Stupra Glacies

Lunar Surface Operations - Lunar Sample Coring Device

ERAU Microgravity Club

Embry-Riddle Aeronautical University, Daytona Beach

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I. Technical Section

A. Abstract

The Lunar Sample Coring Device is uniquely designed to efficiently cut and store a sample of ice or concrete. The proposed coring bit design is inspired by commercially available coring bits, and improved with new ideas. This new design introduces a screw-like bit within the device. The location of this smaller bit will be on the inside, top of the drill bit, entering the core as the core sample reaches the maximum length. This smaller bit will act as an anchor for the sample. When the internal drill bit comes into contact with the core sample it will enter the material, allowing the user to contain it within the Lunar Coring Device. This internal bit is specifically designed to contain the ice or concrete core sample. This Lunar Sample Coring Device operates over a wide range of temperatures and materials, as well as harsh or hazardous environments. The material that will be used to machine the coring device will be Tungsten Carbide. Thanks to its properties, using this material will insure that the drill remains structurally stable while it drills into the concrete. The bit will also have synthetic diamond teeth, which will allow the drill to core into any material in the upper bound of the Mohs Scale of mineral hardness.

B. Design Description

1. Inner Screw

Ice screws are a design feature used by many ice climbers built to withstand extremely cold temperatures along with being able to take up to forces between 8 kN to 12 kN (Warren,10). Ice screws are traditionally hollow because of the advantages it gives to climbers. The inner screw for this design will be similar to an ice screw except it will be solid. This design only requires the physical aspect of an ice screw, such as the helix design, and not the advantages that come from the hollowness of a traditional ice screw. A 1 inch ice screw with a diameter of ¼ inch will be placed within the coring bit. It will be used to slightly drill into the ice to have a firm grip of the ice core samples as they are being extracted. As a safety consideration, the bottom of the screw will be squared off, which is different from a usual ice screw.

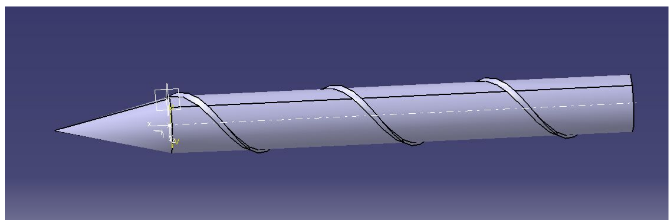

Figure 1: Inner Screw

2. Outer Coring Bit

The outer bit will serve the same purpose as a standard coring bit. The diameter will be 1 ¼ inch in order to obtain a sample of the required size. The material thickness will be ⅛ inch. The material chosen for the outer coring bit is Tungsten Carbide (WC). WC is a chemical compound powder that can be pressed into different shapes. This will allow the WC to be the exact shape and size needed for the outer coring bit. WC can be used to core into ice and rock. A drill called the "Koci Drill" was designed to perform in ice with sand and rock (Green, 105). The drill was first tested in Antarctica in the McMurdo Dry Valleys in the 2006/2007 season, and the drill was able to drill from temperatures ranging from -25 degrees Celsius to -108 degrees Celsius (Green, 105).

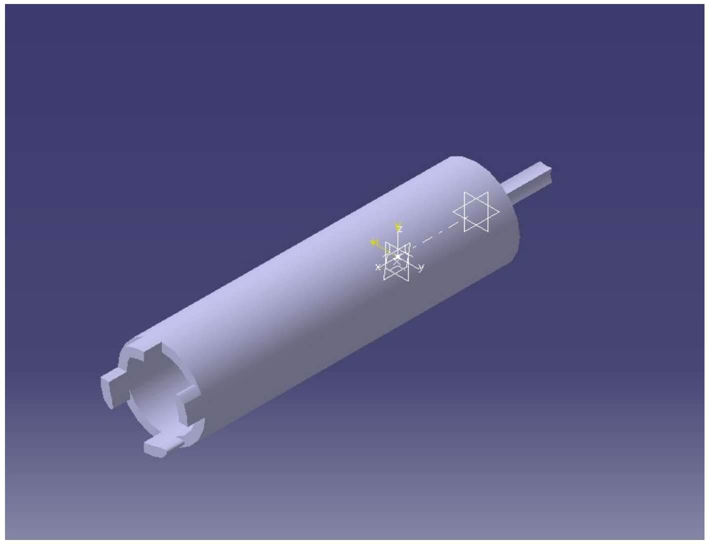

Figure 2: Outer Coring Bit

3. Teeth

The durability of a synthetic diamond tip will be the most beneficial for drilling into concrete and ice. Figure 3, Mohs Hardness Scale, provides a range of materials and their hardnesses. An increase in hardness leads to a decrease in drilling speed, but the diamonds will fit all the other needs of the design (Hoseinie, et al. 1455). The synthetic diamond teeth of the Lunar Sample Coring Device will allow the device to core into ice and or concrete with ease and without being damaged.

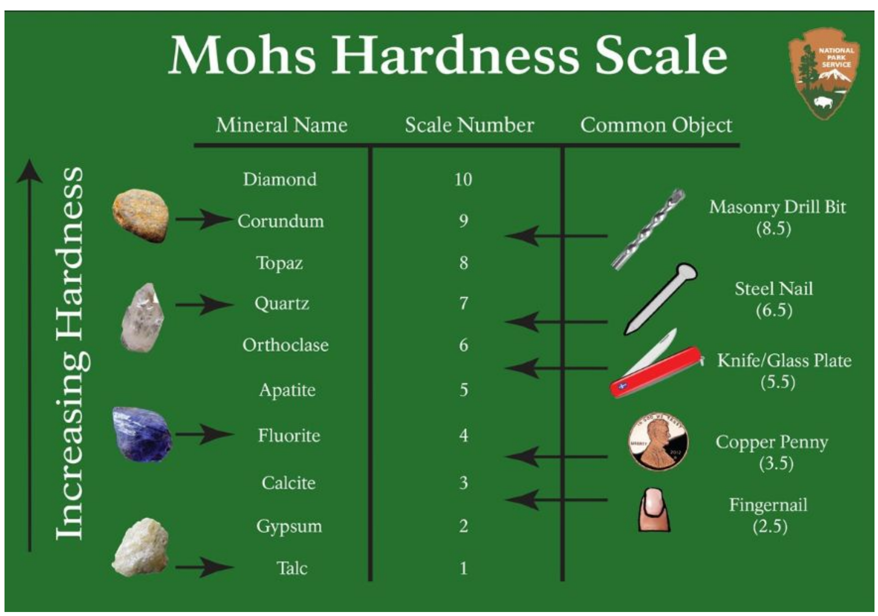

Figure 3: Mohs Hardness Scale (U.S. National Park Service).

4. Stabilizing Jig

The purpose of the stabilizing jig is to allow the astronaut full control of the stability of the drill while coring. The stabilizing jig consists of a large, telescoping casing and a spring. The spring is to provide a small amount of resistance, keeping the drill from wobbling, while remaining weak enough to allow the astronaut to push the drill further inward. As the coring bit travels further into the material, the spring-enforced stabilizing jig will retract enough to allow the full length of the bit to enter the material. Once the coring bit is removed, the jig will expand back into place, at rest. The stabilizing jig will continue to operate with each individual usage of the bit, without requiring replacement.

