LUNAR SAMPLING DEVICE

Lunar Surface Operations - Initial Sample Collection Device

ERAU Microgravity Club

Embry-Riddle Aeronautical University, Daytona Beach

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I. Technical Section

A. Abstract

The Lunar Sampling Device is a tool that fulfills the requirements defined by the *NASA Microgravity Neutral Buoyancy Experiment Design Teams* (Micro-g NExT) "Initial Sample Collection Device" challenge. This challenge involves creating a tool that is capable of collecting a float sample from 0.5" to 2" in diameter, store the sample in the collection device, and then store the collection device in a 6" x 6" x 2" pocket. The Lunar Sampling Device (LSD) is directly based off of NASA's Contingency Soil Sampler. Notable alterations to NASA's design include: a short handle that is operable with a bulky glove, a rotating lid that can be opened and closed in order to store the sample, a handle for the lid for safe operation from the pinch point of the closing lid, and two magnets to lock the lid in the closed position. The total weight of the LSD is 0.9 lbs. The maximum volume of the device is 4.5" x 4.5" x 2.25" however it is collapsible into the required pocket size. The LSD was designed to maintain the simplest possible design while providing the user with an intuitive and efficient way of sampling and storing a lunar float sample.

B. Design Description

1. Design

The design is based off of NASA's Contingency Soil Sampler, whose practical purpose is akin to the LSD. The Contingency Soil Sampler, seen below in Figure 1, was used in the Apollo 11, 12, 14, and 15 missions. Its long collapsible handle was designed for the astronaut to use standing-up. The cylindrical teflon bag was made to collect a sample of lunar soil; the whole device then would be returned back inside the Lunar Module. In accordance with the design requirements, the design team altered and improved upon this pre-existing sampling device. The full design can be seen in the Figure 2 shown below:

Figure 1: Sketch of Contingency Soil Sampler, (Allton)

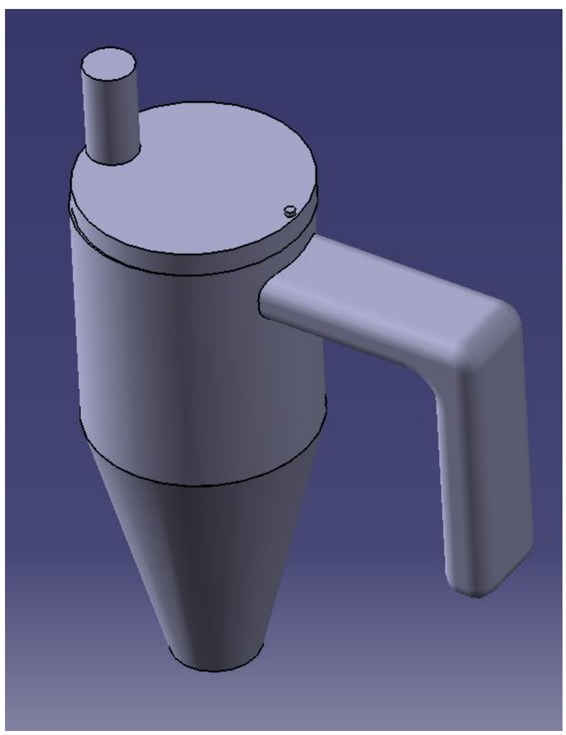

Figure 2: Isometric View of Assembled LSD CAD Model in Closed Position

1) *Bag*

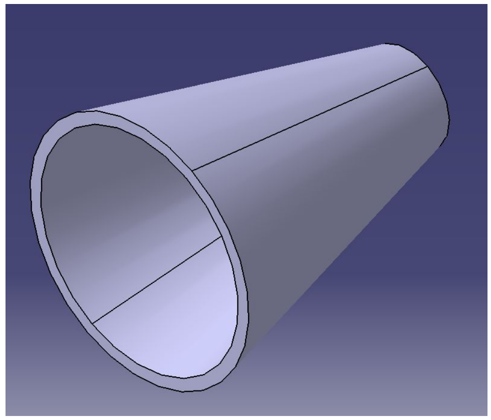

Figure 3: Isometric View of Teflon Bag CAD Model

The conical Teflon bag is very similar to the bag used during NASA's Apollo missions. With a density of 0.078 lb/in^3 (*The Teflon Molecule*), Teflon will be used because it is very lightweight and flexible. This material can be contracted and expanded to conserve and allow space for collecting samples. Teflon will not contaminate or damage any sample that is collected by the device. Therefore, Teflon was the clear choice to be used for the bag to effectively fulfill the required tasks.

2) *Handle*

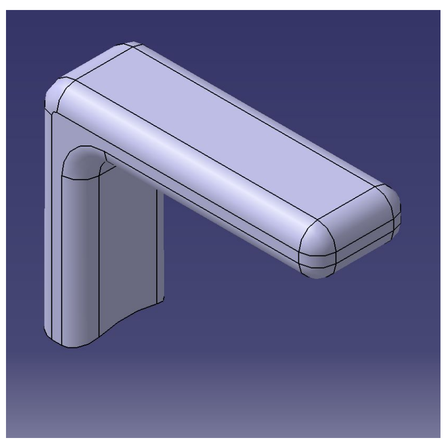

Figure 4: Isometric View of Handle CAD Model

Instead of the long collapsible handle, used on the Contingency Soil Sampler, the LSD has a short rigid handle that attaches to an aluminum ring to minimize pinch points and unnecessary complexity of design. The handle is made out of Aluminum 6061. The advantage of series 6061 over series 7075 is that 6061 is much easier to weld with, and this will be necessary when attaching the handle to the cylindrical ring on the device. For ease of operation in bulky EVA in which dexterity is very minimal, the handle is designed to extend back to a length of 2.5 inches and extends up away from the cylinder 1.75 inches. This would allow for at least two of the astronauts fingers to fit into the handle in order to provide substantial force for successful operation.

3) Cylinder

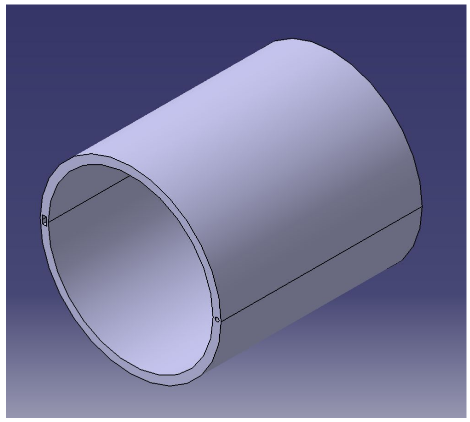

Figure 5: The Isometric View of the Cylinder CAD Model

The Aluminum cylindrical ring will be located at the opening of the bag. It will be made of Aluminum 6061 because it is sturdy and lightweight, with a density of 0.0975 lb/in3 (ASM Material Data Sheet). The inner diameter in the front view, is 2.05in. This is made in order to ensure the proposed device has the ability to collect samples ranging from 0.5in to 2in in diameter. The cylinder will also have a magnetic lock mechanism that connects to a magnet in the revolving lid to secure the lid in the closed position, unless acted on by an astronaut. The magnet will be pocketed into the cylinder at the bottom of the device. When the revolving lid is in the closed position the two magnets will line up which will secure the lid in place.

