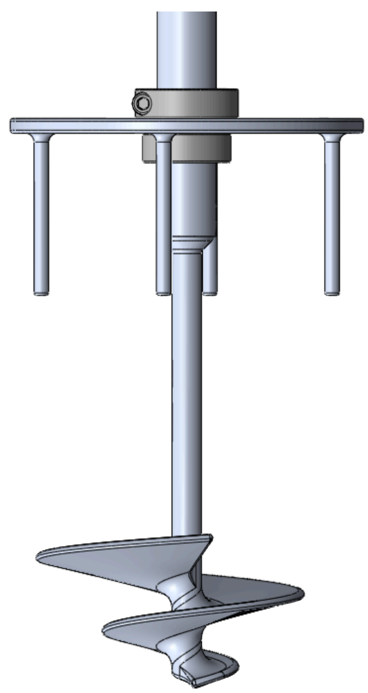

Figure 7. Anchoring System

The auger bit, shown in Figure 8, is designed in a way that will allow the user to easily twist and secure it within the ground. This auger was designed based on data from a journal on installing screw anchors in dry sand [2]. The auger is 9.64 inches in length and the flights are 7 inches in width at the widest point. As the flights get closer to the bottom of the anchor, the width gets smaller and the edge of the spiral gets closer to the main shaft of the anchor. The angle of the flights is 42 degrees from the pole throughout the two revolutions. The pitch of the helix is 1 inch and the entire threaded portion is 2.67 inches in length, accounting for the angle.

Figure 8. Auger Bit

This auger bit was also physically tested. During physical testing, 10 pounds worth of weights were added using a pulley system to simulate a 10 pound load. This testing set-up is shown in Figure 9.

Figure 9. Physical Testing Set-Up for Axial Loading of Auger Bit

Removal of the auger from the bucket was performed by pulling on the hanging weights. A good amount of force was applied before the auger became loose. This indicates that the auger bit design will hold the flagpole secure with the maximum tested load of 10 pounds of force.

In addition to this auger bit, a baseplate is being utilized to provide stability during both the anchoring process and lateral force application. The baseplate system is made up of three main parts: a removable collar, a permanent spacer, and the plate itself. These are all indicated in Figure 7. The removable collar is to provide easy access during testing and prototyping in the case of failure or if changes need to be made. This collar is bolted tightly onto the pole to ensure no axial motion occurs. The permanent spacer, which is MIG welded onto the pole, is located underneath the plate and prevents the plate from sliding down onto the auger. Both of these together hold the baseplate in place axially to allow the baseplate's legs to be driven into the ground with the auger. The baseplate is a loose fit around the pole and is able to spin freely. The legs that are driven into the ground help to secure the flagpole during the application of lateral forces.

The flag itself will be permanently fixed to the top segment of the pole, as shown in Figure 1. It will be sewn tightly around the vertical pole segment to minimize its movement. Along the top horizontal edge of the flag will be two loops of fabric. Each loop will be slightly larger than 1 inch in diameter so that the horizontal pole can be threaded through them. These are indicated in Figure 1.