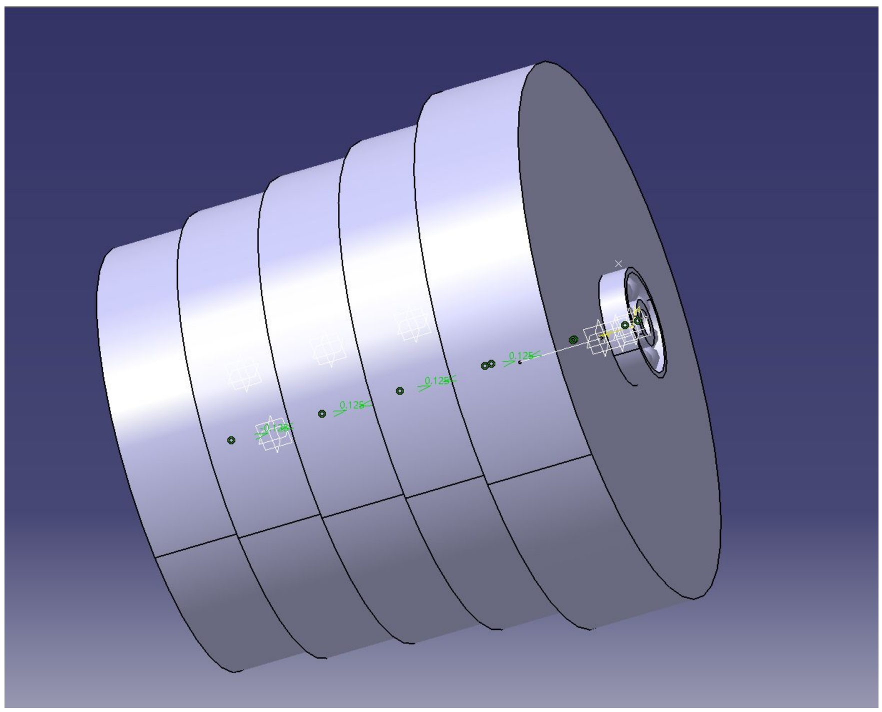

Figure 4: Extended Stabilizing Jig

5. Spring

The spring will provide support and stability to the drill while coring. The spring's purpose is to prevent wobbling. The spring will be weak enough to allow the astronaut to push the coring bit entirely into the material.

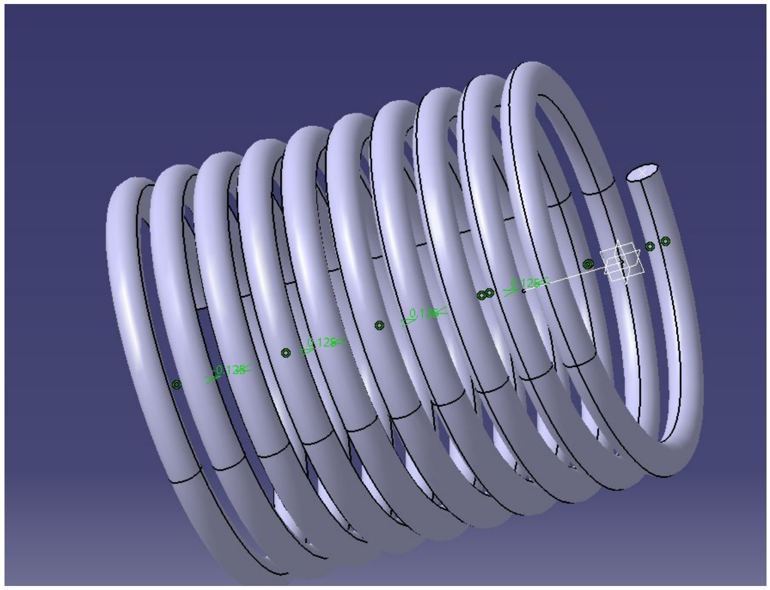

Figure 5: Internal Spring for Stabilizing Jig

6. Telescoping Spring Casing

The casing has been designed to telescope and collapse as the spring is compressed. The spring casing ensures that the spring does not buckle or become lodged with dirt. The flat end of the casing will come in direct contact with the material during coring.

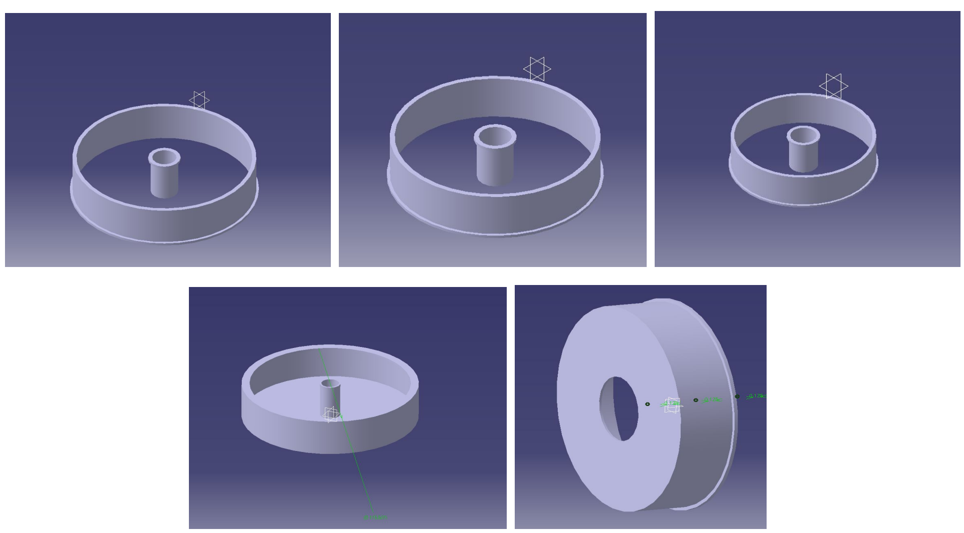

Figure 6: Telescoping Spring Casing for the Stabilizing Jig

7. Ball Bearing

The ball bearing will allow the stabilizing rig to rotate freely of the coring bit. This will allow the stabilizing rig to stay in place and prevent wobbling while the drilling is in process.

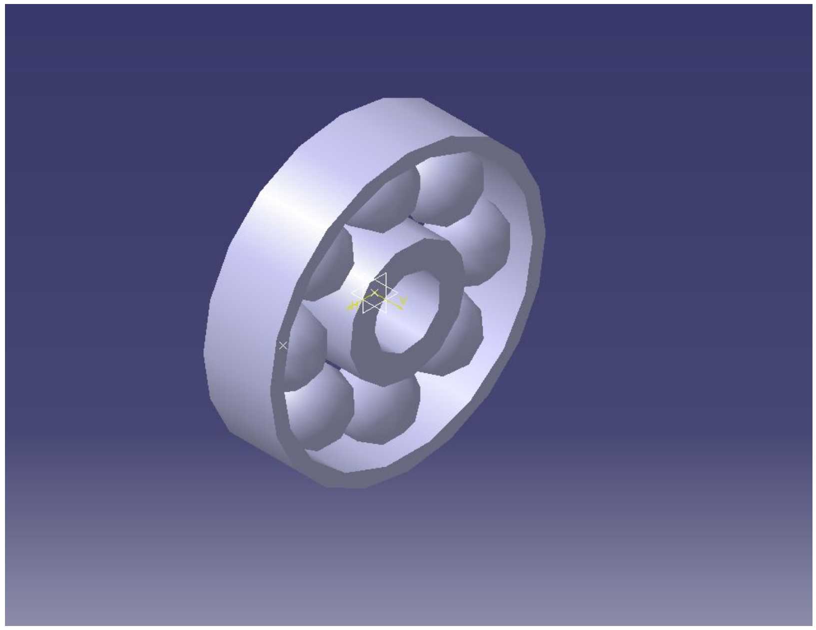

Figure 7: Ball Bearing for the Stabilizing Jig

8. Plate

The plate will be directly attached to the ball bearing and rotate with it. The plate will provide a base for the stabilizing jig. The stabilizing jig will be permanently attached to the plate and will retract up to the plate while coring.

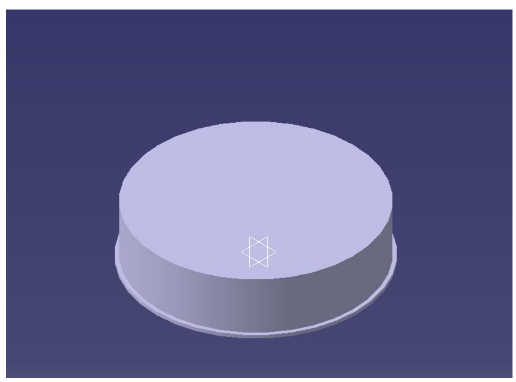

Figure 8: The Plate Base for the Stabilizing Jig

C. Manufacturing Plan

For the coring bit, a C2 Multigrain Carbide blank will be ordered from Zoro Tools. The manufacturing of the coring bit will be partially outsourced and partially completed on the ERAU Daytona Beach campus. Regarding the internal screw, a Water Hard Drill Rod will be ordered from Grainger. The screw will be manufactured on campus. For the JIG casing, a 16-Gauge Steel sheet will be acquired from Home Depot. The JIG itself will be manufactured on campus. Regarding the bearing, a S1602-2RS Stainless Steel Ball Bearing will be manufactured and ordered from Bearings Direct. For the spring utilized in the telescoping case, 15-Gauge music wire will be ordered from MSC. The Spring will be manufactured on campus. The complete device will be assembled and constructed on campus once all the parts are acquired.

