

Lunar Regolith Extruder

Warren Technical Center
Instructor: Nate Olsen
Group Members: Cole Bickell, Josh Kampe, Brody McGrath

Project Background
Lunar Habitats require level ground and a solid foundation. Materials such as bricks and wood are too heavy to transport to space for this purpose.

Solution
By mixing leftover/extra plastic packaging and lunar soil in a high temperature chamber, we are able to produce small foundation bricks.

Goals/Constraints

- Produce 100 1x1x5in bricks per 24 hours
- Create our own input with filtering system

Project Info
Calculations for Auger Temp. @ 400°C solar surface area.

Materials Used

- Modeling ABS
- Aluminum Piping
- 12V Motors
- Blending Motors
- Various Circuitry Components

Mixing Chamber Outlet

Material Feed System Expanded

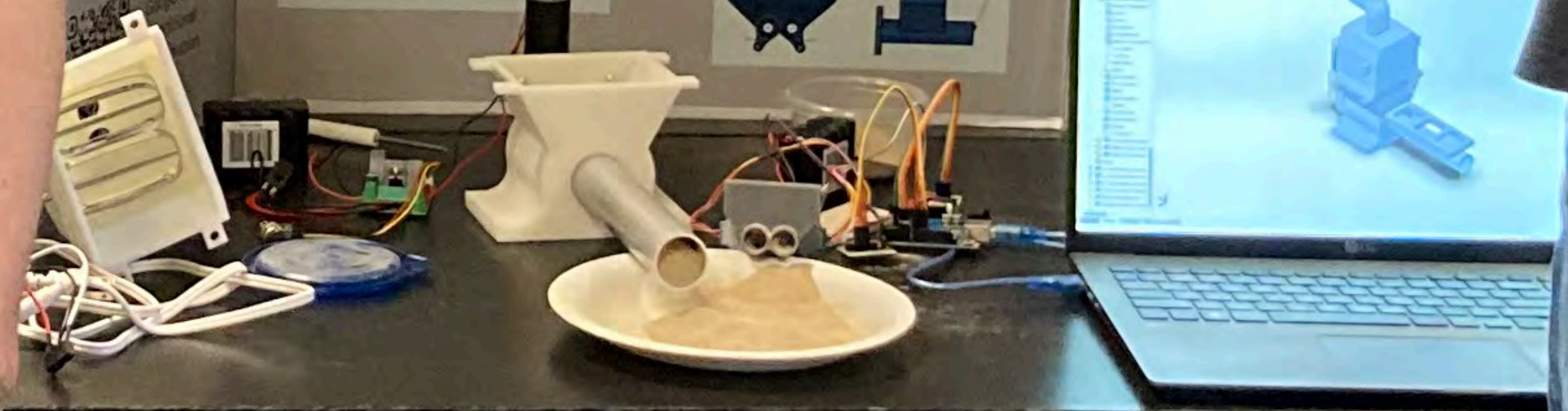
Auger Drive Motor Circuit

Volumetric Feed System

Physical Mixing Chamber Outlet

First Complete Iteration Design

Hopper 1 / 2
Mixing Chamber
Material Extruder
Material Transportation Pipe
Material Transportation Pipe





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Project Background

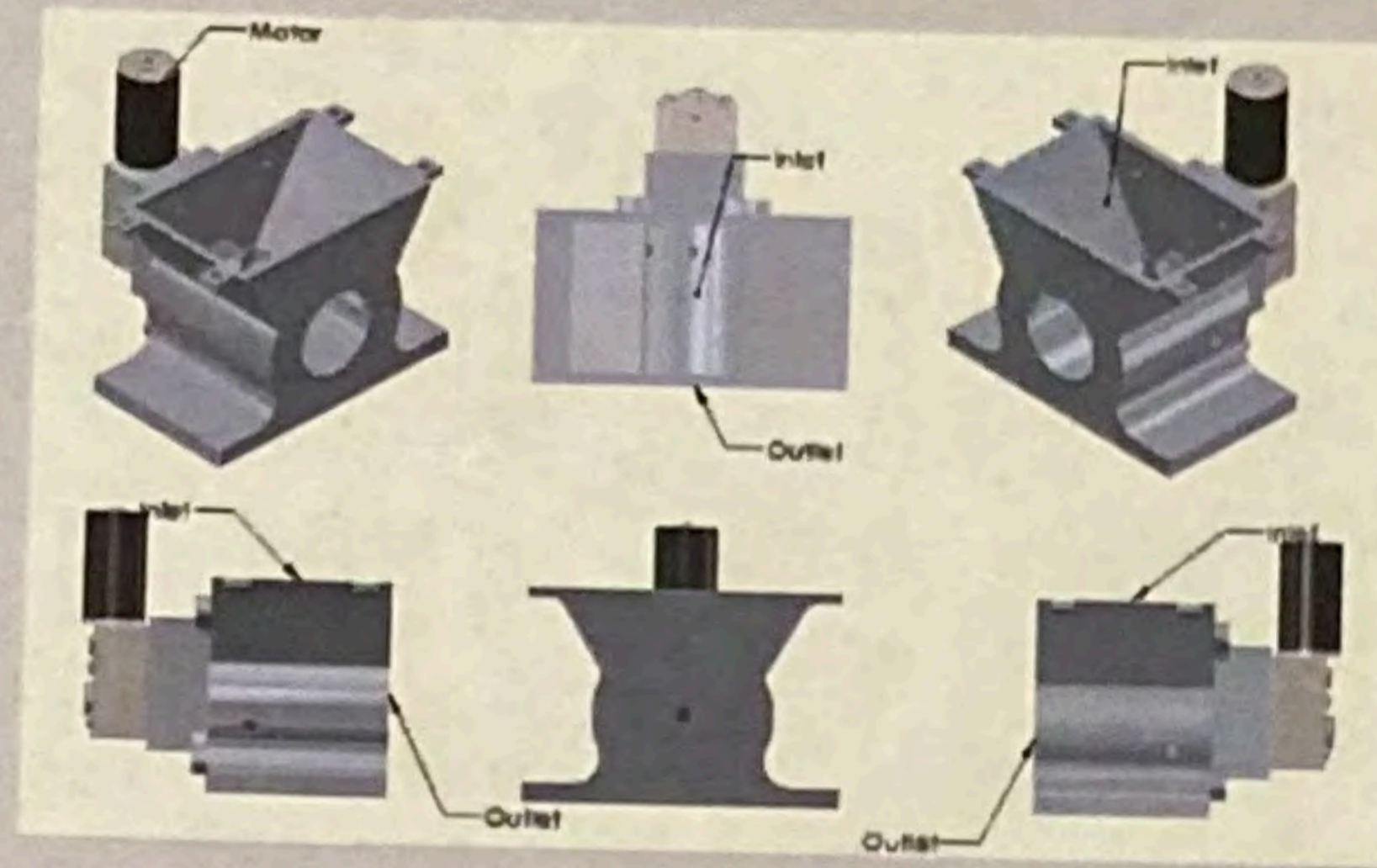
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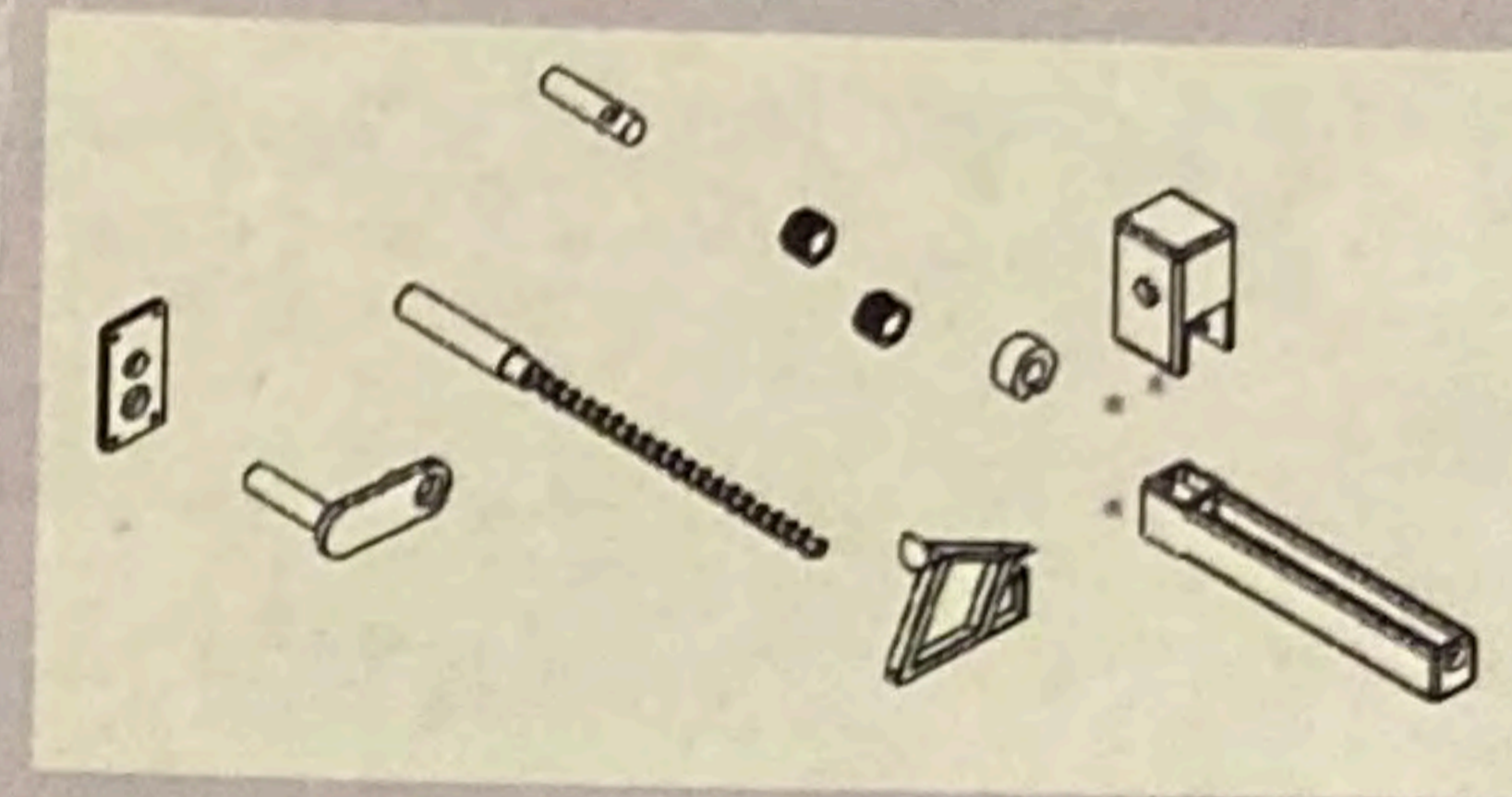
Calculation for
Auger Width
Temp
(1 m² solar
surface area)