4) *Revolving Lid*

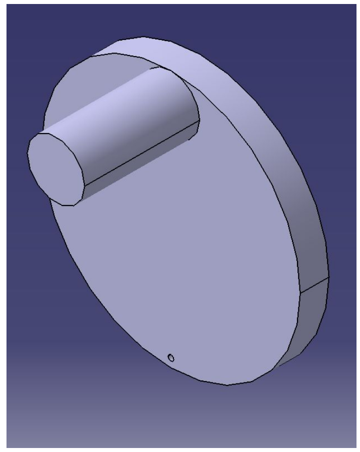

Figure 6: Isometric View of the Revolving lid CAD Model

In order to store the lunar sample in the device, the proposed design incorporates a lid that is able to pivot in order to open and close the opening of the collection device. Aluminum 6061 will be the material for this device. This lid will revolve about a pin attached to the main containment chamber of the device. The extension on the front of the lid can be used as a handhold for the astronaut to grab and rotate the lid about the pivot point to open the container. The revolving lid will be held shut by magnets. One magnet will be located in the bottom of the lid itself and the other will be located in the cylindrical opening of the device. When the LSD is closed the two magnets align and the lid will be secured in the closed position. The magnetic locking mechanism is used to safeguard the sample from contamination.

5) *Pin*

Figure 7: Isometric View of the Pin CAD Model

The pin is used as an axle for the revolving lid to revolve around. This pin is made out of stainless steel because as a small part, that is pertinent to the functionality of the device, the design team decided to make the pin stronger to guarantee it would not break under large forces. Stainless steel is considerably stronger than aluminum, thus stainless steel was used to create the pin. Due to the larger mass, this is the only part that is made of stainless steel to conserve weight.

2. Manufacturing

The manufacturing process for the proposed design should be fairly straightforward. Most of the parts will be fairly easy to build with the exception of the handle. The handle will be more difficult to manufacture because all the edges on the handle are smoothed out for the astronauts protection. The handle's edge, which is attached to the cylinder, is curved to be flush with the cylinder's curvature to make a much smoother design. The team currently agreed on assembling the parts on campus and the exploded view of the assembly is shown below, in Figure 8.

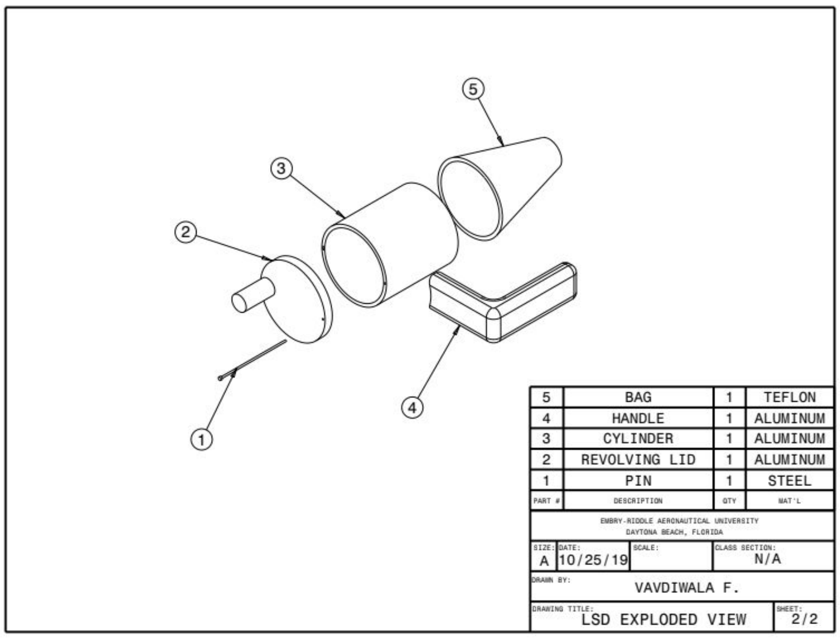

Figure 8: Exploded View Drawing of the LSD CAD Model

For the proposed design, the assembly of the parts will be done as follows:

1) The Teflon bag will be etched in the parts where it attaches to the aluminum cylinder. The etching will insure there are no openings in the assembly which reduces the chances of contamination.
2) The handle will be welded to the aluminum cylinder to make sure the contact is strong enough to withstand the net force on the assembly. A future improvement to this part would be to make the handle a press fit with the cylinder so that it can be detached when not in use, which will make the design even more portable.
3) The lid will be attached to the cylinder using a pin which will connect the two parts only allowing the lid one degree of freedom. The lid has a handle on top so that it can be opened by rotating it clockwise or counter clockwise. For the closing mechanism, the team decided to go with a magnetic contact between the cylinder and the rotating lid.

3. Finite Element Analysis

To ensure the safety of the astronauts, who will use this device, and also to maintain the integrity of the sample, an FEA was performed on the weakest link of the LSD assembly, the handle. The above Figures 9, 10, and 11 show the results of the analysis.

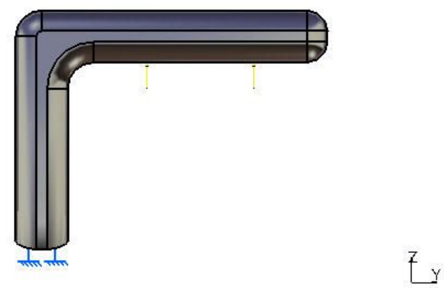

Figure 9: FEA Applied Forces Diagram

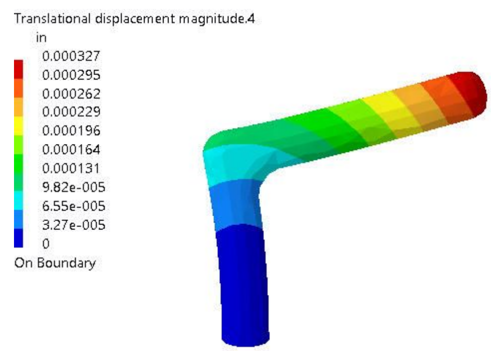

Figure 10: FEA Displacement Magnitude Diagram

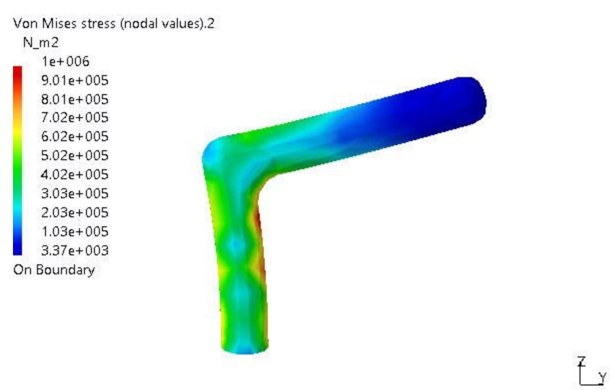

Figure 11: FEA Stress analysis Diagram

Figure 9 shows the position on the handle where it is clamped to the entire assembly and the point where most of the forces will be applied on the assembly during a mission. For this purpose, a distributed load of 20 N was applied to the handle itself which is shown by arrows on Figure 9.