D. Finite Element Analysis

FEA software allows for real world forces to be applied to a product and then simulate how the product deforms. This analysis helps to ensure the product is structurally sound before physical manufacturing takes place. In order to see how the core sampling device would respond under axial compression, torsional loading and tension, CATIA FEA software was utilized. Torsional loading and compression were applied first to the outer coring bit. Two torsional loads of 25 and 100 Newton-Meters were applied, then two compressional loads of 50 and 150 Newtons were applied.

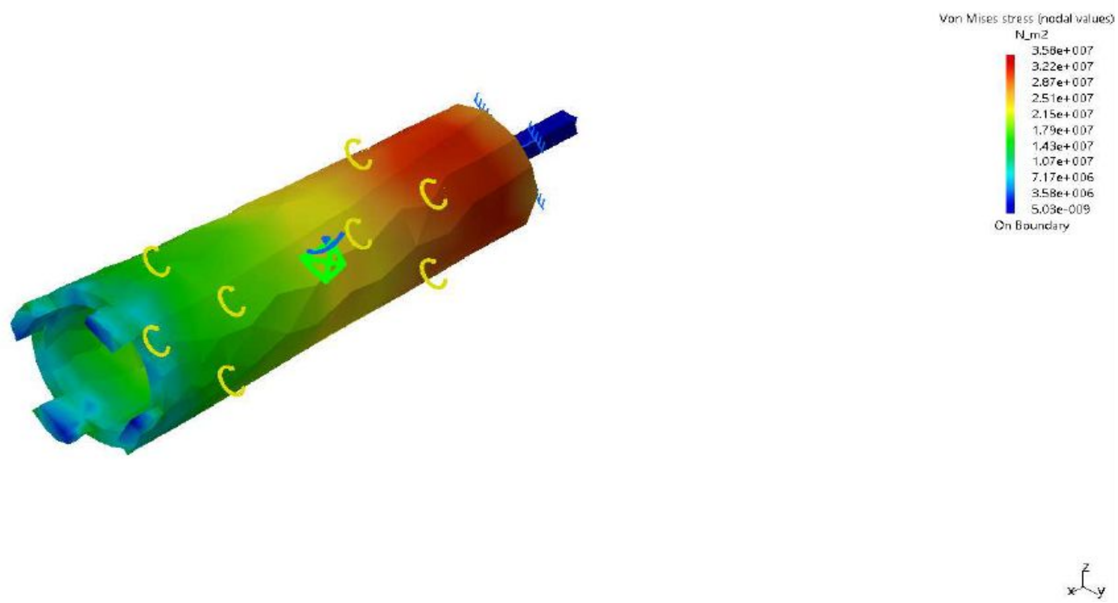

Figure 9: Coring Bit Experiencing 100 Nm Torque

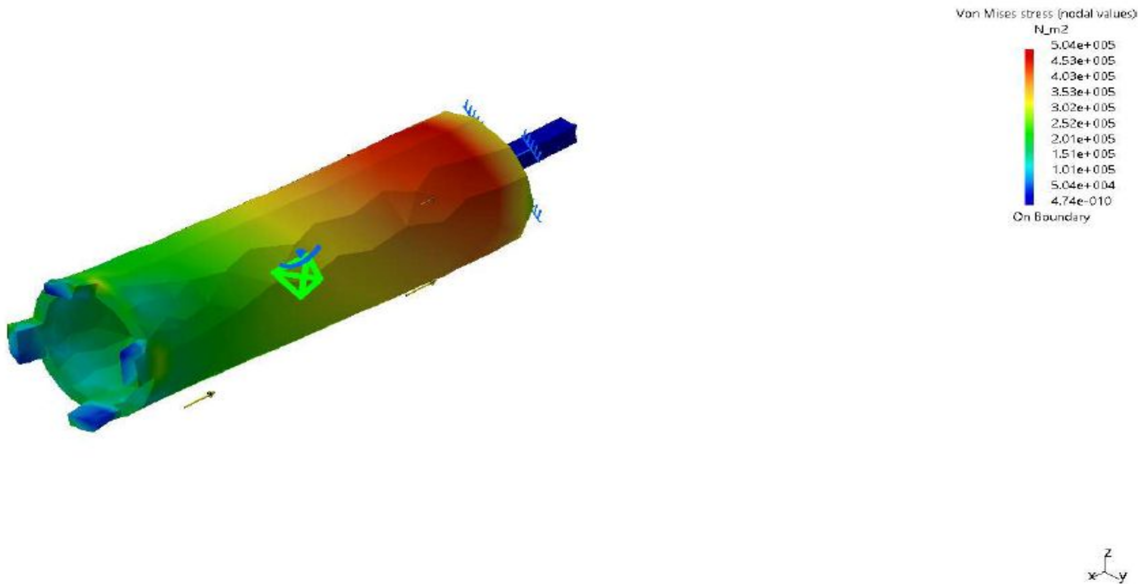

Figure 10: Coring Bit Experiencing 150 N Compressional Loading, Highest Stress at 5.04e5 Nm^2

As shown in Figure 9, the highest stress experienced was 3.58e7 N/m^2 at the rear end of the bit while it underwent 100 Nm of torsional loading. Using the torque applied, tungsten carbide properties, average RPM of 2545 (for a 1 ¼ inch bit), and the dimensions of the outer coring bit, the max shear was calculated to be 3.77e7 N/m^2(*CESSCO).* While under compressional loading, the max stress was 5.04e5 N/m^2. According to the material property data sheet of Tungsten Carbide, its yield compression strength is 1.404e9 (*AZO,1)*. The max stresses seen in the analysis are both under the yield values. Overall, the coring bit remained structurally sound after experiencing 100 Nm of torsional load and up to 150 Newtons of compressional load; it did not critically deform. The analysis of the other two loads can be found in section A of the appendix. Next, the diamond tip screw underwent a torsional loading of 100 Nm and compressional loadings of 100 N and 8 kN.

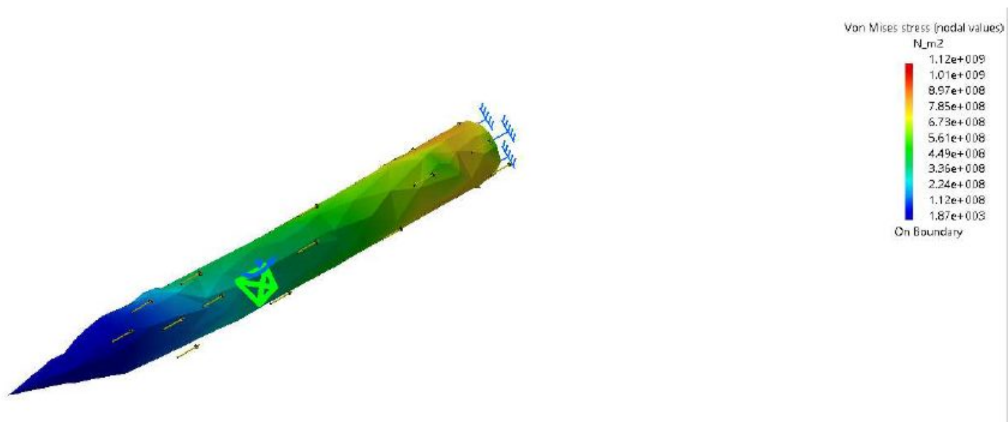

Figure 11: Inner Screw Experiencing 8kN of Compressional Force, Highest Stress at 1.12e9 N/m^2

As can be seen from the image above, the inner screw was able to withstand up to 8kN of compressional load without deforming; this verifies the ice screw properties the design was based from. The torsional load analysis and other compressonal load analysis can be found in Part A of the appendix. These parts are the most critical in the overall design as they will be extracting and containing the sample, so it is important they do not fail. This analysis demonstrates that the material chosen will be able to handle the intended forces applied.