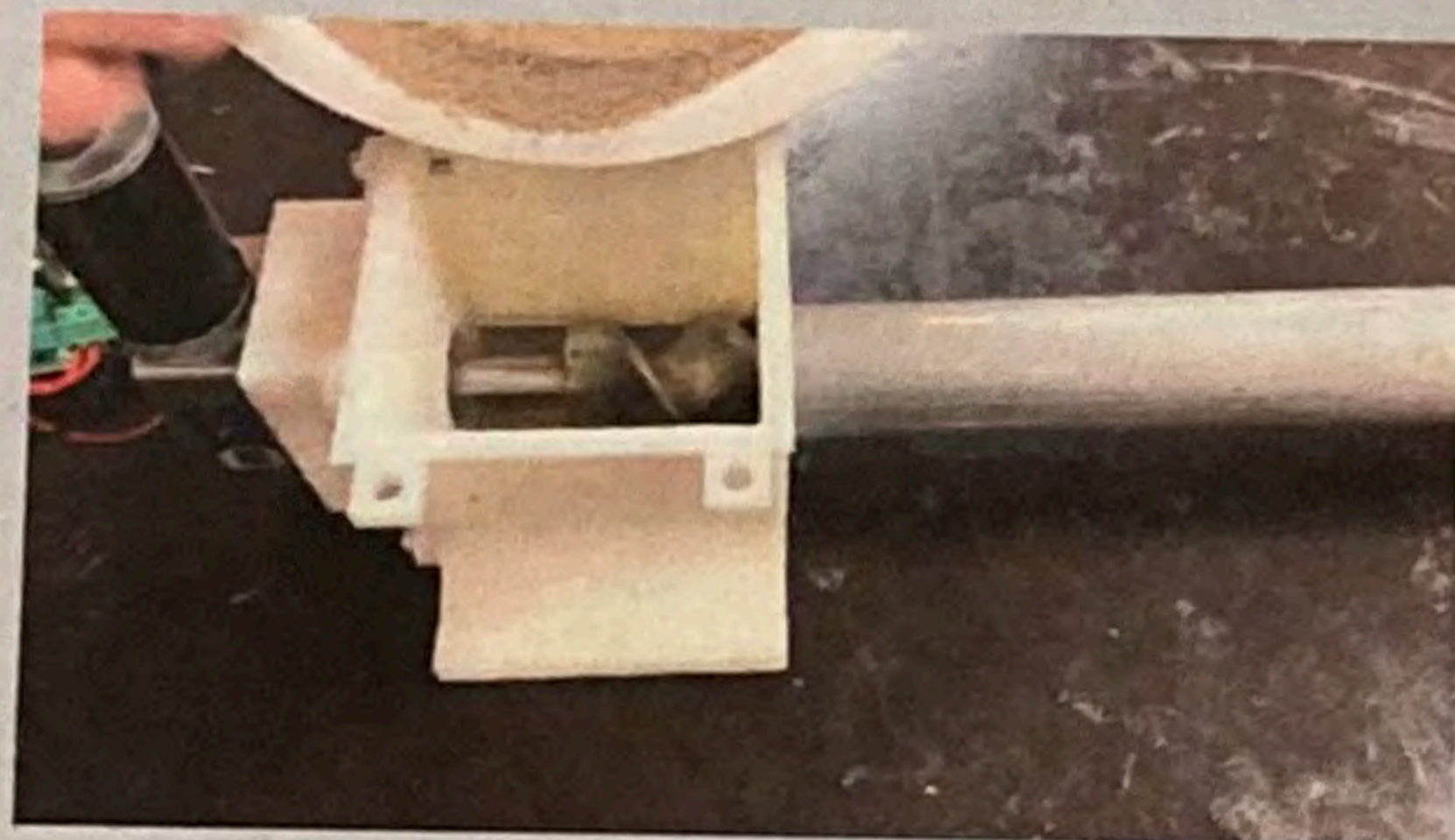
Mixing Chamber Outlet



Material Feed System Expanded



Physical Mixing Chamber Outlet



Auger Drive
Motor Circuit



Solution

By mixing leftover/extra plastic packaging and lunar soil in a high temperature chamber, we are able to produce small foundation bricks.