2. Requirements Compliance Table

Table 1. Requirements Compliance Table

Requirement Number	
1	**A structurally stable, easily deployed flag for lunar EVA shall be developed.**
Met?	The anchoring system keeps the flagpole upright and stable as axial and lateral forces are applied onto the flagpole. The baseplate on the anchoring device plays a significant role in the lateral stability. A single coupler design is used to connect each segment of the flagpole to one another. This allows for the learning of an easily repeatable motion. The flag itself attaches to the horizontal pole using two fabric loops to slip onto the flagpole sections.
2	**Mass of the full flag assembly shall not exceed 10 lbs. in 1G Earth gravity.**
Met?	The mass of the fully assembled flagpole is calculated to have a mass of 4.8 lbs in 1G gravity.
3	**For any mechanisms used: For a linear-actuating mechanism, force required to actuate shall not exceed 20 lbf (89 N). For a rotating mechanism, torque required to actuate shall not exceed 30 in-lb (3.4Nm).**
Met?	When testing the auger bit physically, the amount of torque applied to anchor it seemed substantially less than 30 in-lb.
4	**All mechanisms used shall be dust tolerant.**
Met?	The design of the flagpole being hollow allows for dust and dirt to flow through without negatively affecting the performance of the flagpole. All openings and mechanisms either have no cavities or have substantially large holes to allow for the escape of dust.
5	**The flag shall remain deployed vertically and anchored without the use of an operator.**
Met?	The flagpole uses an anchoring system to secure it in the ground. A base plate with four lateral support beams stabilizes the pole to prevent it from tipping. This anchoring system allows the flag to remain deployed vertically and anchored without the use of an operator
6	**The flag shall be deployable from its stowed configuration in 10 minutes or less.**
Met?	The design of the couplers allows for a quick assembly of all the different flagpole sections. A simple push and twist motion is all that is required to connect all pole segments together.
7	**When deployed, lunar flag shall remain anchored when pulled upward with a 10 lb. force.**
Met?	To keep the lunar flag anchored and withstand 10 pounds of force vertically, an auger bit was designed. Physical testing of the anchor was performed, and the anchor successfully supported 10 lbs of upwards force using a pulley system.
8	**When deployed in the ground, lunar flag shall remain anchored when pulled laterally from the top of the flagpole with a 10 lb. force.**
Met?	To keep the lunar flag anchored and withstand 10 lbs of force laterally, a baseplate with vertically descending poles was affixed to the bottom of the flagpole to create a counter moment, assisting in resisting a 10 lb lateral force.
9	**A 1 in. tether loop shall be included at the top of the flagpole for use in applying axial and side loads during testing.**
Met?	The flagpole has a 1 inch steel eyebolt used for the tether loop on top of the flagpole.
10	**The flag shall have a method of remaining unfurled in the absence of wind.**
Met?	The flagpole has a pole segment that connects at a 90 degree angle to the top of the main pole. The flag will remain unfurled in the absence of wind by being connected to the main pole shaft with a sleeve. The top of the flag will also have loops of fabric so that it can hang under the adjacent pole.
11	**Height of the deployed flag shall be no less than 96 in. and no more than 120 in.**
Met?	The flagpole consists of two 36 inches sections, one 40 ⅜ inches section, and one 7 inch section for a total height of _____
12	**Flag size shall be 3 ft. x 5 ft.**
Met?	The flag will be those dimensions and the flagpole has been designed to accommodate this.
13	**Flag shall not touch the ground during deployment operations or once deployed.**
Met?	Provided that the user does not drop the flag in the process of deploying, the flag shall remain off the ground during and after deployment. During deployment, the flag will remain wrapped around the main pole, fixed in place. It will be unfurled while attaching the crossbeam that will hold the flag up, but it will not touch the ground. The flag will remain above the ground once deployed due to the adjacent pole at the top of the flagpole that the loops of fabric attached to the top edge of the flag will be threaded onto.
14	**Flag shall be the flag of the institution the student team is from. For multi-institution teams, please contact jsc-reducedgravity@nasa.gov for guidance.**
Met?	A flag with the Grand Valley State University logo will be acquired and utilized.
15	**Flag assembly shall be collapsible into an EVA-compatible stowed configuration* that fits within a volume of 48 in. x 12 in. x 8 in.**
Met?	Per Figure 2, all pieces have been shown to fit within a volume of 48 inches by 12 inches by 8 inches.
16	**The proposed design shall specify all materials the provided hardware will be made from.**
Met?	In Table 2, the manufacturing and materials of each component is laid out
17	**All materials used must be on the NBL Approved Materials List**. A waiver may be granted on a case-by-case basis. (No regular PLA allowed. Tough PLA is okay.)**
Met?	All materials in Table 2 have been cross-referenced with the NBL Approved Materials List. There are no conflicts with the list.
18	**Stress analysis and physical testing shall be conducted on the flagpole and anchoring system to ensure the materials and design are properly selected to ensure no structural damage occurs. You are expected to show stress analysis in the proposal. Physical testing may be done later.**
Met?	Several FEA have been shown in the proposal for showing stresses during loading as well as with Moon gravity. These simulations indicate that the design will not fail under loaded conditions.
19	**Factor of safety of at least 1.25 shall be used in stress analysis and physical testing. Specify the factor of safety used in the proposal.**
Met?	
20	**The flag, flagpole, and anchoring system shall be usable with EVA-gloved hands (like heavy ski gloves).**
Met?	The assembly process consists of moving and twisting large sections of pipes, so a user with a gloved hand will be able to assemble this.
21	**The flag, flagpole, and anchoring system shall use only manual power.**
Met?	The assembly process is powered purely by the user. This is done via a torque applied for the auger bit and a twisting motion for the couplers.
22	**There shall be no holes or openings which would allow/cause entrapment of fingers on the device.**
Met?	All holes and openings in the design are either small enough or large enough to prevent finger entrapment.
23	**There shall be no sharp edges on the device.**
Met?	All exposed edges have been filleting to a minimum radius of 0.04 inches.