E. 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	Requirement Description	Compliance Statement
1	The device shall be able to collect cylindrical core samples 0.5″ diameter and 3″ deep from concrete or ice.	The coring bit has been designed to be slightly larger than these dimensions to compensate for melting and chipping, allowing for the required sample size to remain intact. The inside of the coring bit is 1′′ by 4.5′′.
2	The device shall not extend beyond the plane of the drill chuck toward the diver (all components must be below the drill chuck).	The entirety of the coring bit extends out and away from the drill chuck, including the stabilizing jig.
3	The device shall mechanically interface with a 13mm (0.512″) drill chuck.	The coring bit has a 12.7 mm (0.5″) diameter.
4	The device shall not be externally powered or pressurized.	The device is entirely mechanical, including the coring bit and stabilizing jig. The only power input will be from the drill itself.
5	The device shall drill a core, capture the core, and contain the core when the drill is removed from the sample target.	The device has been modeled after modern coring bits to ensure a proper cut into the material. It is designed to grab and hold the sample with the internal bit.
6	The device (all parts, in stowed configuration) shall fit within a 6″ diameter x 6″ long cylinder.	The entire device has a length of 6″ and a maximum diameter of 5″.
7	The device (all parts) shall operate underwater.	There are no parts of this drill that require waterproofing. All components will work in an atmosphere, a vacuum, or underwater.
8	The device (all parts) shall have a dry weight less than 3 lbs.	The whole device will be just under 3 lbs. The casing can be made of plastic or sheet metal,

		depending on the weight of the bit.
9	The device shall be compatible with a chlorine water and a salt-water environment.	Chlorine and salt have a negligible effect on the materials used in the device
10	The device shall operate within an environment from 23 °F to 86 °F (-5 °C to 30 °C).	The device will be able to operate able to operate within an environment from -5 °C to 30 °C.

F. Operations Plan

1. Preliminary Testing Operations Plan

The preliminary testing of the device will take place at the Embry-Riddle Aeronautical University gym pool to simulate the Neutral Buoyancy Lab (NBL) in Houston, TX. A block of concrete and a separate block of ice will be weighted to the bottom of the pool in order to drill into them safely and accurately. This will enable the stabilizer and the coring bit to be tested underwater on both concrete and ice to make sure that the design fits is able to satisfy everything asked of the design.

2. Testing Objectives

a) The drill bit will obtain a three-inch core sample with a diameter of half of an inch from a given block of ice or concrete from NASA.
b) The coring device will be attached to a 13 mm drill chuck that will be given when at the testing site by NASA.
c) The drill bit will begin drilling into the given sample.
d) As the drill bit continues drilling, at a length of 3 inches the screw inside the bit will attach to the core sample to make storing and removing the core easier.
e) Once the coring device reaches the maximum length of 4.5 inches, the drilling will stop by the user.
f) The user then will pull the coring bit out with the ice/concrete core stored inside the bit.

3. Test Plan

The testing of the Lunar Sample Coring Device will take place at the NASA Johnson Space Center NBL. The coring device will be given to the user in which they will place it into the NEMO underwater drill. The user then will begin drilling into a block of ice or concrete. When the drill reaches a depth of 3 inches the internal screw will attach itself to the core sample. This will help the extraction as well as storing of the core. Once the drill bit reaches the maximum length of 4.5 inches the user will stop drilling. The user then will pull the coring bit out of the ground which will contain the core sample. The sample then will be removed from the device and then will be analyzed if the testing was a success or failure.

4. Test Procedures

a) *Test preparation phase*

(1) Remove the Lunar Sample Coring Device from the container.
(2) Give the coring bit to a certified NASA diver (user).
(3) The user then will attach the bit to any existing drill via the chuck.

b) *Test Execution Phase*

(1) Once the bit is secured in the drill the test can begin.
(2) The user will apply pressure downwards into what they are drilling.
(3) The user will constantly apply this downforce as they are drilling.
(4) The test is complete once the whole bit is inside the given block.
(5) After this, the user will pull the coring device out of the block with the core sample inside the bit.

G. Safety

1. Inner Ice Screw

The inner screw that keeps hold of the sample will have slightly sharper edges compared to the outer ice screw of the drill. To prevent any pinching of the astronaut's suit the inner screw will be melded with the coring bit instead of attached lowering the risk of the screw detaching in any situation.

2. Temperature Sample

The sample and device are safe to handle at all times, being able to operate within an environment from -5 °C to 30 °C.

3. Environmental Safety

Tungsten Carbide when exposed to water will not oxidize after prolonged exposure, according to an experiment by the Chalmers University of Technology. According to the Safety Data Sheet for WC the material is insoluble, meaning the device will be able to last in water for a long enough period of time (*General Carbide,* 5).

H. Technical References

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Warren, Bennett and Alziati, Stefano. “Simulating and Testing Ice Screw Performance in the Laboratory.” *Massachusetts Institution of Technology.* https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-622-experimental-projects-ii-fall-2003/projects/alziati_bennett.pdf

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' outreach. This group includes students at local elementary and high schools. The local middle school that we will be pairing with is Silver Sands Middle School, which is located in Port Orange, Florida. Specifically, we will be working with their fifth grade students. The goal of the outreach to the fifth grade students at Silver Sands Middle School 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 the 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 sixth grade teams Silver Sands School which will require them to use basic materials to craft a bottle rocket. The goal of the competition will be to see which rocket goes the highest (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 rocket, such that they will have a better understanding of the processes used in the design and development of real rocket, while also getting to have a hands-on arts and crafts activity. While learning about the uses and construction of rockets, the students will also learn more about space travel as a whole, thus tying into the Micro-G NExT Lunar Sample Coring Device (Challenge 5), as by their nature, rockets are useful for getting the astronauts to the Moon to conduct their experiments. In addition, this activity ties into the Florida 6th grade science curriculum standards of "exploring the law of gravity," as rockets and space travel are both very much affected by this law. Learning about ways that gravity interacts with rockets will supplement and build upon the knowledge they've been learning throughout their sixth grade year.

To conduct this activity, the 5E model (Engage, Explore, Explain, Elaborate, and Evaluate) will be applied to create the following lesson plan:

a) Engage: Students will listen and participate in a presentation about rockets and how they are used and made.

b) *Explore:* The students will identify and develop knowledge of the various properties of rockets through their construction of their bottle rockets
c) *Explain:* The students will build their bottle rockets and will be able to successfully demonstrate their understanding of the properties of rockets by discussing their designs.
d) *Elaborate:* The students will learn more about gravity's effect on rockets and the emergency procedures involved in the use of rockets.
e) *Evaluate:* The students will demonstrate their understanding of rockets and gravity by being able to discuss what they have learned through some basic closing questions.

The required materials and procedures for this project are listed below. All materials will be obtained using the club's budget, which is detailed in Table 4.

a) *Materials:*
   Water bottles, bicycle pump, scrap cardboard

b) *Procedures:*
   (1) Use the materials provided to design and build a bottle rocket.
   (2) Compete to see who's rocket can reach the highest.
   (3) Discuss the properties of the rockets, gravity, and emergency procedures and what worked and what did not.

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 April 2020. At both of these events, the Microgravity Club will be showcasing their designs 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.

B. 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.

C. Communication Logs

Contacts: Lynn Bartholomew, Principal's Secretary
ljbartho@volusia.k12.fl.us

Communication Logs:

I conducted a phone conversation with the principal's secretary, Lynn Bartholomew, and she has copied me into an email to their STEM director, which is illustrated in the image below.

Bartholomew, Lynn J. <ljbartho@volusia.k12.fl.us>
Wed 10/30/2019 7:16 AM
Mosteller, Zachary J.; Alligood, Kevin G. <KGALLIGO@volusia.k12.fl.us>

Zach Mostellzer will be calling you about an opportunity for STEM outreach from their Club.