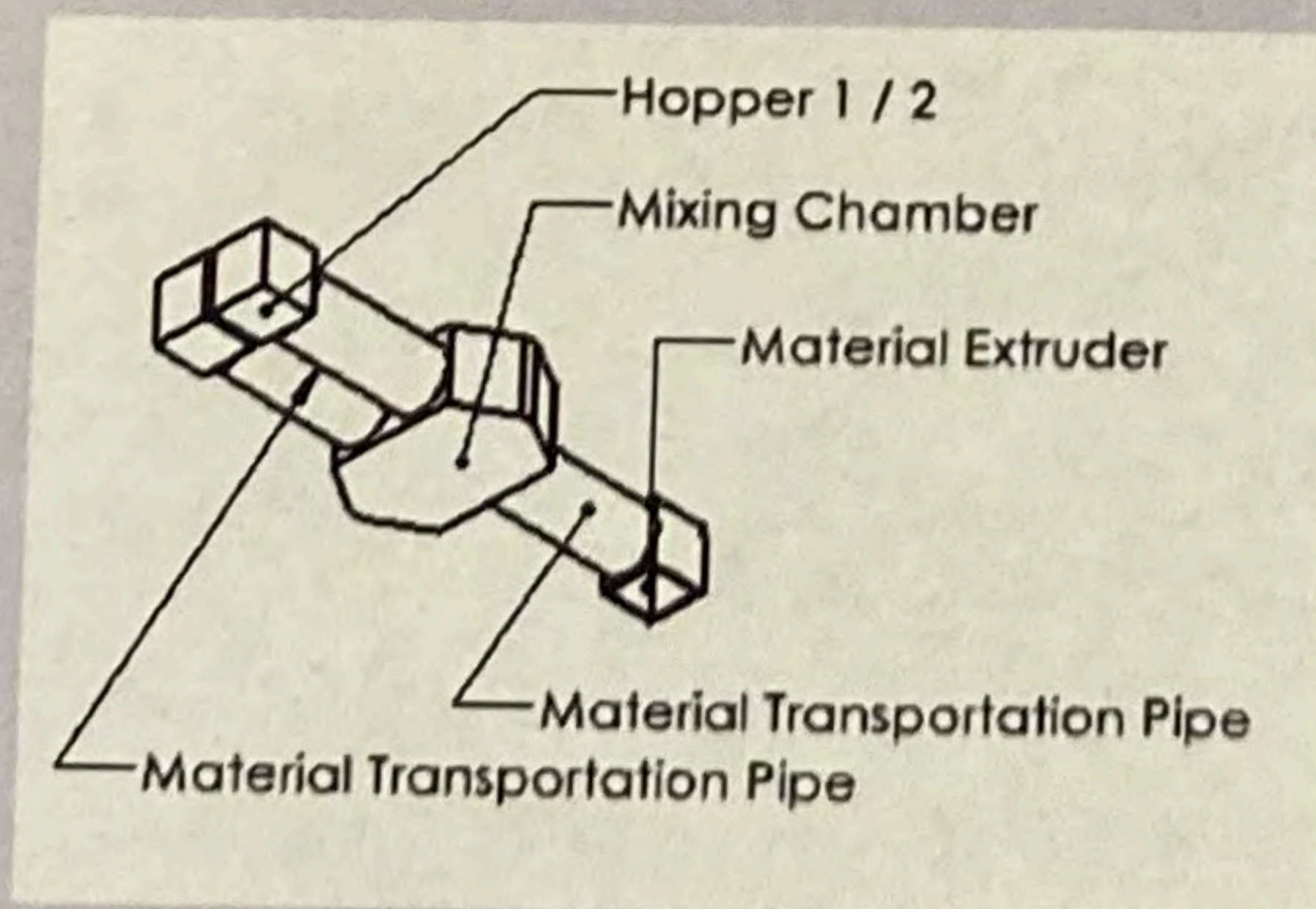
Materials Used

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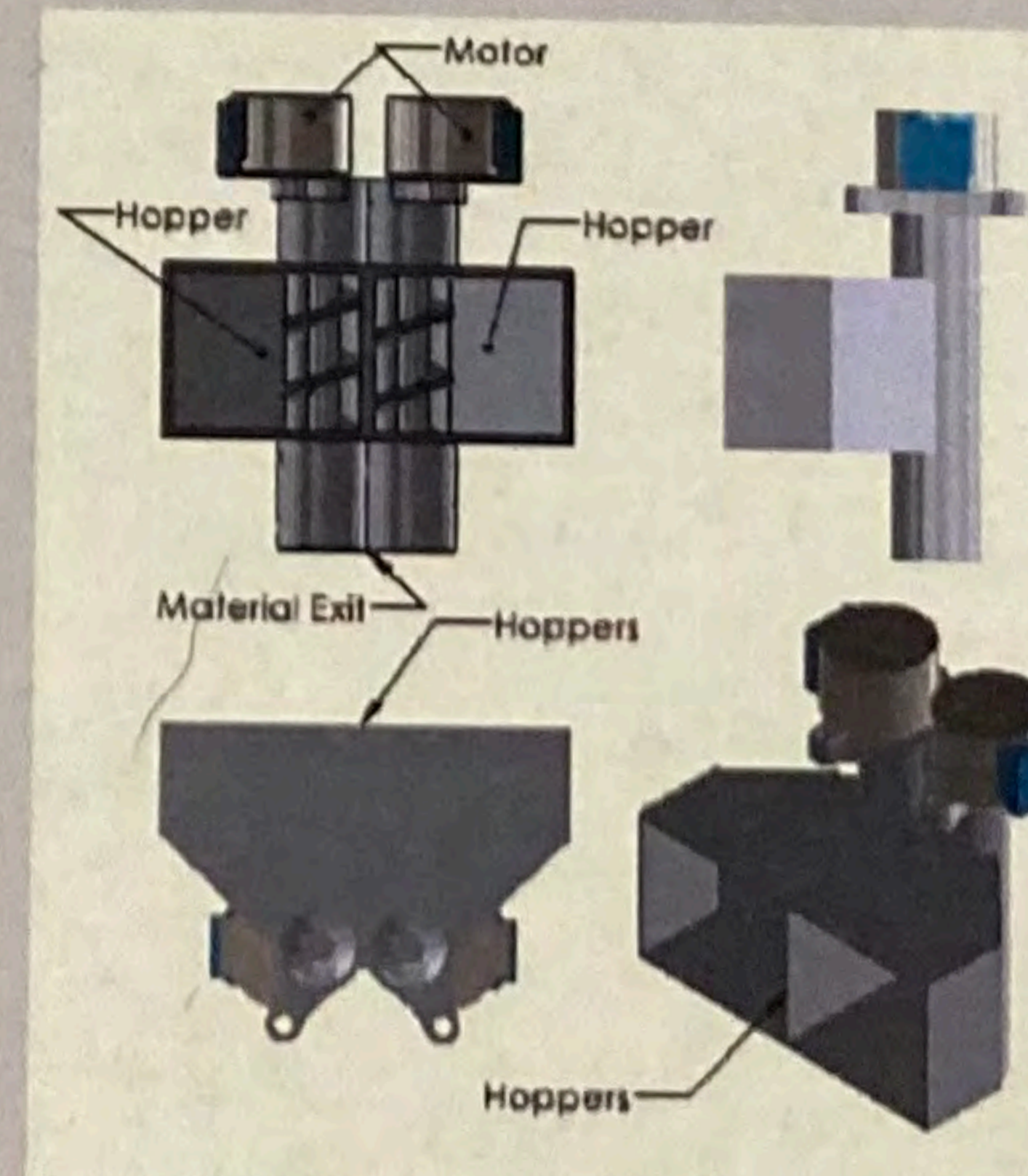
Goals/Constraints

- Produce 100 1x1x5in bricks per 24 hours
- Create our own input with filtering system, mixer, and extruder.
- Determine ideal lunar regolith to plastic mix ratio.
- Produce in a low gravity environment
- Must be heated by Parabolic mirror

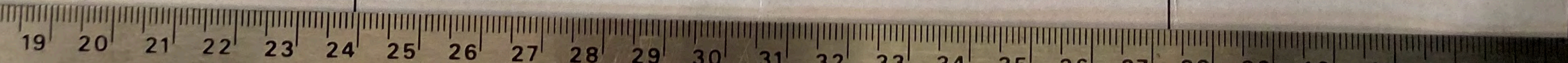
First Complete
Iteration Design



Volumetric Feed
System



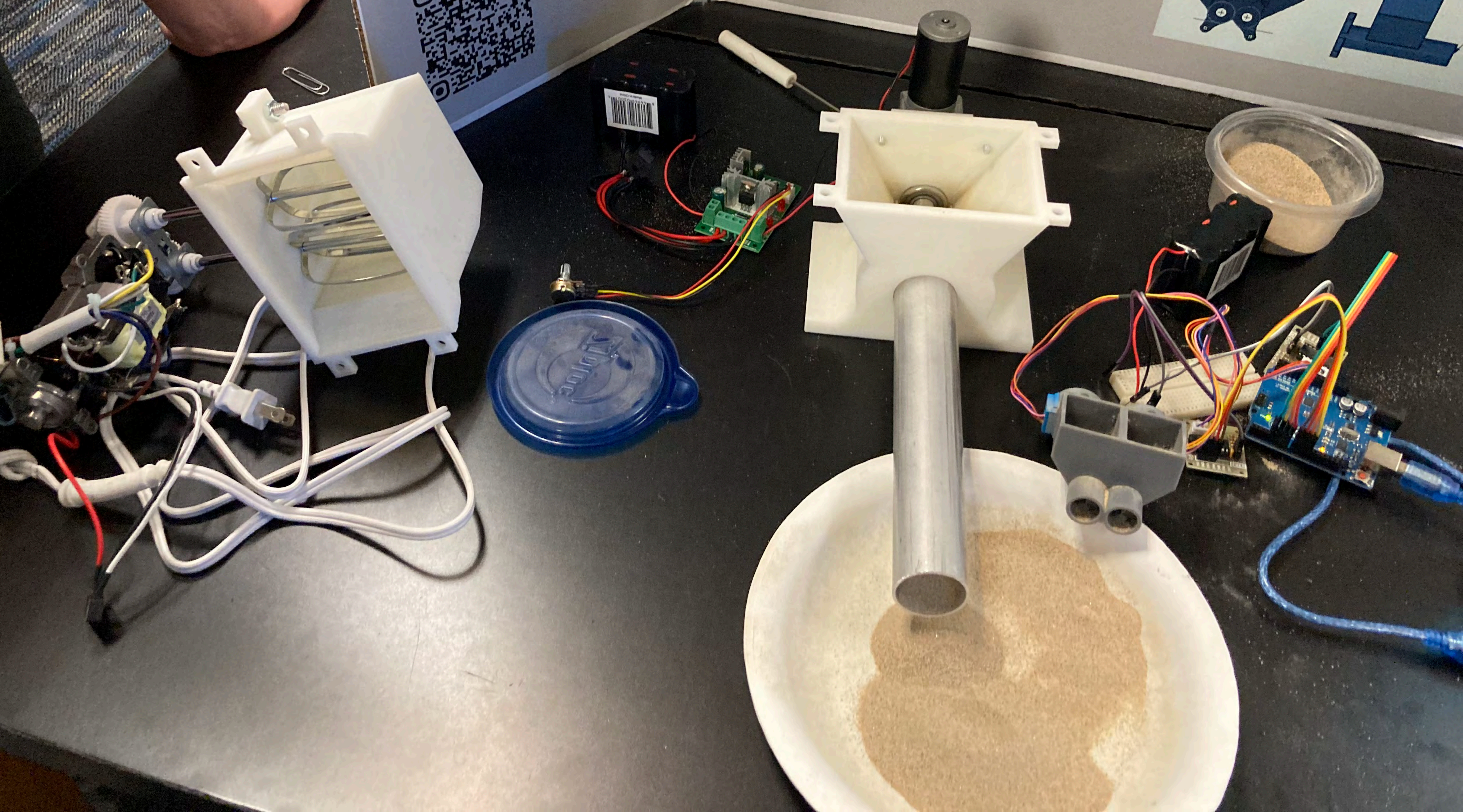
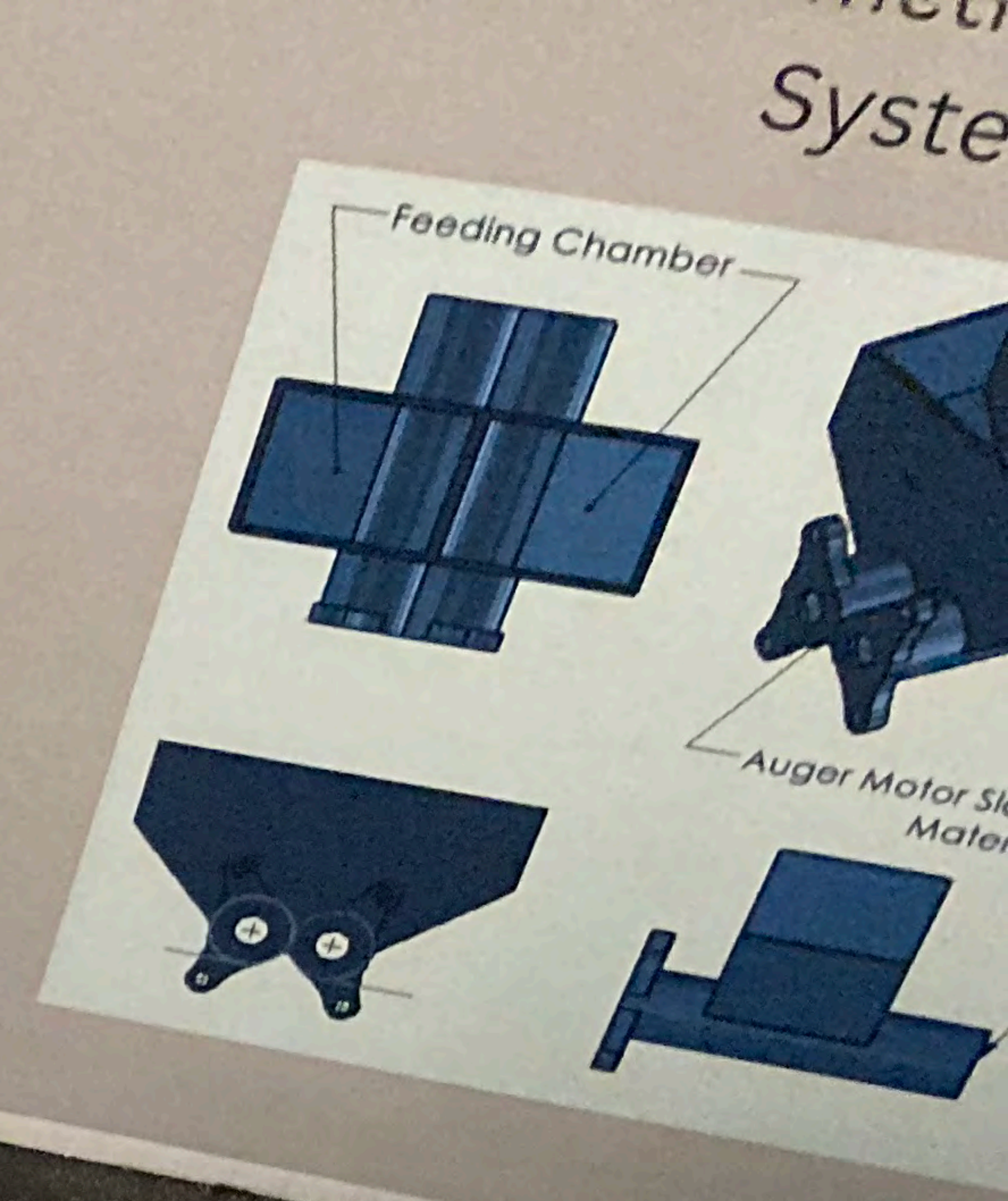
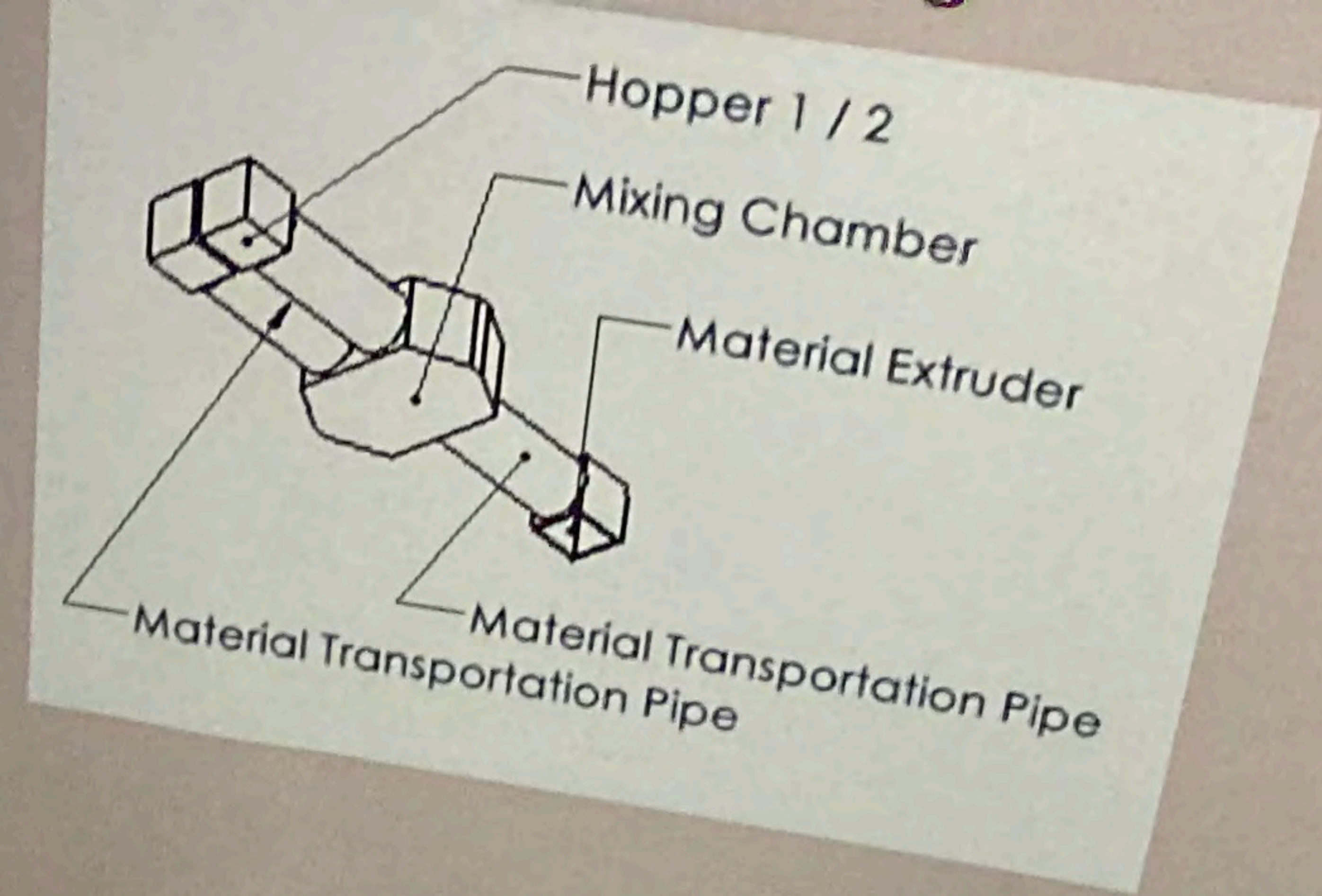
Google Slides
additional
information