Figure 10 and Figure 11 show the displacement and stresses applied on the handle respectively. The distributed load acting on the handle causes a bending moment which is shown in Figure 11. For better visualisation, it can be seen in Figure 10 that the maximum displacement, 0.000327 inches, occurs at the bottom of the handle which was expected. The data collected in this analysis also proves that the material chosen will be able to handle an extremely large force of 20 N relative to the weight of the sample on the Lunar surface

4. Design Requirements Compliance

Table 1: Challenge Requirements. For ease of comparison, the following table lists all baseline requirements for the initial sample collection device challenge and the associated aspects of the LSD that satisfy them.

Number	Challenge Requirements	Requirement Compliance
1	The device shall be able to collect one float sample ranging 0.5” to 2” in diameter.	The LSD has an opening of 2.05 inches to collect a float sample
2	The device shall use only manual power.	The LSD can be operated with minimal force exerted by gloved hands.
3	The crew member shall be able to un-stow the tool, pick up the sample, and stow the tool within 2 minutes.	The LSD has very basic and efficient operating procedures that will easily fit inside this time requirement.
4	The device must be operable with EVA gloved hands (like heavy ski gloves).	The LSD is designed to be operated in bulky gloves with minimal dexterity.
5	The total weight of all parts you provide should be less than 1.5 lbs.	The total mass of the tool is approximately 0.9 lb (14 ounces) on Earth.
6	The device shall be able to pack within 6” x 6” x 2” volume.	When stored in the restricted volume, the teflon will compress to fit the dimensions The maximum dimensions of LSD when used are 4.5” x 4.5” x 2.25”.
7	Tools must not have holes or openings which would allow/cause entrapment of fingers.	The only hole in the device is 2.05in. in diameter which is too large for a finger to become entrapped
8	Tools should be made from Aluminum 6061, Aluminum 7075, Stainless Steel (any series), or Teflon. Any other materials must	The lid, handle, and cylindrical ring are made of Aluminum 6061.The bag is Teflon and a small pin is stainless steel.

	get prior approval from the EVA Tools POC*.	
9	Lubricants must be selected from the NBL approved lubricant list or a waiver must be granted.	Tiolube 460 is the only lubricant used on the device which is on the approved materials list.
10	There shall be no sharp edges on the tool.	There are no sharp edges on the device. All edges are rounded to offer no risk to the safety of the astronaut
11	Pinch points should be minimized and labeled.	The only pinch point is where the lid closes. However, using the extruding part on the lid to open and close the lid will safely avoid any pinching.

C. Operations Plan

1. Preliminary Testing Operations Plan

Our testing prior to official testing at NASA NBL will occur at Daytona Beach with members of the Microgravity Club. We will take our device and fully submerge it in the sand, then remove and pick up a loose sample of 0.5 inches diameter. We will then repeat this process two more times, increasing the sample diameter size to 1.25 and then 2 inches.

2. Operation Procedure

The plan to test the LSD in the NBL is as simple and efficient as the preliminary testing. In order to ensure that it can meet all the requirements outlined by NASA, the divers take the device to a surface similar to the lunar surface with rocks of varying sizes. They will then use the LSD to perform the tasks designated by the steps below:

1) Remove the device from the pocket. Open the revolving lid on the front of the device. Pick up a roughly spherical rock of 0.5 inches in diameter off of the simulated lunar surface. Then return the revolving lid to the closed position.
2) Discard the 0.5 inch diameter sample and then attempt to pick up another rock from the simulated lunar surface of approximately 1.25 inches in diameter. Then in the same way close the device.
3) Discard the 1.25 inch diameter sample and attempt to pick up a sample 2 inches in diameter and close the device once more. Then return the LSD to the pocket of the diver with the 2 inch diameter sample still stored in the device. The diver can keep the device in their pocket until they return to the surface- similar to what the astronauts will do if they use this device on the lunar surface.

3. Testing Outline

In order to prepare the LSD for the NBL, Embry-Riddle's team will follow the timeline depicted in the following schedule and Gantt Chart.

TASK	Start Date	Days to Complete
Final CAD Design	12/10/2019	21
Finalize Part Models	12/10/2019	10
Final Assembly	12/17/2019	7
Creation of Engineering Drawings	12/21/2019	10
Prototyping Phase	12/31/2019	16
Manufacturing Phase	1/15/2020	26
Handle	1/15/2020	7
Cylinder	1/20/2020	7
Bag	1/25/2020	7
Pin	1/30/2020	7
Revolving Lid	2/4/2020	7
Assembley of Parts	2/12/2020	17
Initial Testing Phase	3/1/2020	14
Dry Land Tests	3/1/2020	7
Wet Testing in Pool	3/6/2020	9
Troubleshooting Phase	3/15/2020	16
Final Testing Phase	4/1/2020	30
Finalize All Plans for NBL	5/1/2020	17
Preferred NBL Test Week	5/18/2020	5

Figure 12: Schedule of tasks for ontime completion of device

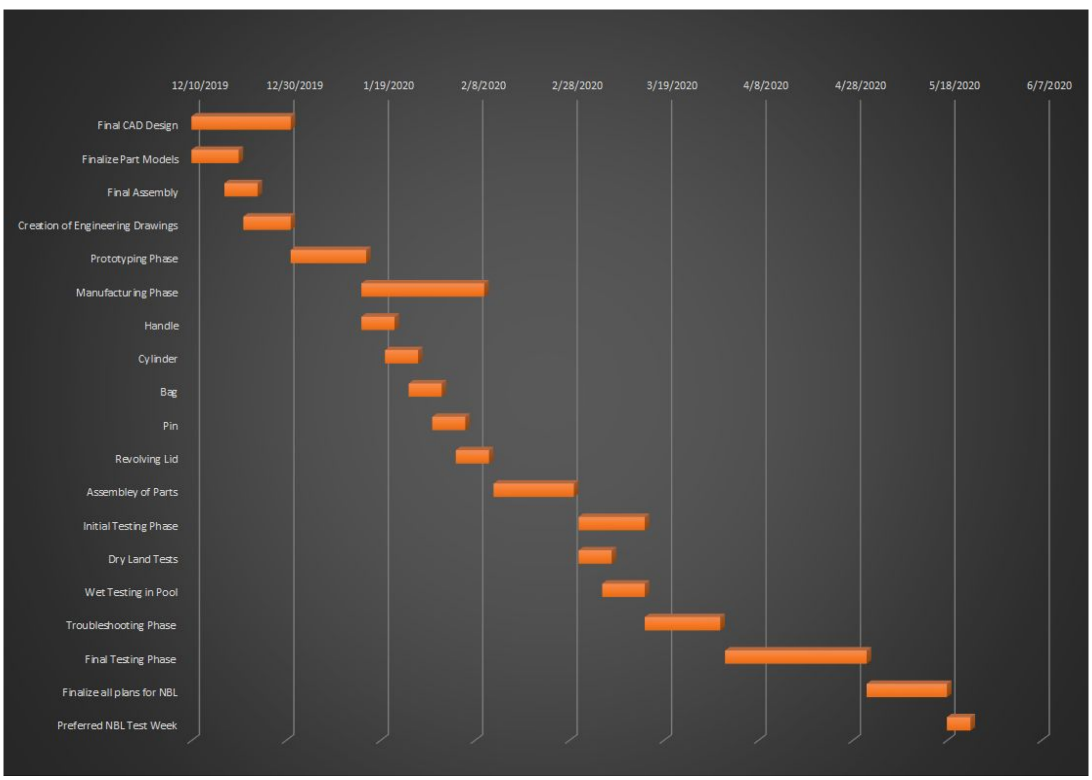

Figure 13: Gantt Chart Design, Manufacturing, and Testing of LSD

D. Safety

Safety is of utmost importance when designing a tool for astronaut use. The tool proposed in this report offers little to no risks to the astronaut. The only opening on the entire device is the one on the front where the sample is collected, but this hole has a diameter of 2.05in. The diameter of single finger on an EVA glove is approximately one inch. Therefore, even if the astronaut gets a finger in the opening it is much too large for them to get it stuck, and with proper operation the astronauts fingers should not be in this opening at any time. There are no sharp edges on the LSD in order to reduce the risk of puncturing the astronauts suit.