Lynn Bartholomew
Principal's Secretary
Silver Sands Middle School
1300 Herbert Street
Port Orange FL 32129
ljbartho@volusia.k12.fl.us
Phone: 386-322-6175, ext. 36422
Fax: 386-506-5042

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 "Lunar Sample Coring 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

D. Statement of Supervising Faculty

EMBRY-RIDDLE
Aeronautical University
DAYTONA BEACH, FLORIDA

Department of
Mechanical Engineering

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

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 "Surface Autonomous Vehicle for Emergency Rescue (SAVER)" 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 "Stupra Glacies" 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 "Stupra Glacies" proposed by a team of undergraduate students from Embry-Riddle Aeronautical University, I will and hereby do grant the U.S. Government a nonexclusive, non transferable, 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

Arjun Chugh – Challenge Lead

Krishna Patel – Member

Norma Nelson – Member

Michael Partridge – Member

Gianna Distefano – Member

Daniella Rios Romero – Member

Jayaprakash B Shivakumar – 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				
Round Blank Sheet Metal Water Drill Rod Ball Bearings Stainless Wire	Link Link Link Link Link	1 3 1 1 1	\$382.60 \$7.45 \$11.50 \$8.20 \$20.33	\$382.60 \$22.35 \$11.50 \$8.20 \$20.33
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				**\$5,904.98**

G. Parental Consent Forms

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

IV. Appendix I

A. Finite Element Analysis

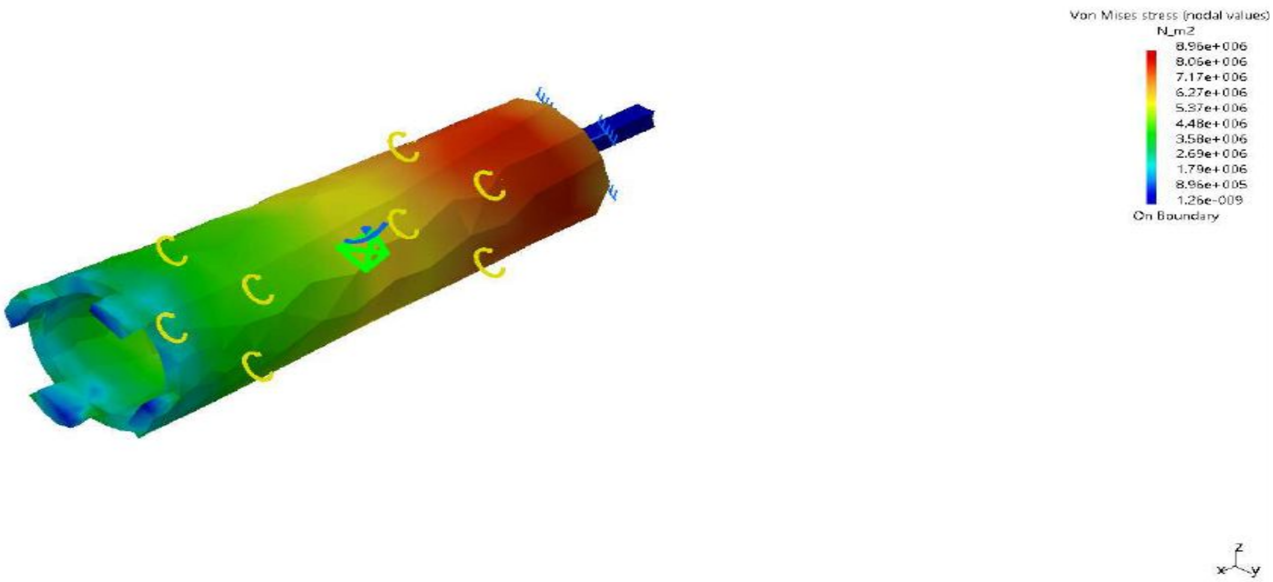


Figure 12: Coring Bit Experiencing 25 Nm Torque, Highest Stress at 8.96e6 N/m²

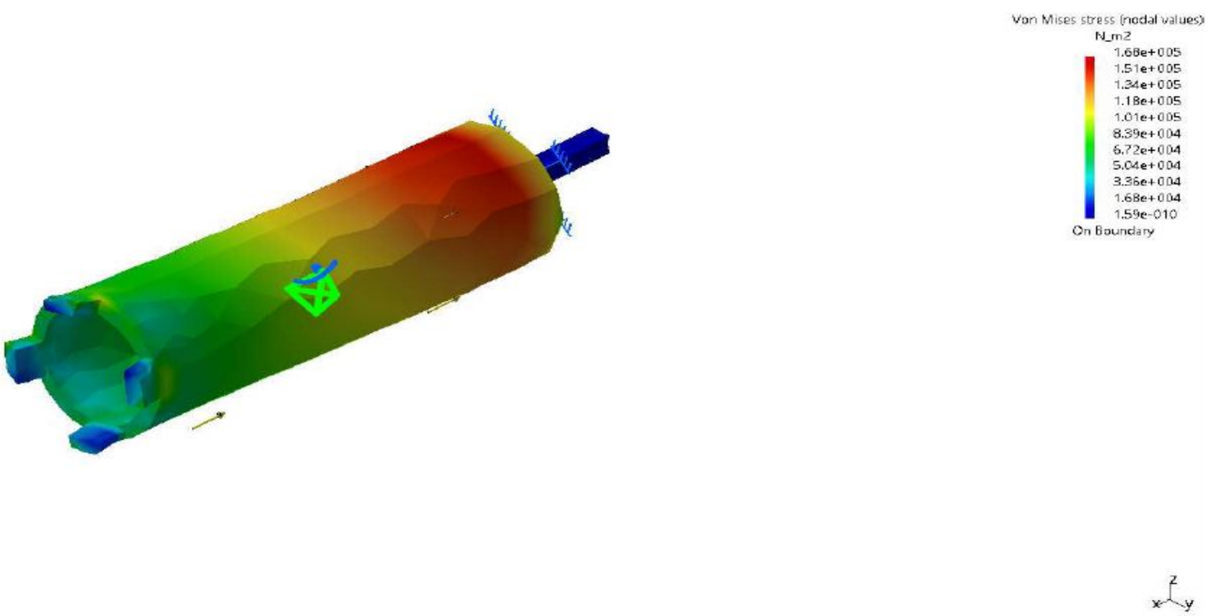


Figure 13: Coring Bit Experiencing 50 N Compressional Loading, Highest Stress at 1.68e5 N/m²

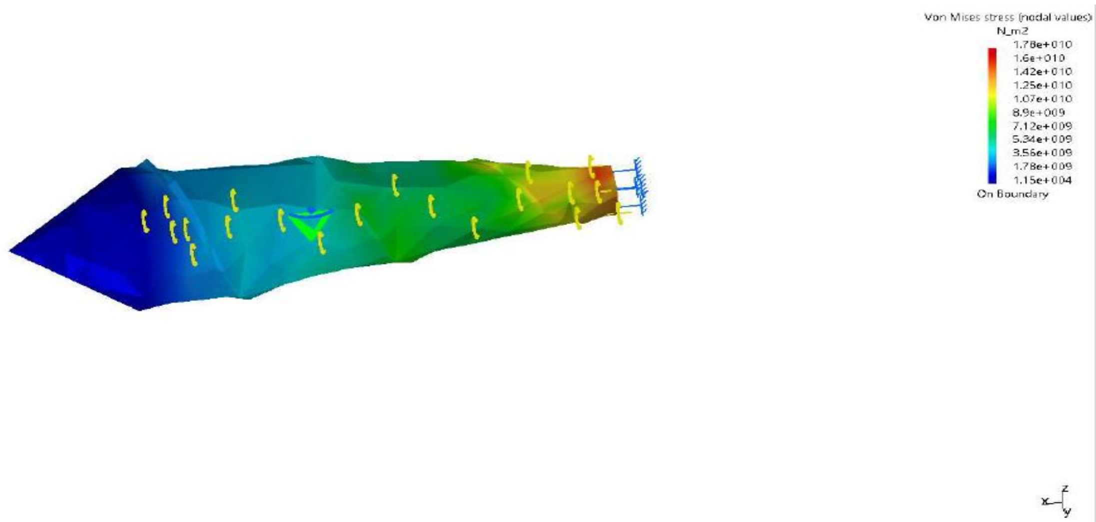


Figure 14: Inner Screw Experiencing 100 Nm Torsional Loading, Highest Stress at 1.78e10 N/m^2