- Model
- Aluminum Piping
- 12V Motors
- Blending Motors
- Various Circuitry Components



Google Slides
additional
information





AUGER PROJECT

3D Design

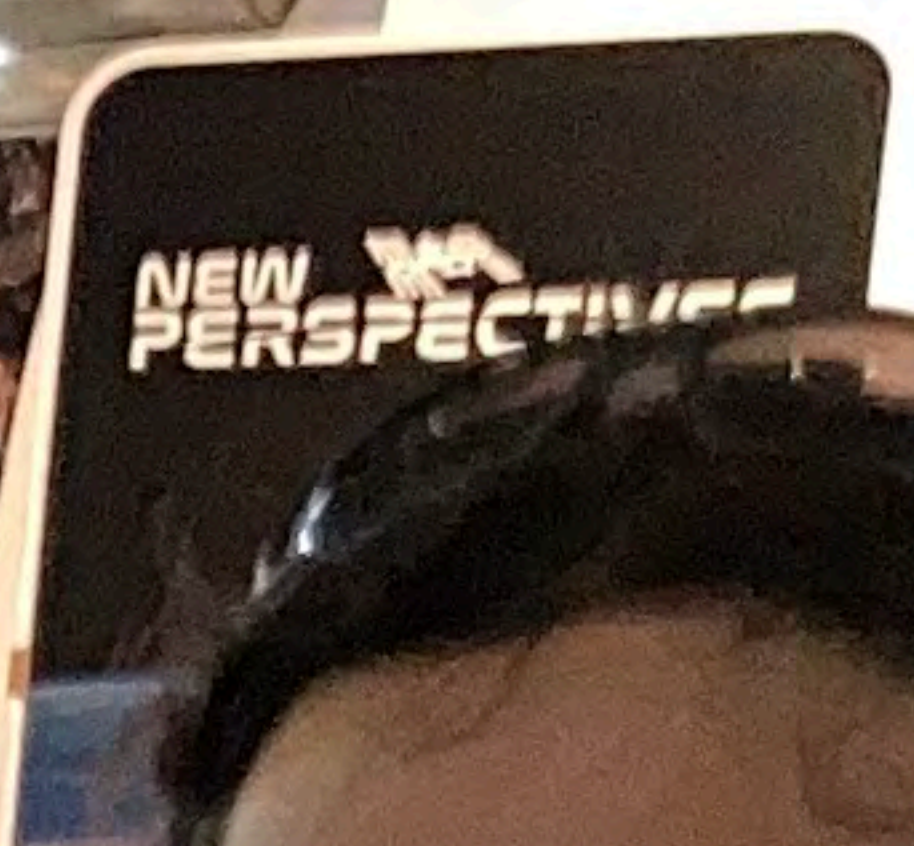
MODEL PROGRESSION

PROBLEM STATEMENT

THE GOAL IS TO MAKE A PIPE, AUGER, AND OTHER DEVS. MAKING THEM LIGHTWEIGHT, RELIABLY PACKABLE, DURABLE, AND FLEXIBLE. A HYBRID OF AT LEAST 2 WILL HAVE MASHBURN SOIL MIXED WITH PLASTIC, HEATS IT, AND CRAFTS BRICKS. THE PROBLEMS ARE GOING TO BE HEATING AND MIXING THE WAX AND PLASTIC. IN THE FUTURE, CONSISTENCY OF THE BRICK BUILDING MATERIAL IS NEEDED THAT CAN STACK UP TO 100.

RESEARCH

PLASTIC: POLYETHYLENE TEREPHTHALATE (PET) IS A COMMON POLYMER USED IN BOTTLES AND FIBER. IT IS STRONG AND DURABLE. POLYPROPYLENE (PP) IS A COMMON POLYMER USED IN CARPETING AND FIBER. IT IS STRONG AND DURABLE. POLYETHYLENE TEREPHTHALATE (PET) IS A COMMON POLYMER USED IN BOTTLES AND FIBER. IT IS STRONG AND DURABLE. POLYPROPYLENE (PP) IS A COMMON POLYMER USED IN CARPETING AND FIBER. IT IS STRONG AND DURABLE.