Table 2: Situation Severity

Situation	Severity	Description	Solutions
Teflon Bag Failure	**High**	The Teflon bag rips or falls off due to some sort of malfunction. This leaves the sample at a potential contamination risk as well as the risk of losing the sample	-Cover the hole with duct tape -Attach a different bag -Attach sock to cylinder using duct tape to act as new bag
Handle Failure	**Medium**	The handle breaks off from the cylinder by some outside force. This leaves the handle unusable.	-The astronaut grips the cylinder itself in order to scoop the sample rather than the handle
Cylinder Failure	**High**	The cylinder breaks causing the device to not have a solid core holding it together. This could lead to loss of sample or contamination of the sample.	-Reweld the Cylinder -Replace the cylinder -Duct tape the broken part of the cylinder to hold it together -Glue the cylinder shut
Revolving Lid Failure	**Low**	The revolving lid breaks or fractures due to some outside force leaving it unusable	-Remove lid and cover the opening with a new cover. For example, a sock. Connect the new cover with duct tape to the cylinder in order to contain the sample
Pin Failure	**Medium**	The pin fractures due to some outside force causes the lid to no longer be able to hold the revolving lid to the cylinder. Also takes away the only pivot point for the lid to revolve around	-Replace Pin -Remove lid and pin all together and use a new cover as described in the cell above

E. Technical References

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II. Outreach Section

A. Outreach Objectives

1. Develop, stimulate, and cultivate interest in the Micro-g NExT challenge and in Science, Technology, Engineering, and Mathematics (STEM) fields of students (including elementary, middle, and high school students) in the local community.
2. Spread awareness of the NASA Micro-g NExT Project to each college at Embry-Riddle Aeronautical University: College of Engineering, College of Arts and Sciences, College of Business, and College of Aviation.
3. In the event of successful completion of the project proposal, share the results of the project and opportunities within NASA, specifically in regards to Micro-g NExT through a project presentation and demonstration.

B. Outreach Audience

The goal of the team is to reach the maximum number of people as possible in order to maximize the positive effects that the project can have on the local community. This target audience can be broken down into three broad categories: students in the local community; students and faculty at ERAU; and the general public.

Students in the local community of Daytona Beach and the surrounding areas are the main focus of the Microgravity Club's outreach. This group includes students at local elementary and high schools. The local elementary school that we will be pairing with is Palm Terrace Elementary, which is located in Daytona Beach, Florida. Specifically, we will be working with their fifth grade students. The goal of the outreach to the fifth grade students at Palm Terrace Elementary is to increase their exposure to STEM, in order to develop an interest in these areas at a young age, and teach these students about the opportunities that are available to them even at such a young age.

Additionally, outreach will be directed to the ERAU community. This goal of outreach to the ERAU community is for increased awareness of the Micro-g NExT project on the campus. More specifically, the goals for outreach to the ERAU community can be represented in two generic categories: faculty and students. Through outreach to the ERAU faculty, the team is hoping to establish further relationships with faculty members that are interested in the Micro-g NExT project. These connections that are made will help to establish relationships that can provide mentorship and resources for the project. Additionally, outreach to ERAU faculty will allow for connections to each of the different colleges at Embry-Riddle: the College of Engineering, College of Arts and Sciences, College of Business, and College of Aviation. The connections to each of these colleges will help to facilitate interdisciplinary collaboration, and will assist in an increased collaboration of the sharing of resources on campus. Through outreach to the students at ERAU, the team is hoping to promote interest in the Micro-g NExT Challenge. Increased interest will promote support of the team and will allow for more individuals to become involved with the Micro-g NExT challenge this year, and in years to come at ERAU.

The final focus audience of the outreach is the general public. The purpose of the outreach to the general public is to broaden the scope of the team's outreach to include individuals that may not be directly interested/linked to these fields that are being worked in so closely. By sharing the project with the general community, it opens up more doors for involvement and collaboration in ways that the team has not thought of themselves.

C. Specific Plans for Activities

In order to meet the objectives for the outreach listed in the above section, the team currently has a variety of activities planned, all of which are listed below. The activities listed follow the same order as the objectives listed in Section A.

1. Outreach to Students in the Local Community

The first activity planned will be to hold a small competition amongst fourth and fifth grade teams at Turie T. Small Elementary School which will require them to use basic materials to craft a small rover. The goal of the competition will be to see which rover rolls the farthest distance (exact procedures and materials for this competition will be listed at the end of this section). The goal of such a competition will be to educate students on the basic principles involved with the construction of a rover, such that they will have a better understanding of the processes used in the design and development of real rovers, while also getting to have a hands-on arts and crafts activity. While learning about the uses and construction of rovers, the students will also learn more about data and sample collection, thus tying into the Micro-g NExT Lunar Sample Collection challenge (Challenge 4). In addition, this activity ties into the Florida 5th grade science curriculum standards of "explore what moons, asteroids, and comets are," as rovers and collection tools are designed to be used in these exact environments, and can be used to learn more about said celestial bodies. Learning about ways that moons, asteroids, and comets can be explored and studied will supplement and build upon the knowledge they've been learning throughout their fifth grade year. To conduct this activity, the 5E model (Engage, Explore, Explain, Elaborate, and Evaluate) will be applied to create the following lesson plan:

1) *Engage:* Students will listen and participate in a presentation about rovers and collection tools.

2) *Explore:* The students will identify and develop knowledge of the various properties of rovers/tools and their design and construction. They will also become familiar with the procedures for making their own rovers.
3) *Explain:* The students will build their own rovers and will be able to successfully demonstrate their understanding of the properties of rovers in their designs.
4) *Elaborate:* The students will learn more about rovers and tools and their applications in microgravity, in the Neutral Buoyancy Lab, and in the team's prototype sample collection device.
5) *Evaluate:* The students will demonstrate their understanding of rovers and tools by being able to discuss their own models and their properties.

a. *Materials*

Toothpicks, Plastic straws, Styrofoam plates, Scrap cardboard, Masking tape, Misc. rubber bands

b. *Procedure*

(1) Use the materials provided to design and build a small rover
(2) Compete with other teams to see which rover will travel the farthest distance
(3) Discuss the properties of each rover and what worked and what did not.