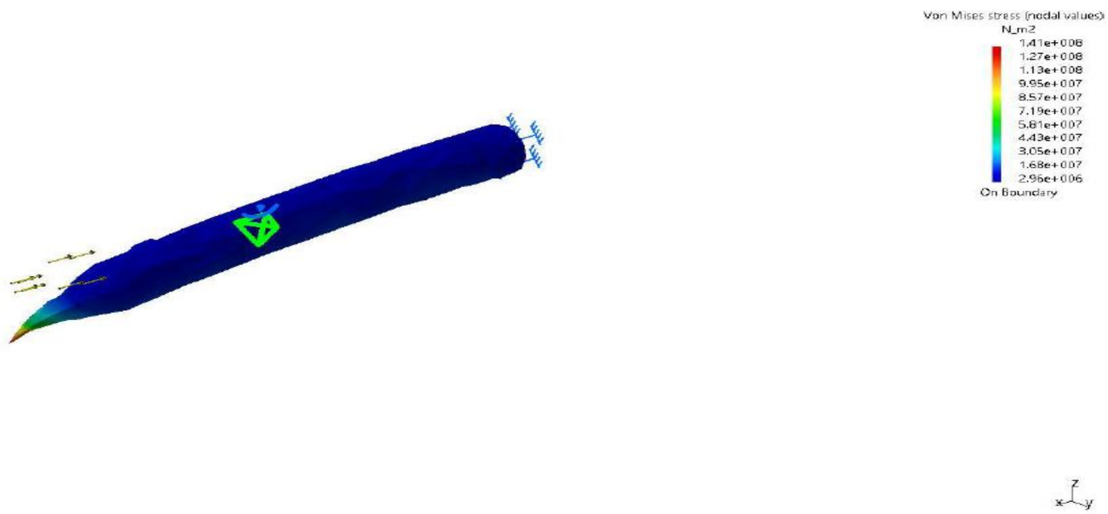
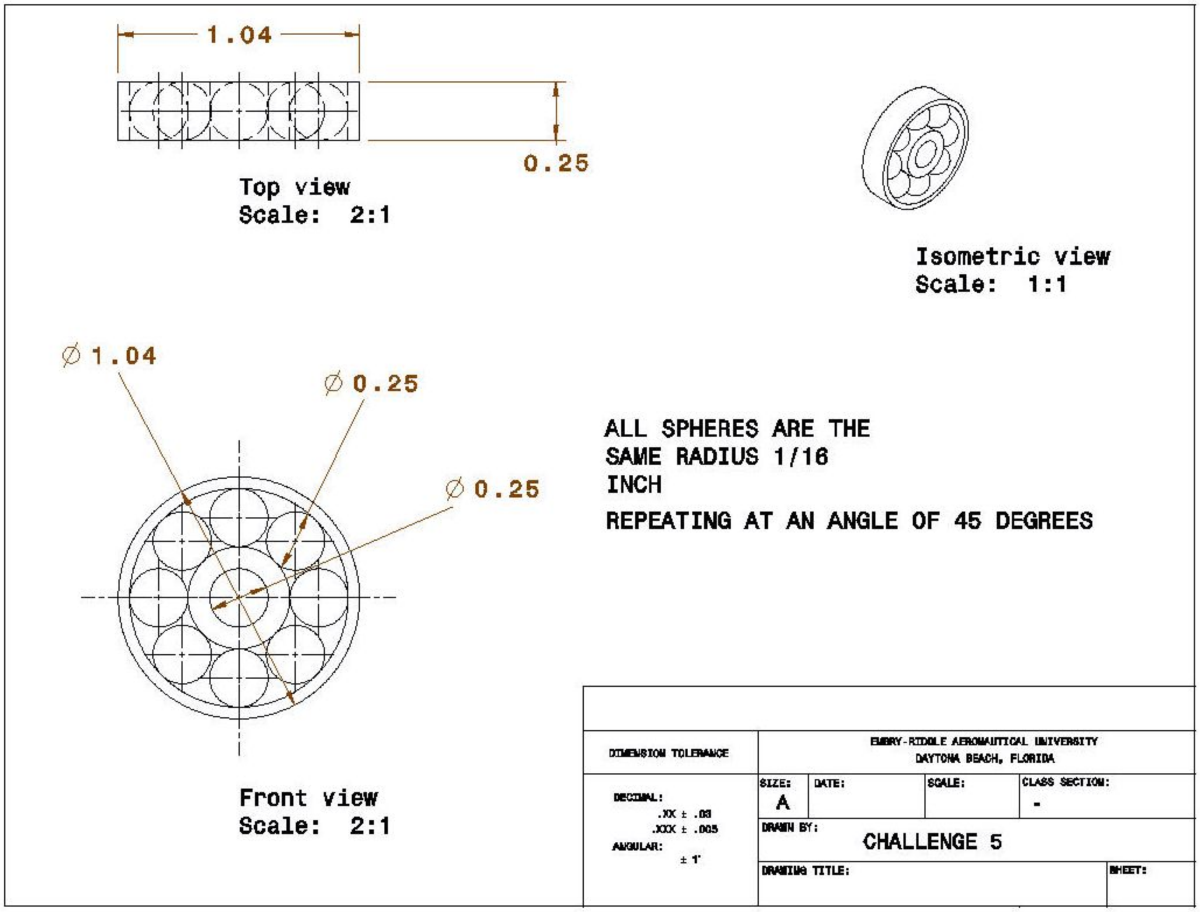
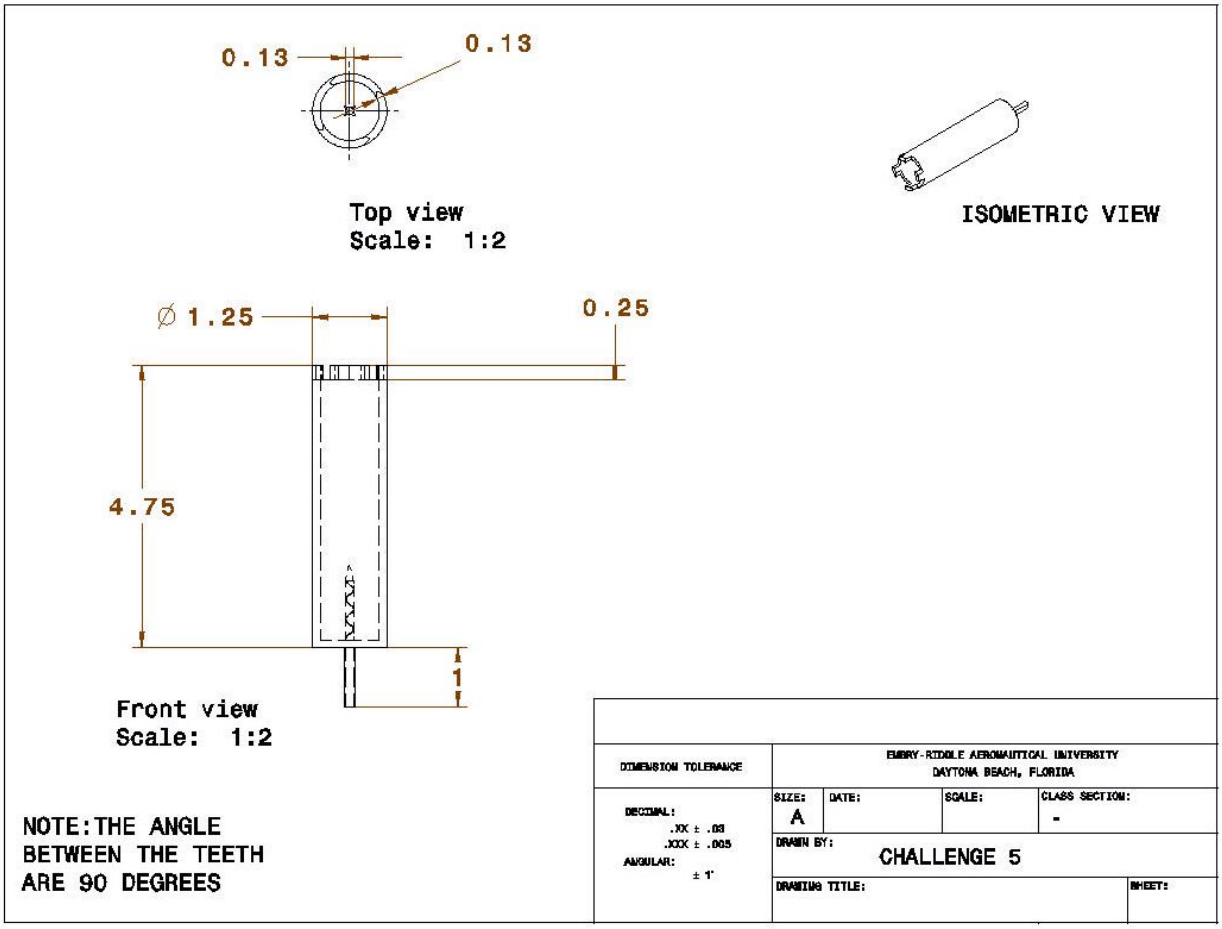