POWER

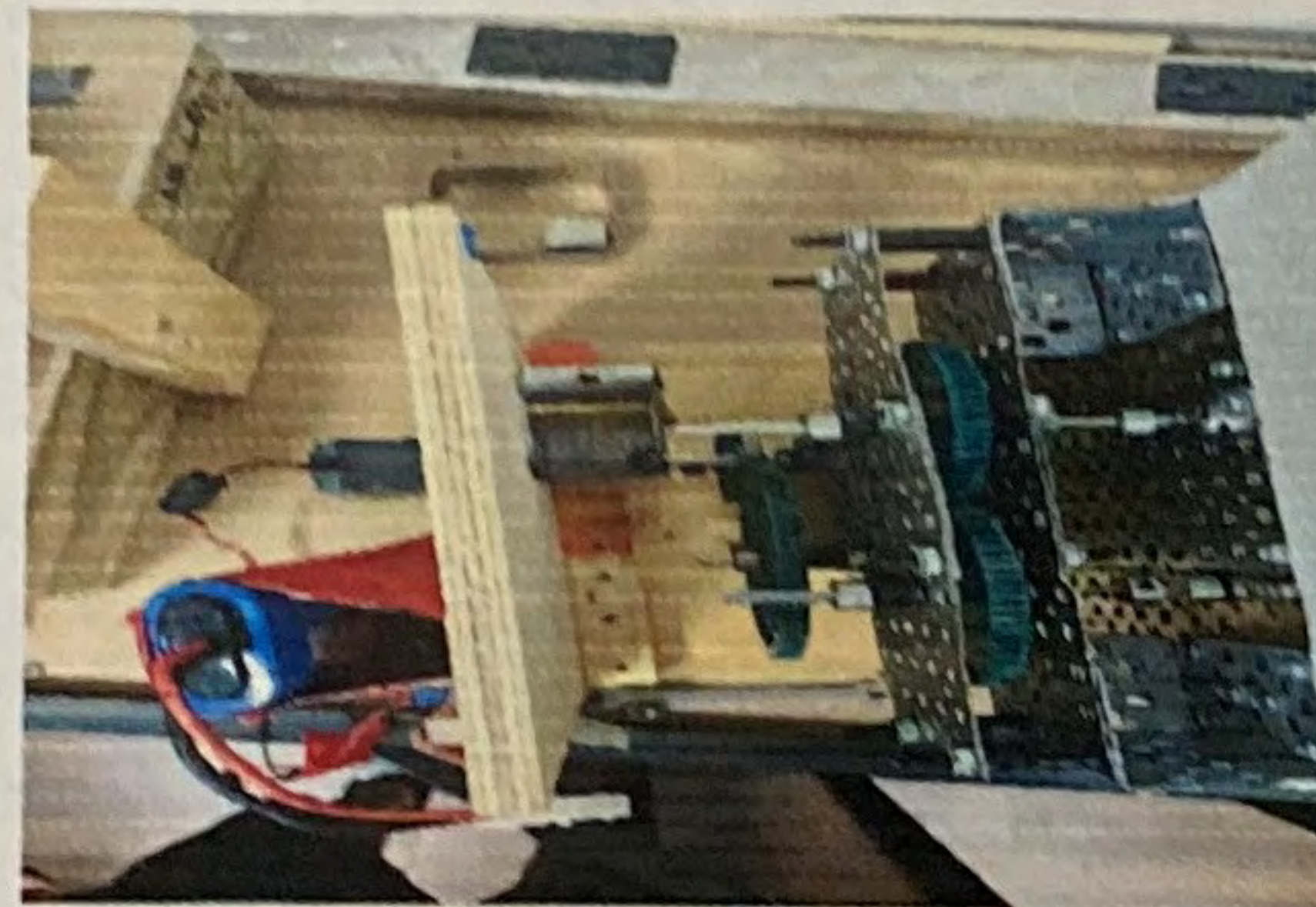
E



Explanation

We received the Auger Pipe, Extruder project. When researching we stumbled upon a hopper that is used to mix concrete. We took inspiration then started creating the hopper system out of foam boards. To make the auger spin we decided to use vex as it was the only platform available. That's when we made our 3-part transmission. After the NASA visit, we received valuable information on how we could improve the transmission. We torqued up the transmission by manipulating the gears to output more torque. After we were done with the transmission we started to focus on the extruder and knife assembly of the auger. We also received advice on how we could cut the bricks to preserve the shape of the brick. We decided to make a windmill cutter to preserve the shape of the brick. Michael did calculations to find the exact rate that a brick would come out. Then we found out the gear ratios needed. And assembled the cutter system.

Final Designs



Auger Project

By
Aadi Hasmukh, Michael Silinsky
and Jayden Rinser
For
Mr. Merritt
Architectural Civil Engineering
Clear Creek High School
Clear Creek ISD
League City, Texas 77573

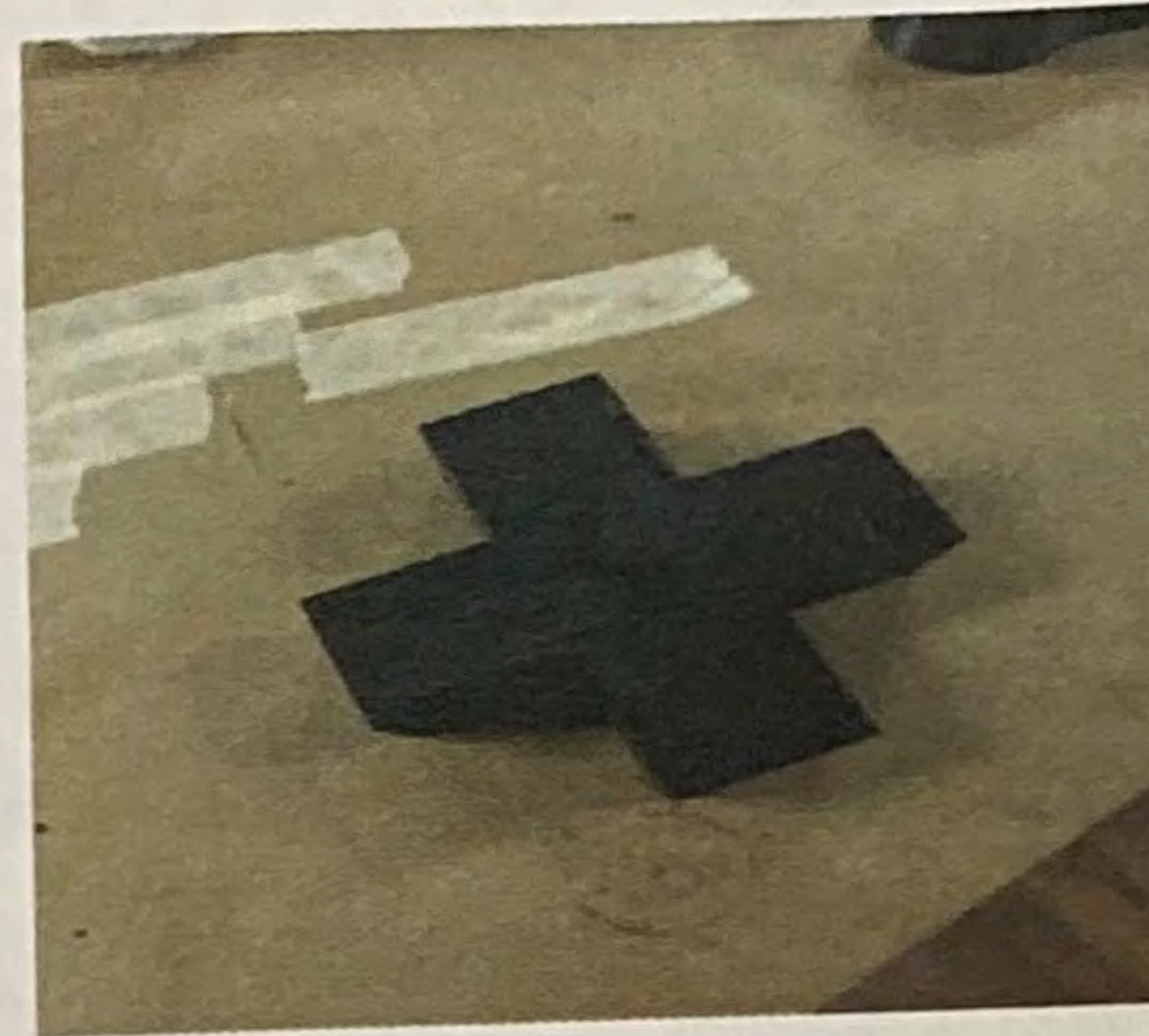




Problem Statement/Video

THE GOAL IS TO MAKE A PIPE, AUGER, AND EXTRUDER. MAKING THEM LIGHTWEIGHT, HEAVY-DUTY, PACKABLE, DURABLE, AND FLEXIBLE. A MECHANICAL BEAST. IT WILL MOVE MARS/MOON SOIL MIX IT WITH PLASTICS, HEATS IT, AND CRAFTS BRICKS. THE PROBLEMS ARE GOING TO BE HEATING AND MIXING THE SOIL AND PLASTIC TO THE RIGHT CONSISTENCY. THE RIGHT BUILDING MATERIAL IS NEEDED THAT CAN TAKE UP TO 200°C.

Printed Designs



Materials

- Plywood
- 4 Small Vex Gears (12T)
- 2 Medium Vex Gears (36T)
- 2 Big Vex Gears (60T)
- 4 Large Vex Gears (84T)
- 1 Servo Motor (100rpms)
- Breadboard
- 8 Vex Axels
- 3-D Printed Parts
- 4 3-D Printer Augers
- 3 Copper pipes
- Foam Board
- Plexiglass
- White duct tape
- Screws
- PVC Pipes

Contact Us

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Pipe, Auger, Extruder

Christian Winandy, Christopher Newton, Colin Wong
Technical Difficulties
Plano ISD Academy High School

Project Objectives

Requirements

Design, build and test a pipe, auger and extruder system that can be heated to 200 C that will mix sand and shredded plastic to a consistent slurry and extrude out into a 1" x 1" x 5" brick.

The goal is to make 100 bricks per 24 hours. Since a lunar day is about 14 days, around 1400 bricks per lunar day.