2. Objective 2: Spreading Awareness at ERAU

A focus of the Microgravity Club's outreach will be outreach toward the ERAU Community. The first step that the team will make in order to connect with various student and faculty members will be posting an advertisement, shown in the appendix, around campus. In each of the colleges at ERAU (College of Engineering, College of Arts and Sciences, College of Business, and College of Aviation) there are digital advertisements presented in each college's atrium. This advertisement will be posted in each of these colleges in order to spread awareness of the project. Additionally, social media will be used to detail the progress of the project, which will assist in outreach to both student and faculty groups. The social media plan discussed in more detail later on in the outreach section.

In order to strengthen the outreach to faculty members, faculty members in each of the different colleges will be contacted detailing the project. One of the goals of Microgravity Club is to establish a group of faculty members that are interested in the Microgravity Club's progress and pursuits in order to increase their network of support and spread awareness of the project. This faculty contact will consist of initial emails to faculty members in each of the colleges, detailing the Micro-g NExT Challenge and what the Microgravity Club's goals for this semester are. After this initial email, interest in becoming involved with the project will be gauged, and any faculty members that are interested in becoming involved in the project will be met with in order to establish a personal relationship between the Microgravity Club and the faculty member. The Microgravity Club will then create an email list consisting of all interested parties, and will send out weekly email updates in order to keep the ERAU community up to date on the progress of the Microgravity Club in the Micro-g NExT Challenge.

In regards to outreach to ERAU students, the Microgravity Club has already begun outreach. On Thursday, September 19, 2019, the Microgravity Club participated in ERAU's student activities fair. At the activities fair, the Microgravity Club presented this year's Micro-g NExT challenge in order to recruit new membership and spread awareness of the project. This event was incredibly successful, as the Microgravity Club was able to talk to numerous students, and additionally received approximately fifty signatures of students interested in becoming involved with the Micro-g NExT challenge. The Microgravity Club will also be submitting articles to the ERAU newspaper, The Avion, detailing the project pursuits, successes, and progress. The Microgravity Club will submit these articles to The Avion once every month. Additionally, the Microgravity Club will be showcasing their project at ERAU's Family Weekend, which will be in February 2020, and Preview Day, which will be in February 2020. At both of these events, the Microgravity Club will be showcasing their design, and talking to prospective and current ERAU students about what the Micro-g NExT Project entails.

In order to strengthen outreach to both ERAU students and faculty, the Microgravity Club will be applying to participate in the Office of Undergraduate Research's 8th Annual Discovery Day, which is ERAU's student research conference, which is currently scheduled for April 2020. At this conference, the Microgravity Club will be able to share a project poster to students and faculty members, which will be incredibly beneficial in spreading awareness of the project at ERAU.

Additionally, the Microgravity Club team will be hosting a workshop for ERAU students providing information and insight on successful methods for completing research projects. During the workshop, the Microgravity Club team will discuss resources available on campus for funding, resources available for manufacturing and operations, and will also discuss the Micro-g NExT Challenge and the resources available in reference to those design challenges. Additionally, the Microgravity Club will discuss their project, and will share their knowledge about what practices worked and didn't work for the leadership and members of the team.

D. Social Media Plan

The Microgravity Club will be utilizing social media in order to supplement the project outreach. The two primary social media platforms will be Instagram (@eraumicrog) and Facebook (@eraumicrog). Each of these social media platforms will be updated at least weekly, with the same weekly report that is sent to the network of faculty supports detailed in the above paragraphs. Additional posts will be made on each of these social media platforms with pictures of testing, outreach activities, and images of design manufacturing. Additionally, the Microgravity Club will be utilizing a website (https://sites.google.com/view/eraumicrog) which will serve as another resource for sharing the progress with the public. This website will be updated at the same frequency as the other social media platforms, and will contain records of all of the weekly reports that are shared.

E. Communication Logs

Contacts: Mr. Paul Strusk, Vice Principal - (386) 258-4680, ptstrusk@volusia.k12.fl.us

Communication Logs:

I conducted a phone conversation with Mr. Strusk, during which he announced that he would be happy to host an Embry-Riddle outreach group again, due to the successes of other groups there in the past. He asked for a detailed plan of the Ocean Worlds activity we have in mind for the school, and for a timeframe and estimated student count.

III. Administrative Section

A. Test Week Preference

The preferred test week for the team is Test Week 1 - May 18-23, 2020

B. Mentor Request

The Embry-Riddle Aeronautical University Microgravity Club requests the mentorship of Stephanie Johnston. She has been our mentor in previous years and we truly enjoyed her help. It would be an honor to have our club be in contact and mentored by her again this year.

C. Institutional Letter of Endorsement

EMBRY-RIDDLE
Aeronautical University
DAYTONA BEACH, FLORIDA

Department of
Mechanical Engineering

Tel: 386-226-6667
Fax: 386-226-6011

October 28, 2019

Micro-G NExT Selection Board
Johnson Space Center
2101 NASA Parkway
Houston, TX 77058

RE: “Statement of Department Chair of Mechanical Engineering” for the 2019-2020 NASA Student Micro-G NExT Design Challenge.”

Dear Micro-G NExT Selection Board:

The Department of Mechanical Engineering endorses the 2019-2020 NASA Student Micro-G NExT Design Challenge entitled “Initial Sample Collection Device” proposed by a diverse team of undergraduate students from Embry-Riddle Aeronautical University, Daytona Beach Campus under the advisorship of Drs.Gangadharan, Dikici and Llanos.

We concur with the concepts and methods by which this project will be conducted. We understand that any default by this team concerning any of the Program requirements (including submission of final report materials) could adversely affect the selection opportunities of future teams from Embry-Riddle Aeronautical University at Daytona Campus.

Sincerely,

Eduardo Divo Ph.D..
Professor and Chair, Mechanical Engineering
Embry-Riddle Aeronautical University
Daytona Beach, Florida 32114
Tel: (386) 226-7987
Fax: (386) 226-6011
Email: divoe@erau.edu

embryriddle.edu

D. Statement of Supervising Faculty

Department of
Mechanical Engineering

Tel: 386-226-6667
Fax: 386-226-6011

EMBRY-RIDDLE
Aeronautical University
DAYTONA BEACH, FLORIDA

October 27, 2019

Micro-G NExT Selection Board
Johnson Space Center
2101 NASA Parkway
Houston, TX 77058

RE: "Statement of Supervising Faculty" for the 2019-2020 NASA Student Micro-G NExT Design Challenge."

Dear Micro-G NExT Selection Board:

As a faculty advisor for the experiment entitled "Initial Sample Collection Device" proposed by a diverse team of undergraduate students from Embry-Riddle Aeronautical University, Daytona Beach Campus, I concur with the concepts and methods by which this project will be conducted. I will ensure that all reports and deadlines are completed by the student team members in a timely manner. I understand that any default by this team concerning any of the Program requirements (including submission of final report materials) could adversely affect the selection opportunities of future teams from Embry-Riddle Aeronautical University at Daytona Campus.