Figure 15: Inner Screw Experiencing 100 N Compressonal Loading on Tip, Highest Stress at 1.41e8 N/m^2

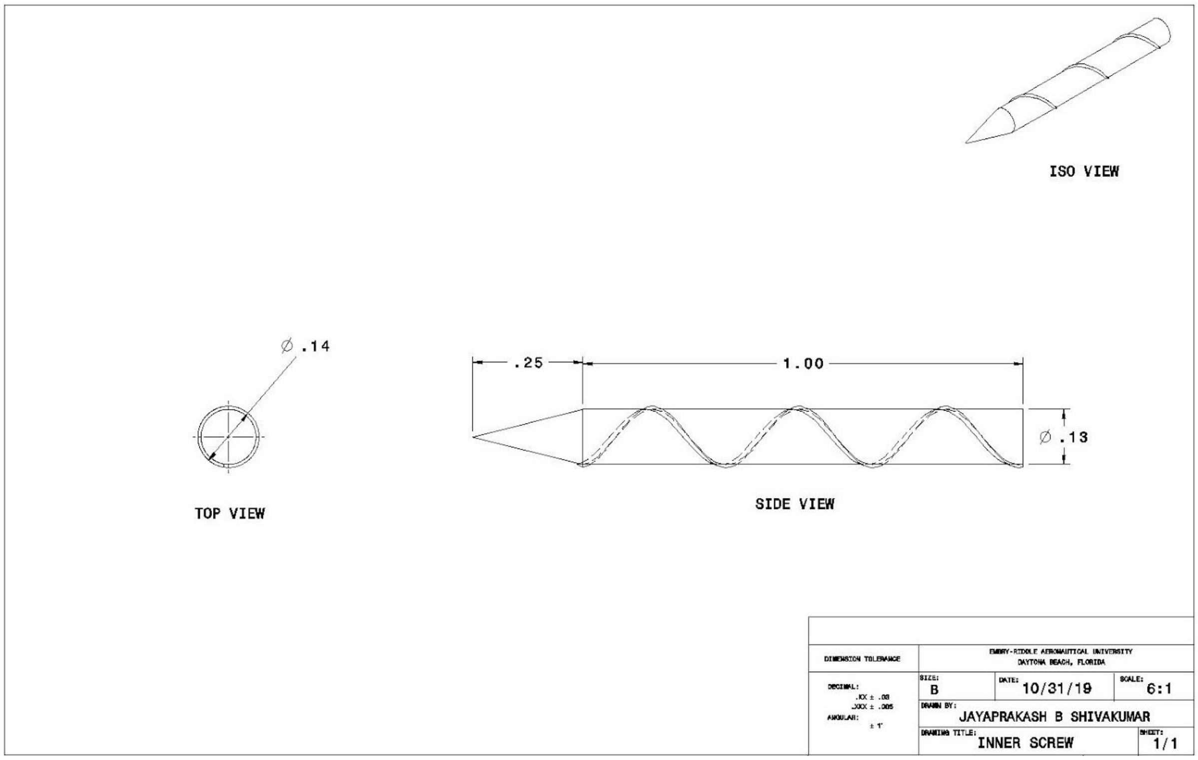
B. Ball Bearing CATIA Drawing (Inches)



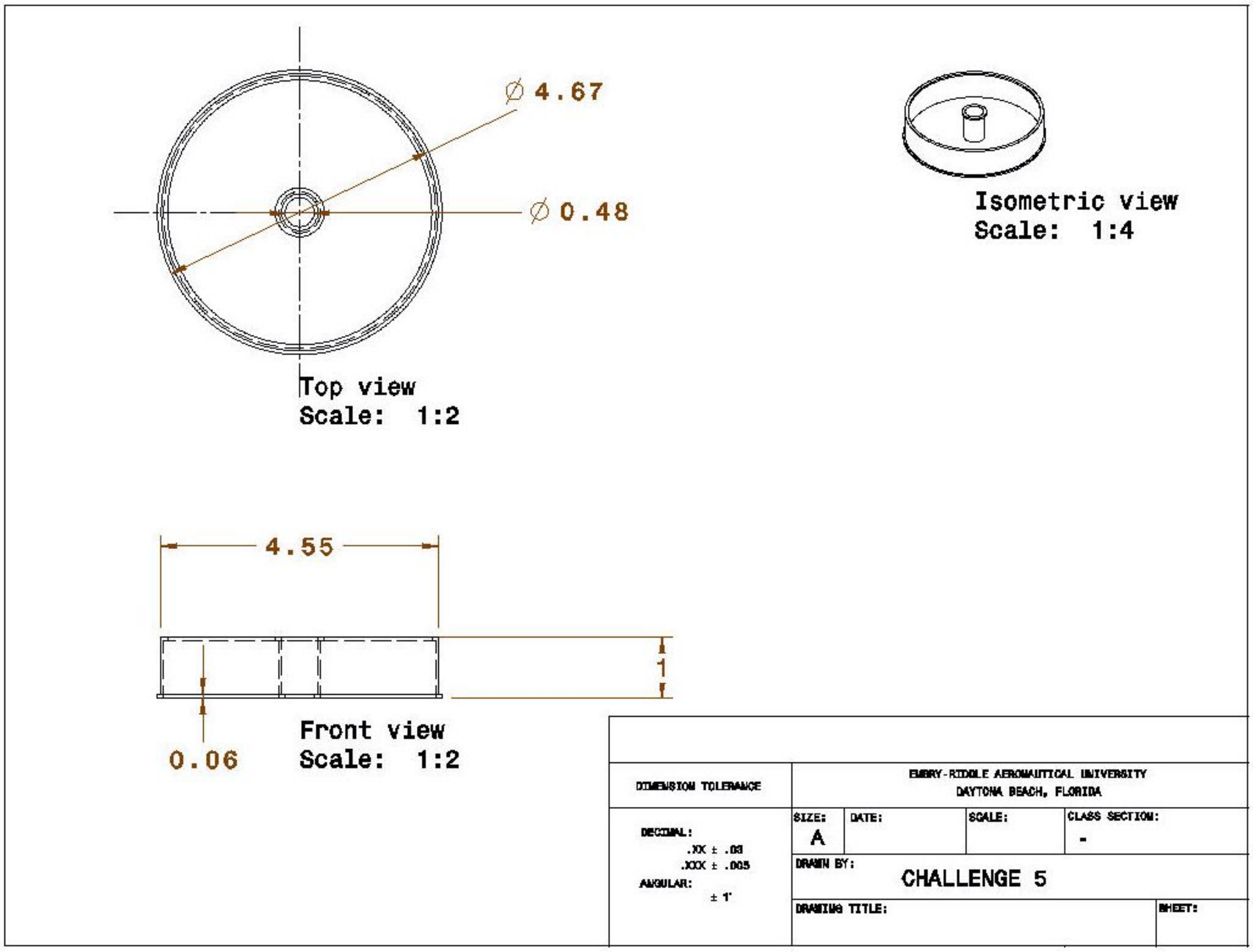
C. Coring Bit CATIA Drawing (Inches)