Constraints

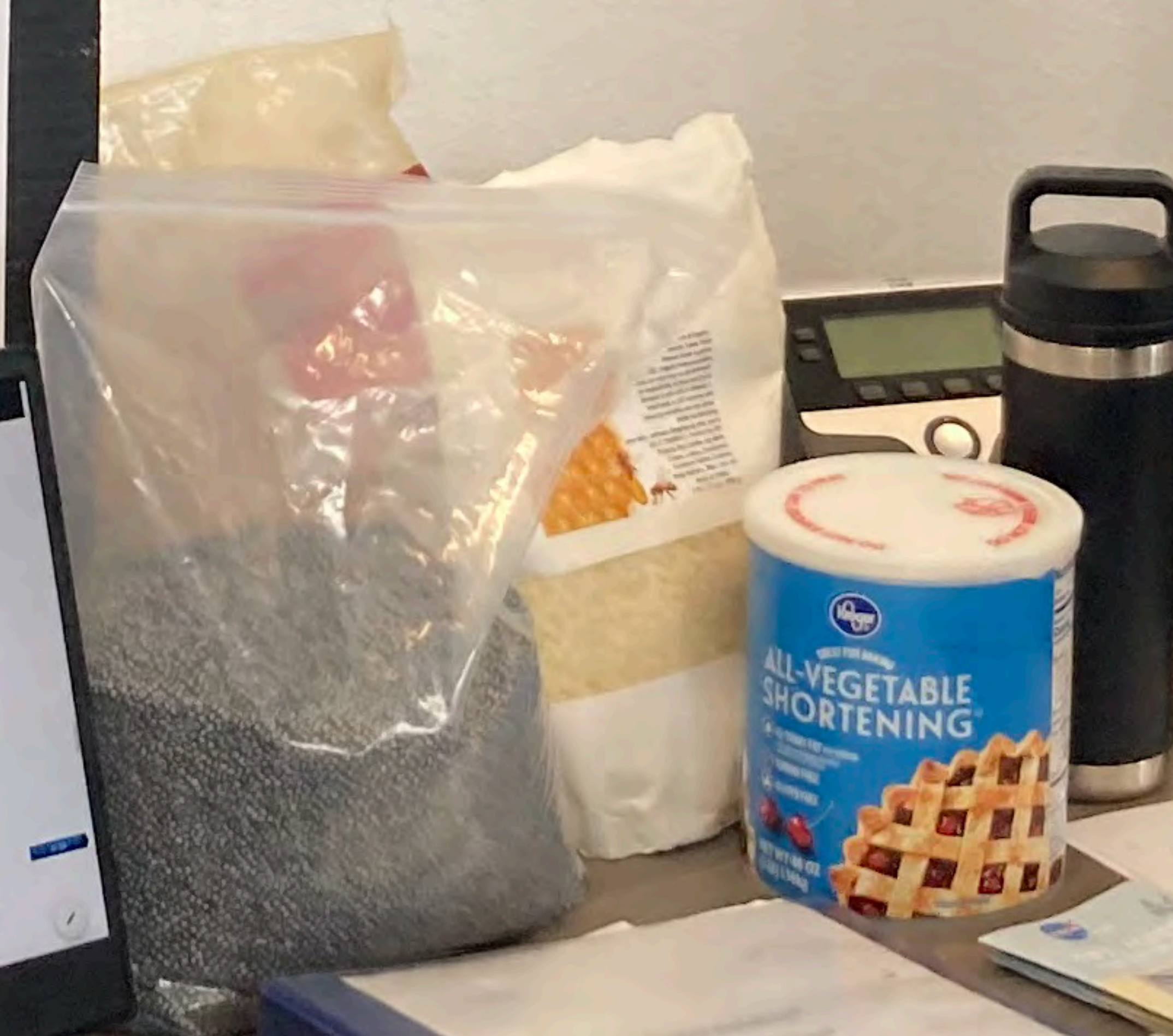
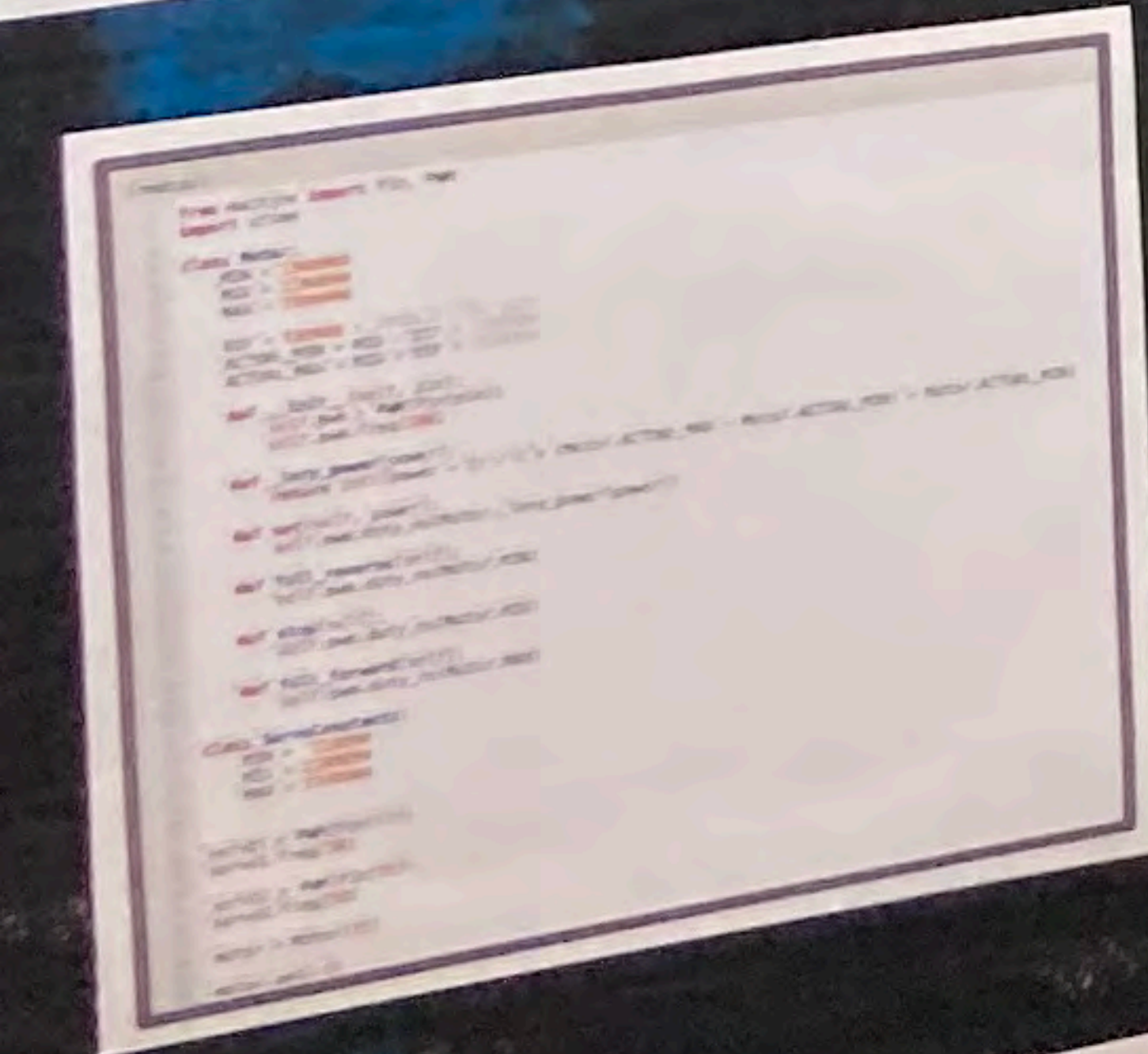
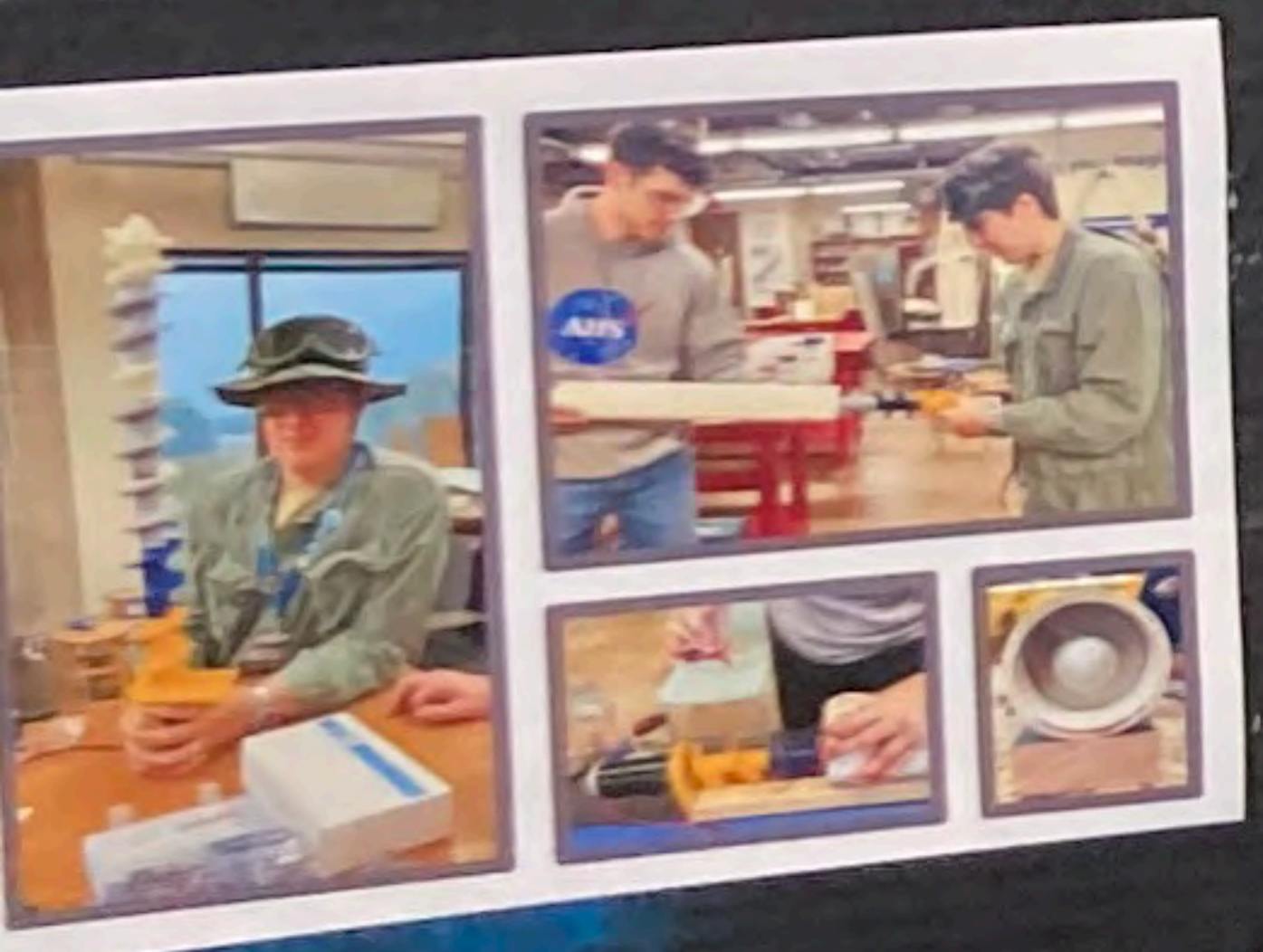
- Extruder must be able to resist heat of 200°C
- Micro-gravity is inaccessible
- Auger screw...