Sincerely,

Sathya Gangadharan Ph.D., P.E., C.Mfg.E.
Professor, Mechanical Engineering
Embry-Riddle Aeronautical University
Daytona Beach, Florida 32114
Tel: (386) 226-7005
Fax: (386) 226-6011
Email: sathya@erau.edu

embryriddle.edu

E. Statement of Rights of Use

As a team member for a proposal entitled "Lunar Sampling Device" proposed by a team of undergraduate students from Embry-Riddle Aeronautical 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.

As a team member for a proposal entitled "Lunar Sampling Device" proposed by a team of undergraduate students from Embry-Riddle Aeronautical University, I will and hereby do grant the U.S. Government a nonexclusive, nontransferable, irrevocable, paid-up license to practice or have practiced for or on behalf of the United States an invention described or made part of this proposal throughout the world.

Signed:

David Jefts – President

Austin Dunbar – Vice President

Christopher Rivera – Treasurer

Greta Fergus – Secretary

Zach Mosteller – Outreach Team Lead

Hunter Hatchell - Student Advisor

Justin Randall – Student Advisor

Boone Lynch – Team Co-Lead

Joshua Sonderegger –Team Co-Lead

Fahad Vavdiwala– Lead Designer

Andrew Heiles – Member

Mason Gawler – Member

F. Funding and Budget Statement

1. Estimated Funding Statement

Funding Source / Sponsor	Total Possible Funding (USD $)
Microgravity Club Savings	$380.00
Membership Dues ($20 x 30)	$600.00
IGNITE (Undergraduate Research Program)	$1,000.00
Aerospace Engineering Department	$500.00
ERAU SGA Annual Fund	$2,500.00
Florida Space Grant Consortium (FSGC)	$3,000.00
Total	**$4,980.00**

2. Estimated Expenses Statement

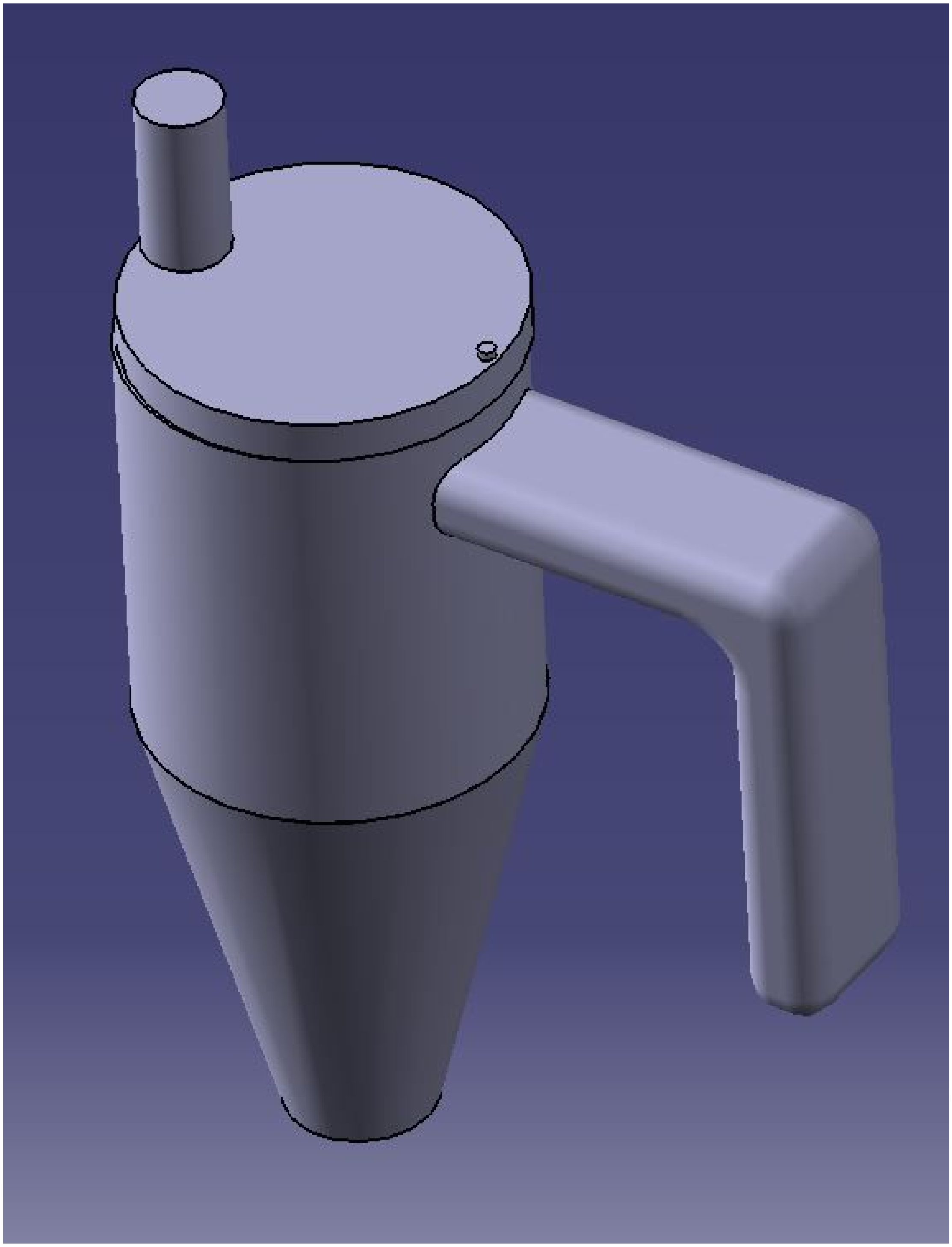
Items	Link / Reference	Quantity	Price Per	Total Cost
Design Materials				
Teflon Bag 3x3 Cylinder Revolving Lid Handle Pin	Link Link Link Link Link	1 1 1 1 1	$9.23 $87.44 $46.63 $59.16 $10.16	$9.23 $87.44 $46.63 $59.16 $10.16
Manufacturing Costs				
N/A	N/A	0	0	0
Outreach Materials				
				$100
Travel				
Gas				$600.00
Hotel				$3,500
Food		84 meals	$15	$1,260
Total				**$5,672.71**