3. Manufacturing Plan

All parts that require manufacturing will be fabricated on the Grand Valley State University Campus, with the exception of any welding. The auger bit of the anchoring system will be cast. This will be done by creating a mold out of clay using a 3D-printed part. Using the furnaces on campus, 6061 Aluminum will be melted and subsequently poured into the mold.

Figures 10 through 12 show components of the flagpole design with the corresponding number assignments. Components 2, 3, and the “T” shape of the pipes in Figure 12 will need to be MIG welded in addition to the manufacturing plan listed in Table 2.

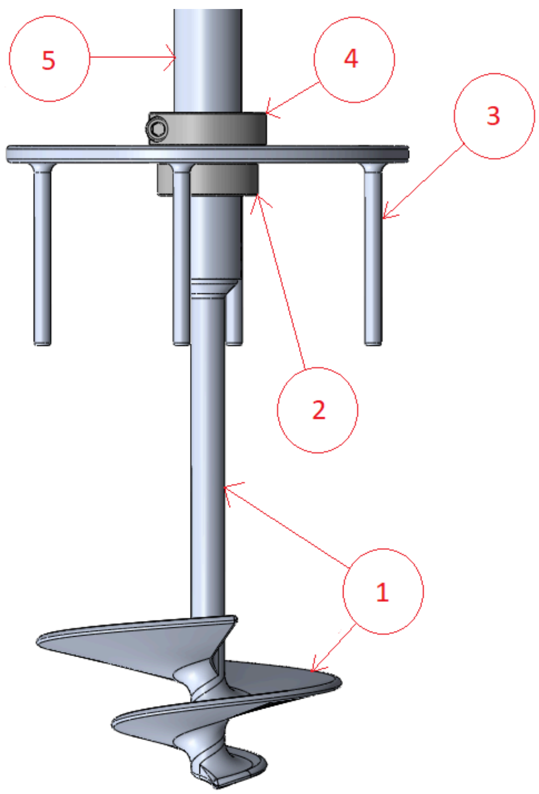

Figure 10. Anchoring System Component Reference

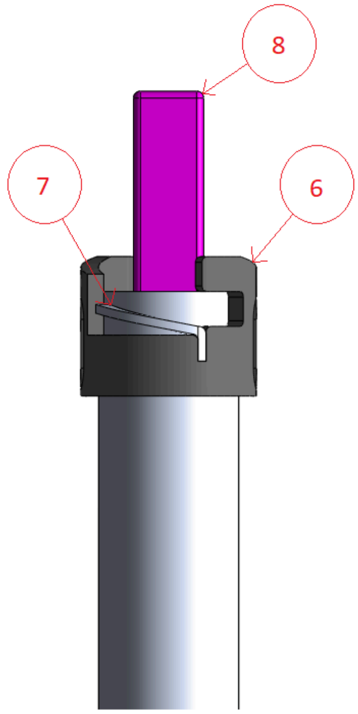

Figure 11. Coupling and Torque System Component Reference

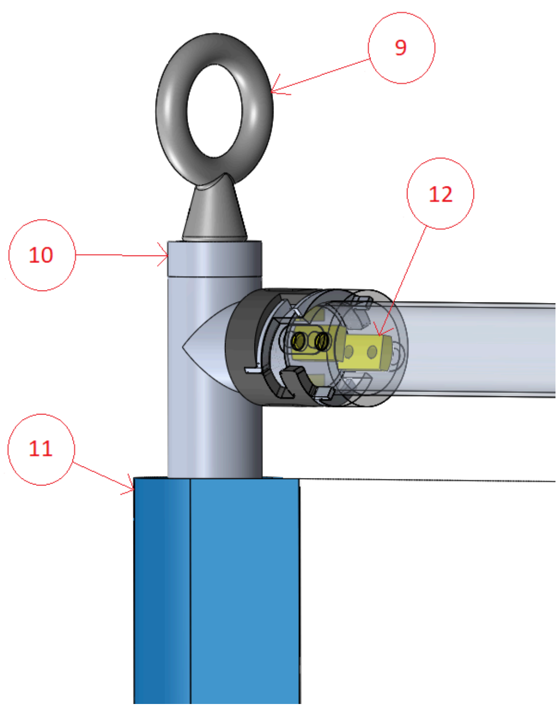

Figure 12. Misc. Component Reference

Table 2. Manufacturing Plan and Materials for Each Component

Component	QTY	Manufacturing Plan	Material	Process Time	Location
1. Auger Bit	1	Cast	6061-T6 (SS)	3 Weeks	GVSU
2. Permanent Spacer	1	Purchased Part	6061 Aluminum	3 Weeks	GVSU
3. Baseplate	1	Machined	6061-O (SS)	3 Weeks	GVSU
4. Removable Collar	1	Purchased Part	2024 Aluminum	2 Weeks	GVSU
5. Aluminum Piping	5	Bought/Machined	6061 Aluminum	4 Weeks	GVSU
6. Coupler	8	3D Printed	ABS	2 Weeks	GVSU
7. Coupler Fin	16	Machined	3003 Alloy	3 Weeks	GVSU
8. Square Torque Extrusion	1	Machined	6061-T6 (SS)	3 Weeks	GVSU
9. Eyebolt	1	Purchased Part	Steel	2 Weeks	GVSU
10. Pipe End Cap	1	Machined	6061 Aluminum	3 Weeks	GVSU
11. Flag	1	Purchased Part	Polyester	2 Weeks	GVSU
12. Coupler to Pipe Connector	14	Machined	6061-O (SS)	3 Weeks	GVSU

C. Operations Plan

1. The lunar flagpole is a collapsable device that, once assembled, will be able to withstand axial and lateral forces on the surface of the Moon. The device will be transported to the testing site contained within a 48” by 12” by 8” box.

2. The diver will take the container with the device to the testing site at the bottom of the pool.

3. Once at the testing site, take from the container the 2 foot pole section as well as a 3 foot pole section. The 3 foot pole section should have couplers on both ends and a square cut in it, shown in Figure ___.