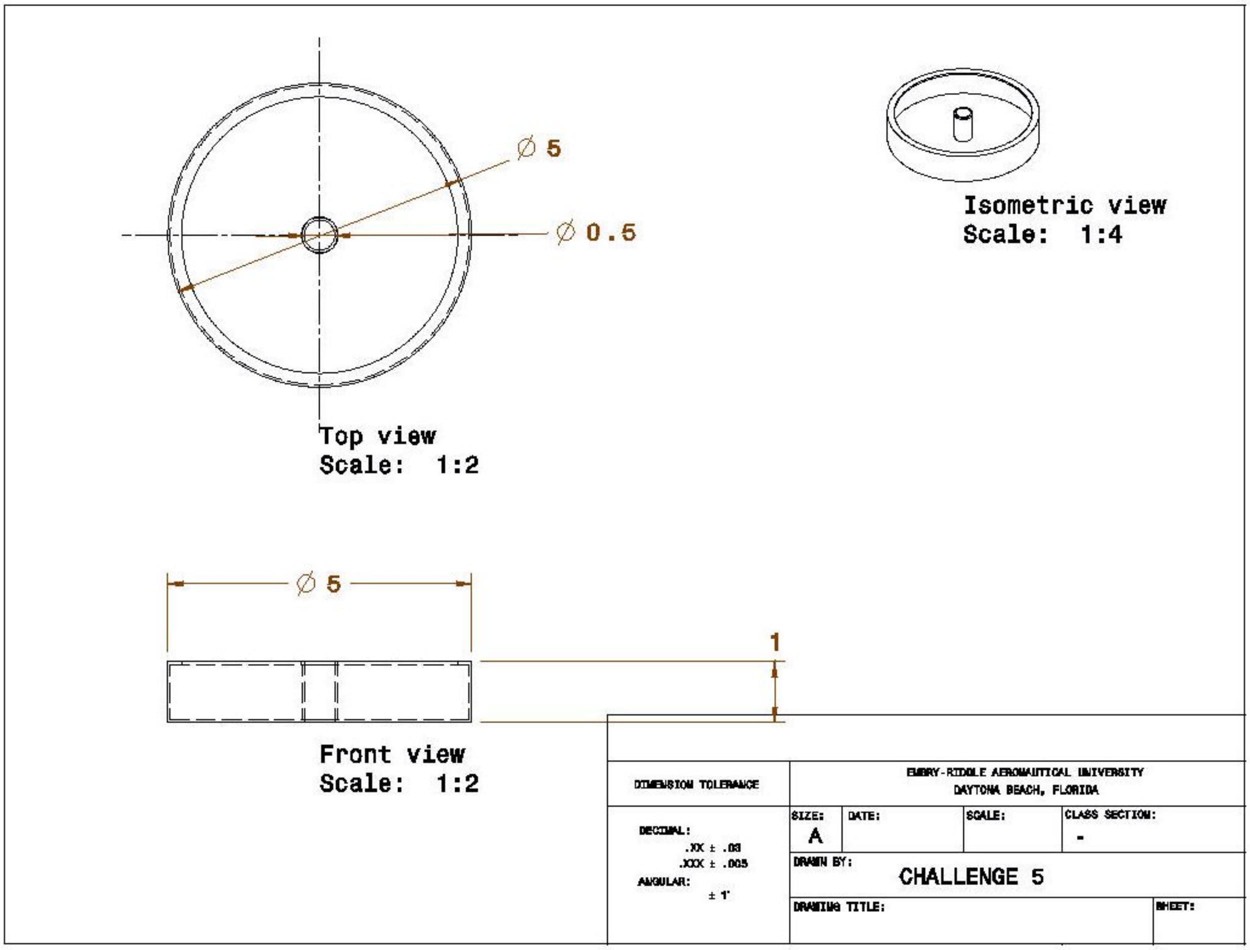
D. Inner Screw CATIA Drawing (Inches)



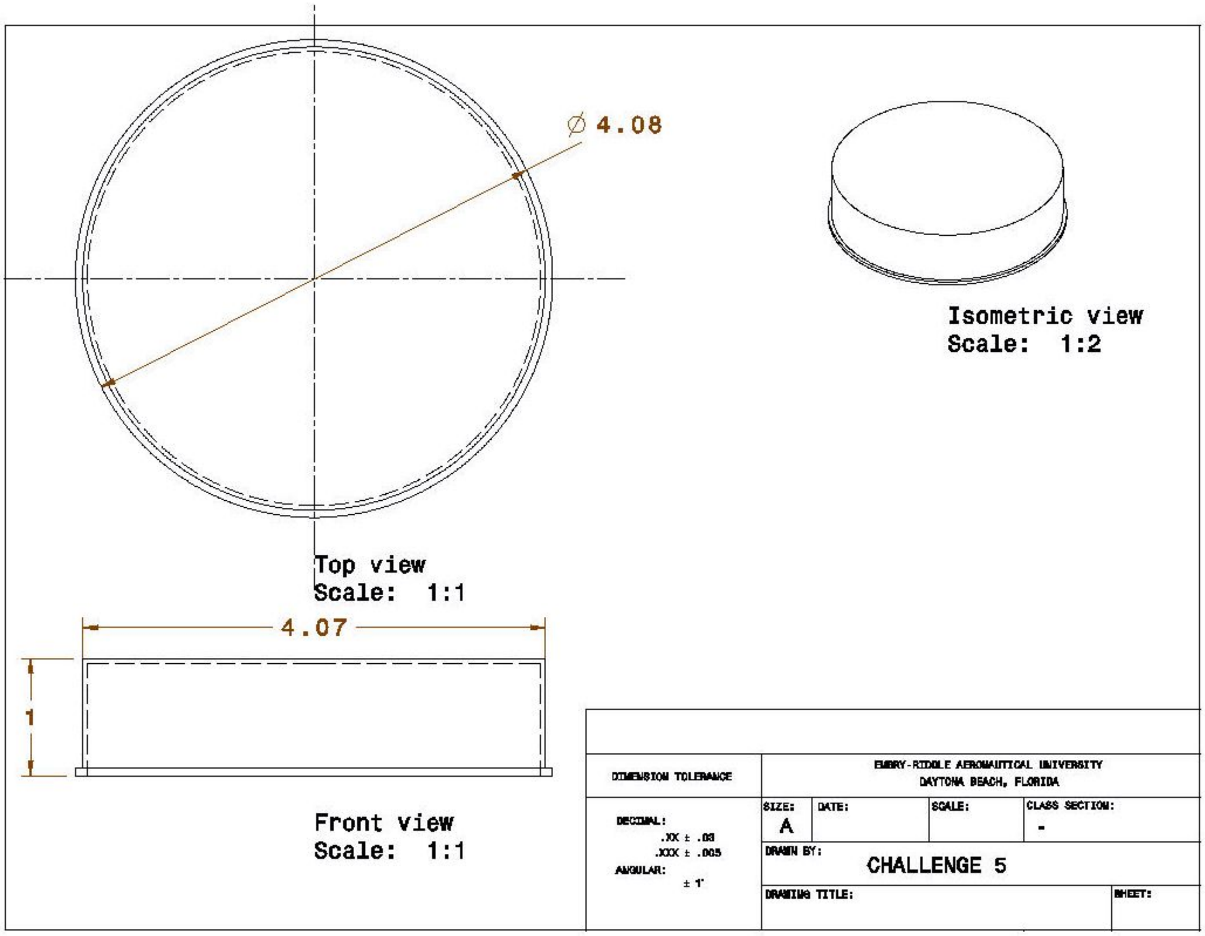
E. Middle Telescope CATIA Drawing (Inches)



F. Telescope Top Level CATIA Drawing (Inches)



G. Telescope Bottom (Inches)



H. Gantt Chart