G. Parental Consent Forms

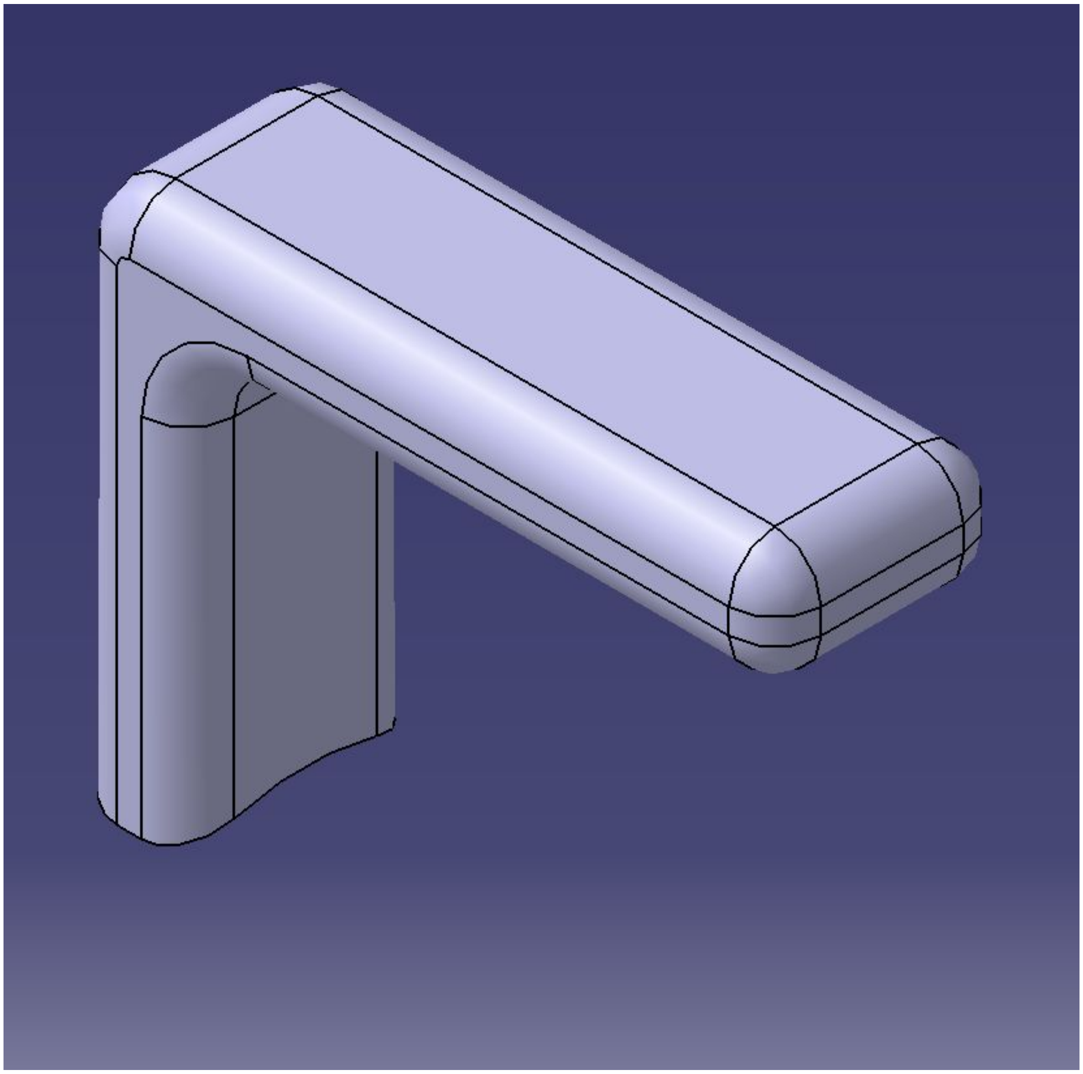
We do not have any team members who are below the age of 18.