4. Connect these two poles using the attached couplers; the orientation of the 3-foot pole does not matter. This is done by inserting the protruding locking pieces of the one coupler into the empty spaces of the opposing coupler. While doing this, the opposing coupler's protruding pieces will slide into the empty spaces of the held coupler. After this, finish the connection by twisting the two poles in opposite directions until stopped. Any mention of attaching pole pieces via couplers is to be done in this same manner.

5. Set the newly assembled component back into the storage container.

6. Remove the anchoring base with the attached pole, shown in Figure 7, from the box.

7. Take the other pole segment out of the container that has a square hole cut through it.

8. Fit the hole over the square extrusion on the pole attached to the anchoring base.

9. Position the anchoring base and pole vertically with the bottom tip of the auger pushed slightly into the sand.

10. Use the middle pole to apply torque to the top of the pole to drive the auger into the sand. Continue this action until the base plate of the anchoring system is resting firmly on the ground surface.

11. Remove the middle pole from the square extrusion.

12. From the storage container, grab the pole piece with the eyebolt at one end. This will be the top of the pole.

13. Connect the middle pole segment and top pole segment using the couplers.

14. Remove the previously assembled pole from the container.

15. Carefully unfurl the flag from the top pole segment.

16. Thread the shorter pole segment through the loops on the top of the flag, shown in Figure 1. This should be at a 90-degree angle to the main flagpole segment

17. Position the shorter pole to be ready to connect via the couplers, making sure that both fabric loops on the flag have been threaded through.

18. Connect these two segments of pipe together via their couplers.

19. Take the L-shaped pipe assembly and connect it via couplers to the anchoring device and pole that is secured in the ground.

20. This concludes the assembly of the flag. At this point, no parts should be left in the storage container for the flagpole.

D. Safety

One of the main safety concerns with this design are pinch points between each segment of the pole. This safety concern has been mitigated by including a simplistic and reusable locking mechanism design to allow the user to become familiar with the design through practice. The locking mechanism was designed for the user to grip the poles rather than the locking mechanism itself to prevent accidentally pinching themselves during assembly. As shown in the pole section of the flagpole in Figure ___, there is a 0.5 inch by 0.5 inch square opening on the surface of the pole. The square hole will remain exposed during deployment, possibly posing a safety risk. It is a fairly small opening, so there may be no safety risk. Once physical models are made of this section, testing will take place to know if this needs to be addressed. The user should not have their hands close to this opening during assembly due to placing their hands on the pole ends when handling, minimizing this potential hazard.

E. Technical References

1. Connoly, John, and David W. Carrier. “An Engineering Guide to Lunar Geotechnical Properties.” 2023, pp. 1-8. *NTRS - NASA Technical Reports Server*.

2. Ghaly, Ashraf, et al. “Installation Torque of Screw Anchors in Dry Sand.” Soils and Foundations, vol. 31, no. 2, June 1991, pp. 77–92, doi:10.3208/sandf1972.31.2_77.

3. Jiang, Tong. “Experimental study on the deformation of sandy soil around multi-helical anchor piles under horizontal load.” *Applied Ocean Research*, vol. 139, 2023, https://doi.org/10.1016/j.apor.2023.103721.

4. Mesloh, Wiranda, et al. "The Effects of Extravehicular Activity (EVA) Glove Pressure on Hand Strength." *National Air and Space Administration (NASA)*, National Air and Space Administration (NASA), July 1992, Ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20100008464.pdf.

5. Niromund, Hamed. “Design and construction of helical anchors in soils.” *Sustainable Engineering Products and Manufacturing Technologies*, 2019, pp. 113-157. *Science Direct*, https://doi.org/10.1016/B978-0-12-816564-5.00005-0.

II. Outreach Section

The section includes Astro Anchor’s plan for their outreach activities. Letters from the institutions confirming their interest can be found in Appendix C.

Allendale High School

The Astro Anchors will visit the Science Olympiad and workshop students of Allendale High School and present to the students about design challenges and how these problems motivate engineers to create solutions. The team will specifically talk about the challenges astronauts face when installing flagpoles and the instability of the pole when taking off from the moon's surface. The team will also discuss how the device we designed would make it easier for astronauts to deploy the flag.

A Microsoft PowerPoint will be used to help illustrate and explain the design process that the team went through to design the flag pole. The 5E instructional model will be utilized during the presentation by team members. A slide show of details and images will be used to emphasize the decision-making process and steps taken to manufacture the device. A large portion of the presentation will focus on the various tests and the importance behind verifying the developed concept through in-house testing and the tests conducted within Houston’s Neutral Buoyancy Lab.

Generally, the team will go through the standard ‘Engineering Design Process’ (EDP) which consists of:

1. Ask
2. Research
3. Imagine
4. Plan
5. Create
6. Test
7. Improve

Each area will be thoroughly explained and applied to how we, as a team, went through each step. Questions will be asked throughout each section to keep the high schoolers engaged. Time will be set aside to answer any additional questions the high schoolers may have.

Following this, the students will be split into groups of 3-4 and given the challenge of building the strongest bridge with newspaper and masking tape. They will be asked to use the EDP to come up with a solution. The challenge will be timed and upon completion, each team will be asked to present their EDP to the rest of the class. This activity will help reinforce the importance of working as a team towards a common goal while using the EDP. It will also sharpen their ability to critically think through a challenge and devise a solution within a time restriction.

Roger That!

The *Roger That! Conference* is an annual event to be held in February 2024 (exact dates TBD) at the Grand Rapids Public Museum. The event is dedicated to celebrating space exploration and honoring Roger B. Chaffee. Design to engage and educate; the event will cater to a diverse audience including students, intellectuals, and the general public.

The team will feature as an exhibit at the Grand Rapids Public Museum as concurrent events take place, including a keynote guest speaker who will describe how NASA uses water in the Neutral Buoyancy Lab to help prepare for space. Visual aids will help attendees gain insights into challenges faced by astronauts in space missions. The team will emphasize how devices created by engineers make simple tasks easier for astronauts in space.

The presentation will transition to briefly explaining the Micro-g NeXT competition and the team's developed design to simplify the task of installing a flagpole on the lunar surface. A 3-D printed prototype will be created and showcased to demonstrate the functionality of the device. The team will also emphasize the importance of the installation of a flag pole for the Artemis mission.