IV. Appendix

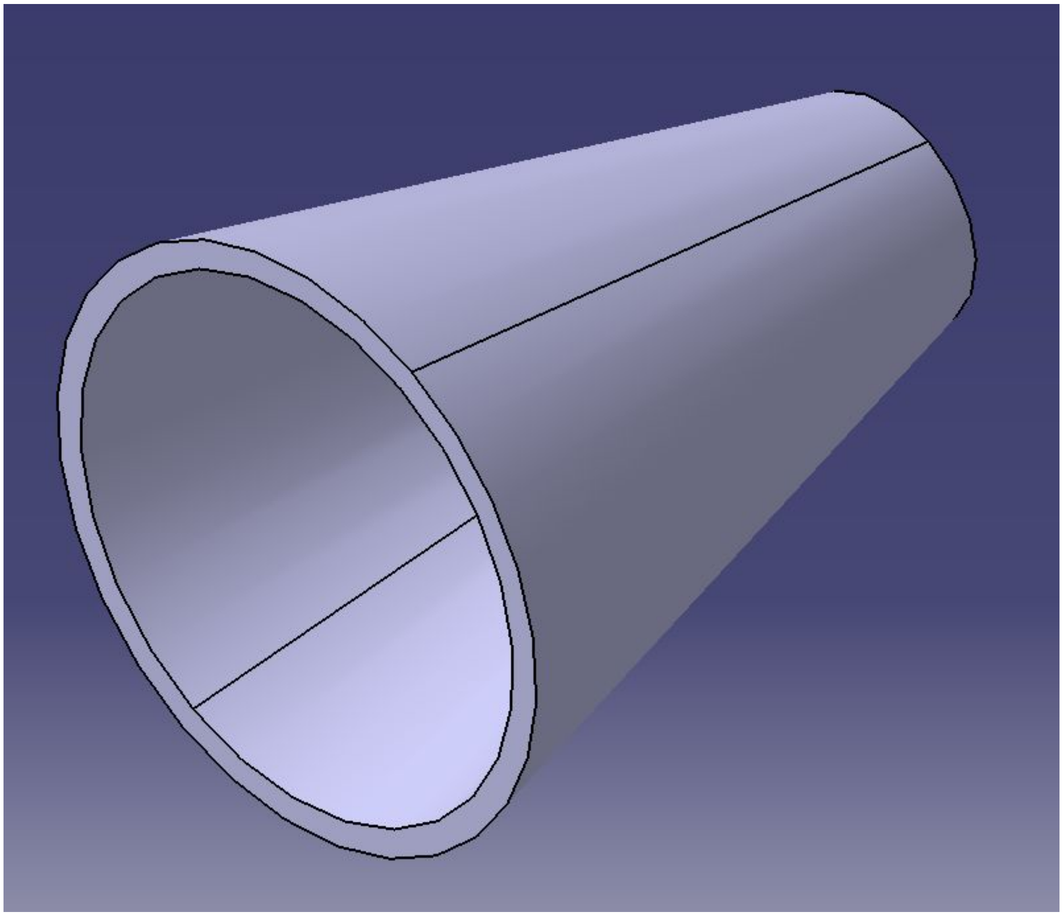
A. Full CAD model Assembly



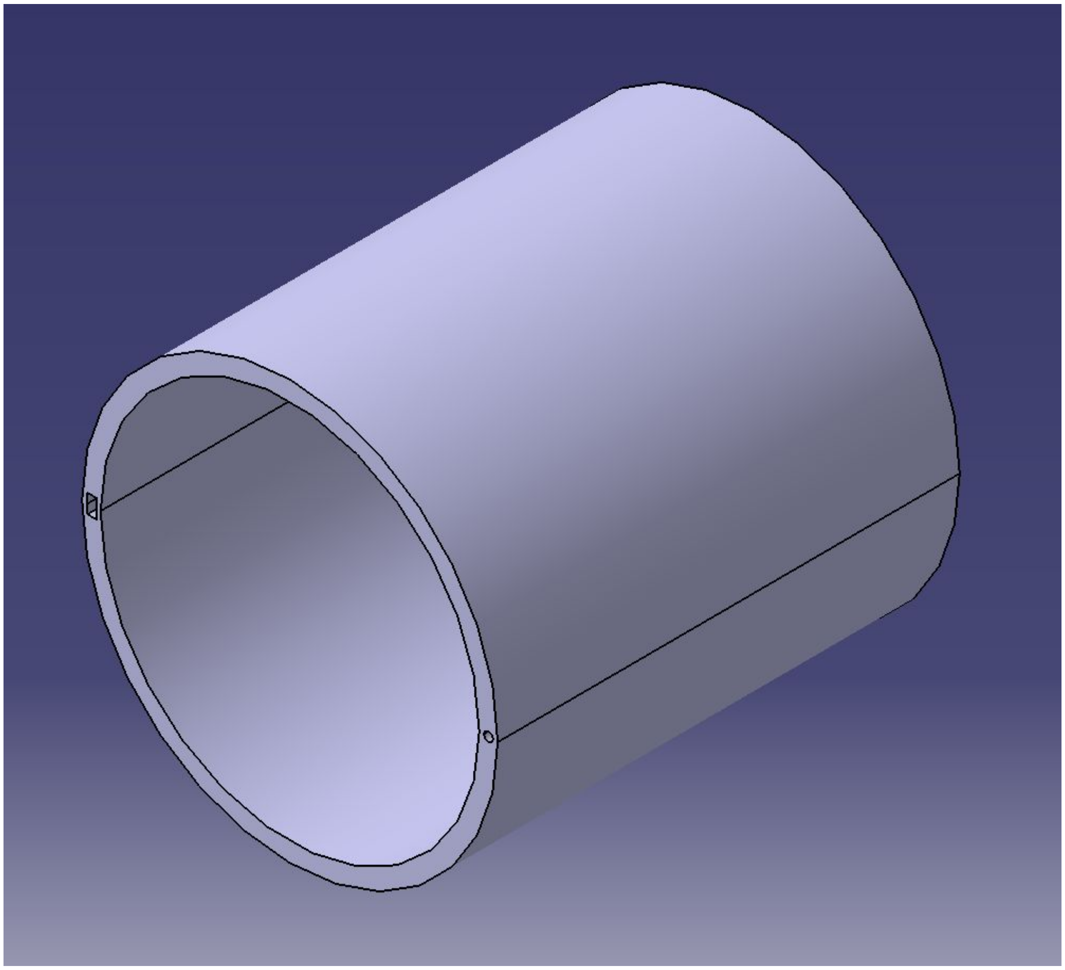
B. Handle CAD model



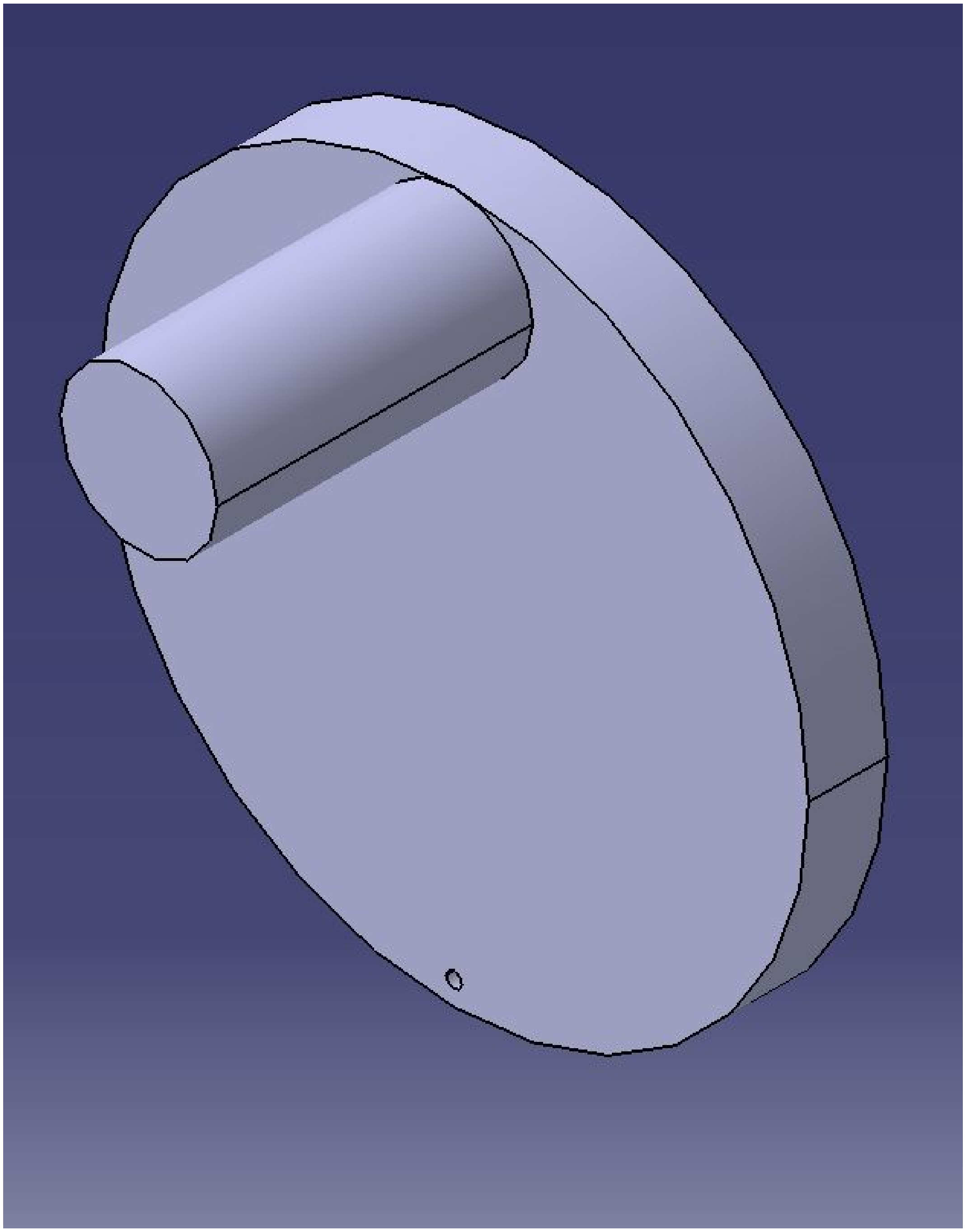
C. Bag CAD model



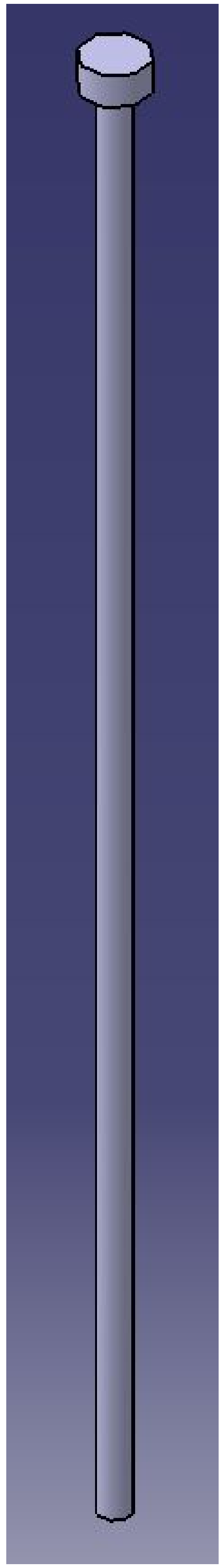
D. Cylinder CAD model



E. Revolving Lid CAD model



F. Pin CAD model



G. Isometric Drawing