Social Media

The social media plan will include exposure on the GVSU ASME Instagram and Twitter page, a featured post on the GV Engineering Instagram, and a written feature on the GVSU PCEC website.

III. Administrative Section

A. Mentor Request

As a team, we would prefer to have someone who is familiar with geological simulations.

B. Institutional Letter of Endorsement

C. Statement of Supervising Faculty

D. Statement of Rights of Use

As a team member for a proposal entitled "Lunar Flagpole Device for Microgravity Challenge - Astro Anchors" proposed by a team of undergraduate students from Grand Valley State University, I will and hereby do grant the U.S. Government a royalty-free, nonexclusive and irrevocable license to use, reproduce, distribute (including distribution by transmission) to the public, perform publicly, prepare derivative works, and display publicly, any data contained in this proposal in whole or in part and in any manner for Federal purposes and to have or permit others to do so for Federal purposes only.

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Tasmiya Shaikh

Cebrina Kader

Owen Kirkpatrick

Aiden Latchaw

Isabelle Moore

Simon Morgan

Rock Phelps

Dayna Straub

Abigail Way

Statement of Rights of Use

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Sanjivan Manoharan

E. Funding and Budget Statement (This needs to be updated still)

The financial representative from Grand Valley State University will be Dr. Sanjivan Manoharan. He can be reached by email (manohars@gvsu.edu), or by phone (616-331-6024).

Item	Unit Cost	Quantity	Cost
Materials and Supplies			
Housing Plate	$31.94	1	$31.94
Upper Tube	$4.81	3	$14.43
Middle Tube	$4.81	3	$14.43
Lower Tube	$4.81	3	$14.43
Support Block	$28.66	1	$28.66
Magnet Holder Block	$28.66	1	$28.66
Top Dust Cover	$11.51	1	$11.51
Bottom Dust Cover	$11.51	1	$11.51
Handle	$11.75	1	$11.75
Neodymium Button Magnet	$0.65	4	$2.60
Standoff	$3.18	1	$3.18
Adapter	$19.99	1	$19.99

Item	Unit Cost	Quantity	Cost
Coring Bit	$208.00	1	$208.00
Thrust Bearing	$40.00	1	$40.00
Radial Ball Bearing	$40.00	1	$40.00
Inner Spring	$5.15	3	$15.45
Outer Spring	$4.91	3	$14.73
Head Hex Drive Screws	$7.25/pkg	1	$7.25
Flanged Head Hex Drive Screws	$12.39/pkg	1	$12.39
Low Profile Socket Head Screws	$9.38/pkg	1	$9.38
Manufacturing Cost			
CNC Milling (Housing Plate)	$500.00	1	$500.00
CNC Milling (Handle)	$400.00	1	$400.00
Travel			
Air Fare (6 students/1 faculty)	$ 350.00	7 people	$2,450.00
Food (5 Dinners, 7 people)	$ 20.00	35	$700.00
Lodging (2 rooms)	$ 150.00	5 nights	$750.00
Car Rental	$ 75.00	5 days	$ 375.00
Other (gas, parking, ect.)	$ 150.00	1	$ 150.00
Miscellaneous			
Total			***$5,865.29***

F. Parental Consent Forms

All Moon Miner team members are 18 years old or older, therefore no parental consent forms are necessary.

Appendix A - (this all will be updated)

Appendix C

Letters of Confirmation from Institutions for Outreach

Allendale Public Schools
Allendale High School | 10760 68th Ave. | Allendale, MI 49401 | 616-892-5585

October 08, 2023

I am writing this letter to recognize a Grand Valley State University (GVSU) student team, ASME (American Society of Mechanical Engineers), and the ASME team's proposal to interact and inspire our students at Allendale High School (AHS) regarding space exploration. ASME's proposal to engage with our AHS students is welcomed with excitement and gratitude.

The ASME team is currently participating in a NASA challenge to design and build a flagpole to be deployed by astronauts on the moon's surface. ASME would like to work on this challenge with our AHS students. The concepts found in this challenge promotes a perfect inclusion of mathematics, physics, and engineering within our science and industrial technology courses.

This letter serves as a confirmation of our partnership with AHS and GVSU's ASME.

Please feel free to contact us with any questions or further information.

Sincerely,

Troy VanderLaan

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