Technical Difficulties Website



Ingredients	Shortening and Silica Sand	Basement and Silica Sand
Similar Mass	100.00 g	100.00 g
Binder Mass	100.00 g	400 g
Ratio	2.95 to 1	3.89 to 1
Temperature	No External Heating	60 - 95 °C
Brick Consistency	Sludge	Solidified
Homogeneity	Slightly mixed	Even distribution

How can we build a pipe, auger, and extruder mechanism that can be solar-powered brick-making lunar rover to produce 100 bricks every 24 hours?



Problem Statement

How can we build a pipe, auger, and extruder mechanism into a solar-powered brick-making lunar rover to produce 100 bricks every 24 hours?

Requirements

Design, build and test a pipe, auger and extruder system that can be heated to 200° C that will mix sand and shredded plastic to a consistent slurry and extrude out into a 1" x 1" x 5" brick.

The goal is to make 100 bricks per 24 hours. Since a lunar day is about 14 days, around 1400 bricks per lunar day.

Constraints

- Extruder must be able to resist heat of 200°C
- Micro-gravity is inaccessible
- Auger screw and pipe must be abrasion-resistant



Plano ISD Academy High School
Mrs. Gunnels
Design and Prototyping
Brian Winandy, Colin Wong,
Christopher Newton

For More Photos and Videos



Our Website



PIPE, AUGER, AND EXTRUDER

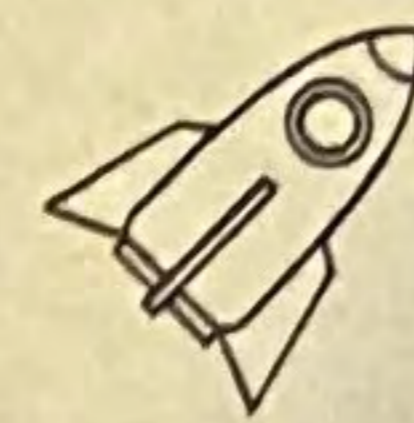


Our Solution

The Pipe Auger Extruder mechanism is the plastic-brick-making sub-system on the lunar rover. We created a dual screw system to maximize mixing and extrusion. The mechanism is driven by a 12v brushless motor at a 60 to 1 gear reduction.



Data Collection



Ingredients	Shortening and Silica Sand	Beeswax and Silica Sand
Simulant Mass	101.01 g	103.69 g
Binder Mass	399.46 g	400 g
Ratio	3.95 to 1	3.86 to 1
Temperature	No External heating	60 - 95 °C
Brick Consistency	Sludge	Solidified
Homogeneity	Slightly mixed	Even distribution

Limitations

Improvements

There was insufficient power to conveyor, compress, and extrude simulant.

We added a 60 to 1 gear reduction and replaced a brushed CIM motor with a brushless Neo.

There was no compression.

We changed screw geometry to have a spiral tip and created a gap between the screw and die.

There were no binds made between materials.

We replaced the pipe material with conductive steel and the screw material with heat-resistant carbon-fiber nylon so we could melt the binder in the compression process.

There was insufficient mixing.

We changed our design to a dual screw system.

The motor runs an auger through the gearbox and translates the rotary motion to a mirrored parallel auger using two gears. The pitch distance between each flight on each auger decreases, so that all material is compressed for extrusion. The augers have end screw tips. These are placed into 2' steel pipes that are welded together with an overlapping cross-section. At the end of the pipe are 3 inches of space and a 1 x 1 die. We used Micro Python on a Raspberry Pi Pico to control the motor over PWM.

Preliminary Design Prototype



NASA HUNCH - Pipe, Auger, Extruder iSchool Of Lewisville TEAM P.A.X.

PROJECT DESCRIPTION

- NASA plans to pursue traveling to the moon's surface once again, with hopes to establish a permanent presence.
- Construction materials required to build lunar habitats, i.e. bricks.
- The PAX project would turn regolith and recycled plastic into bricks.
- This project allows bricks to be made on the moon, rather than sending them up.
- This decreases the amount of materials NASA would need to send up to the moon.
- This system provides <https://www.nasa.gov/technology/robotics/robotics.html>

CONSTRAINTS & PART EXPLANATION

Requirements need to be highly efficient with very little to no maintenance and last a long time. All materials need to be made in America or Canada.

- Funnel:** Lets the sand enter properly & efficiently through the hole into the cone.
- Pipe:** Constraints for the auger: Rounded cylinder, needs regolith & plastic in different shapes and masses. Two holes needed for pipe: one for plastic and the funnel for sand.
- Auger:** Batch feeding to mix the regolith and plastic, connected to a drill controlled by Arduino. Needs regolith and plastic together into a dough.
- DRILL/DRILL BIT:** Drill bit that is attached to a drill motor that spins the auger.
- Arduino program:** Controls motor the auger and mixes the dough together.
- Extruder:** Needs to extrude the plastic and regolith dough into the extrusion extruder to shape the bricks.
- Silicone Mold:** The dough with the extruder into the extruder needs to be formed into a 2" x 2" x 2" brick.
- Brick Bucket:** After the correct dimensions a bucket filled with the brick. Brick is placed into bucket to cool & cure for 24 hours.

PROJECT REVIEW FEEDBACK

- Plastic in Check!
- Testing with Chemicals: Cures to 24 Hours!
- High Speed Bricks!
- Stronger: Extruder: 1000g & Brick Check!



Josh Shultz
Matthew Hagan

Research

- Chemistry
- Low Gravity Physics
- 3D Simulation
- Material Science

PRODUCTION EFFICIENCY

Brick #7 (most efficient)

Time	10 min
Material	10g
Energy	10W
Temperature	100°C

TESTING

Testing Brick #3, November 15th

Key Points:

- Ratio of 50% brick produced
- Ratio of 50% regolith, 50% plastic
- Ratio of 50% regolith, 50% plastic
- Ratio of 50% regolith, 50% plastic

Final Testing: Brick #7, February 20th

Key Points:

- Ratio of 50% brick produced
- Ratio of 50% regolith, 50% plastic
- Ratio of 50% regolith, 50% plastic
- Ratio of 50% regolith, 50% plastic

Silicone Mold

- Silicone Mold provides a reusable and flexible mold for our bricks.
- Silicone Mold has a high chemical resistance and heat resistance higher than 200°C.

FAQ

- How does the system or process work in moon gravity?
- What are bricks made out of?
- How long does the process take?
- What does your team plan to do after this?
- How will this help the astronaut?

Next Steps

- Automate the system
- Improve the system
- Improve the system
- Improve the system

Testing: Brick #4, January 6th

Key Points:

- Ratio of 50% brick produced
- Ratio of 50% regolith, 50% plastic
- Ratio of 50% regolith, 50% plastic
- Ratio of 50% regolith, 50% plastic

Testing: Brick #5, Jan

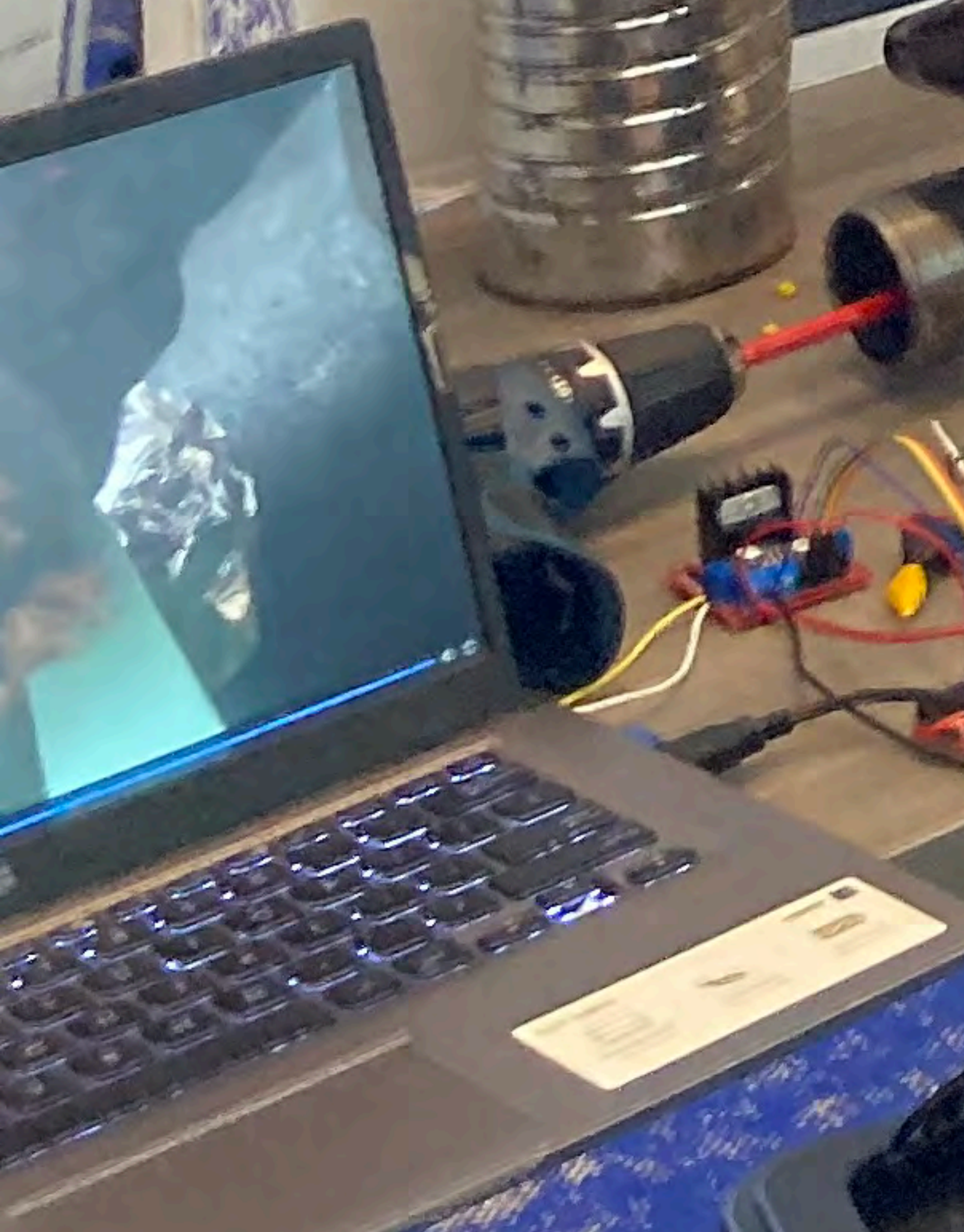
Key Points:

- Ratio of 50% brick produced
- Ratio of 50% regolith, 50% plastic
- Ratio of 50% regolith, 50% plastic
- Ratio of 50% regolith, 50% plastic

Testing: Brick #6, Jan

Key Points:

- Ratio of 50% brick produced
- Ratio of 50% regolith, 50% plastic
- Ratio of 50% regolith, 50% plastic
- Ratio of 50% regolith, 50% plastic



PROJECT OVERVIEW

The Pipe, Auger, and Extruder project constructs a device that turns lunar soil and recycled plastic into bricks.

Making the bricks on the moon instead of sending them up would significantly decrease the amount of materials NASA would need to send up to the moon, providing more room in rockets at a cheaper cost.

Team P.A.X. has the goal of creating an automated device that produces strong 1"x1"x5" bricks made of plastic and regolith.

P.A.X. TEAM



Krish, Daniel, and Hogan



Team Website

NASA HUNCH

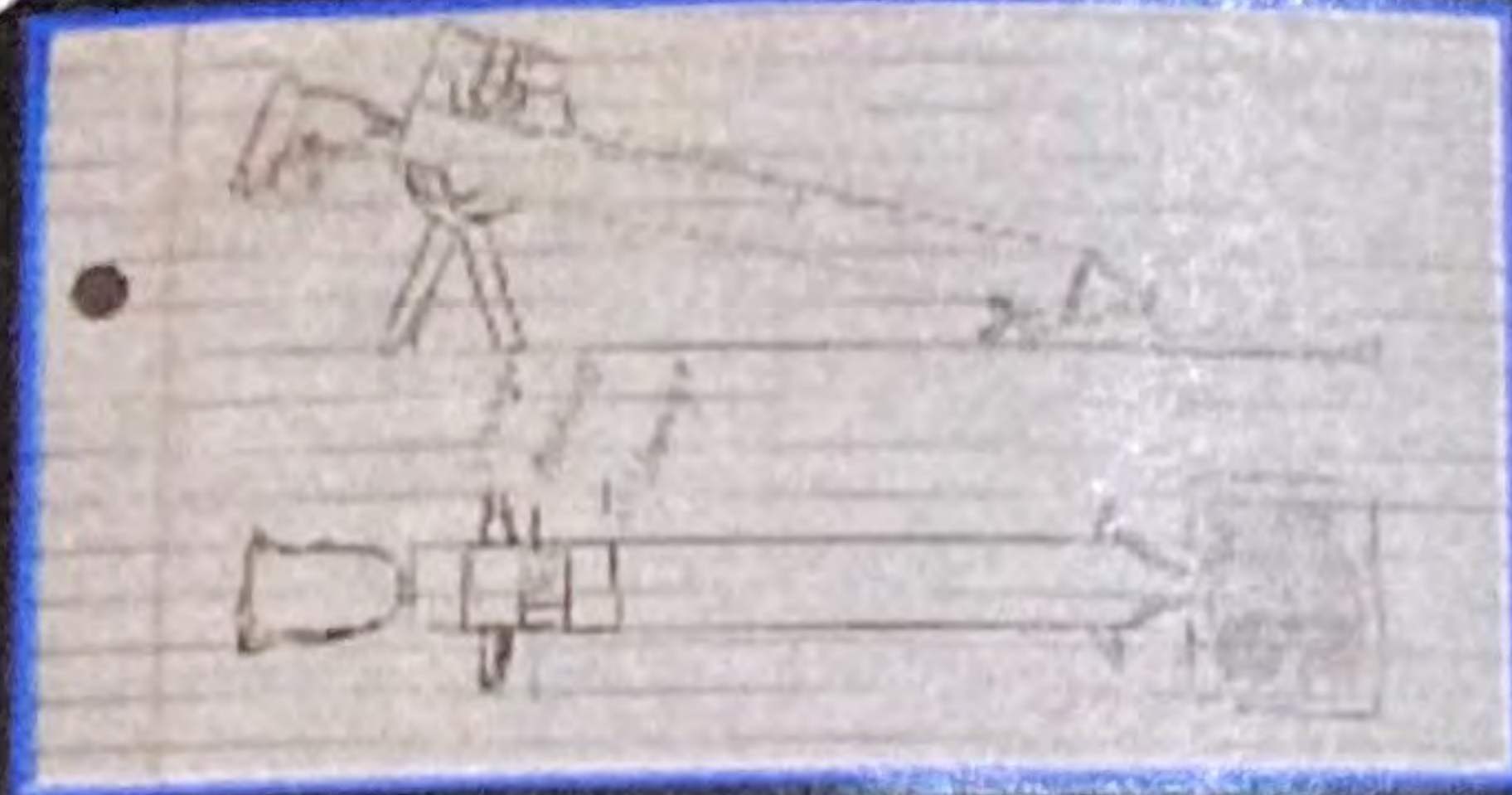
PIPE, AUGER, EXTRUDER

TEAM P.A.X.

Our Design Storyboard

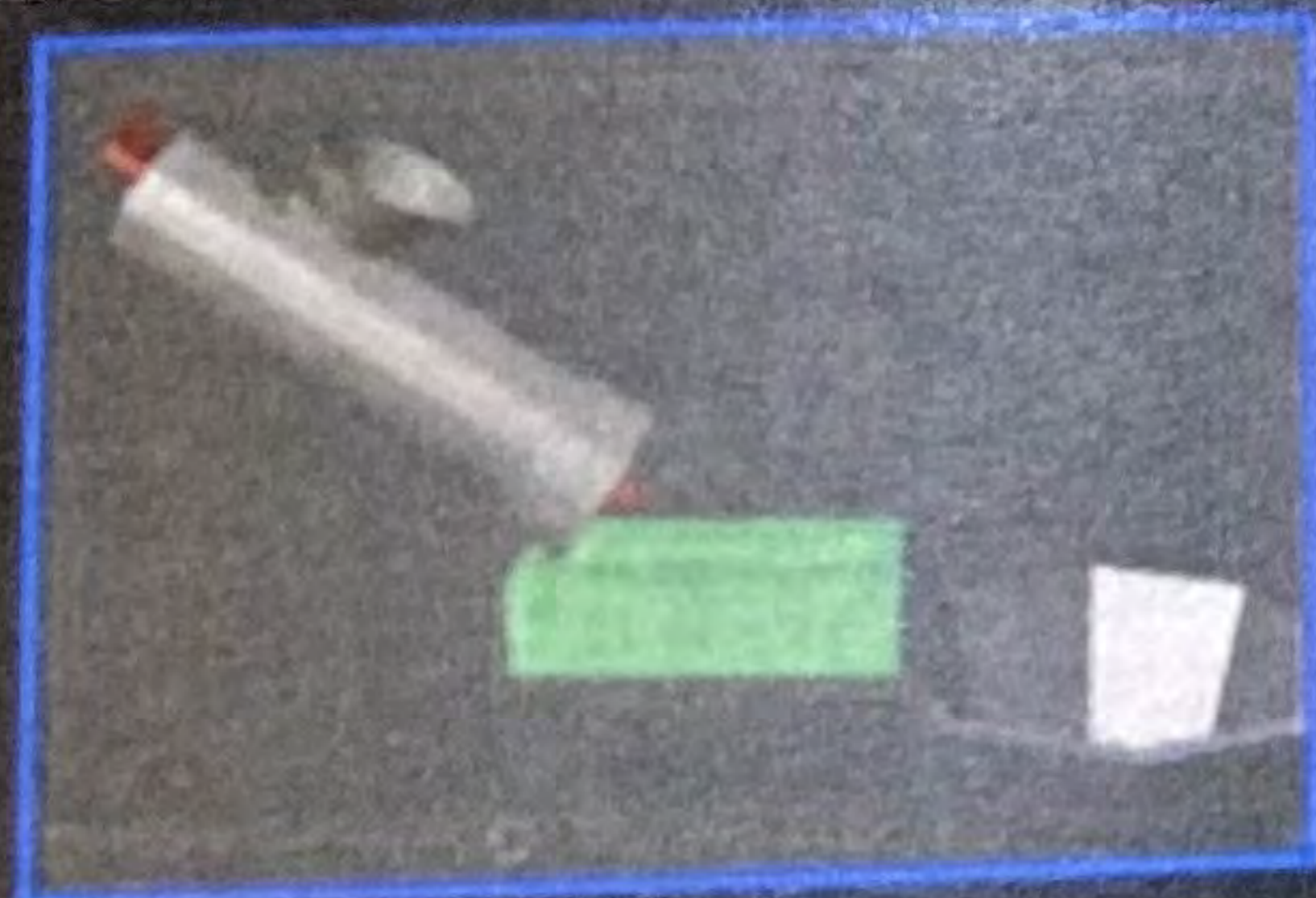
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Sketches



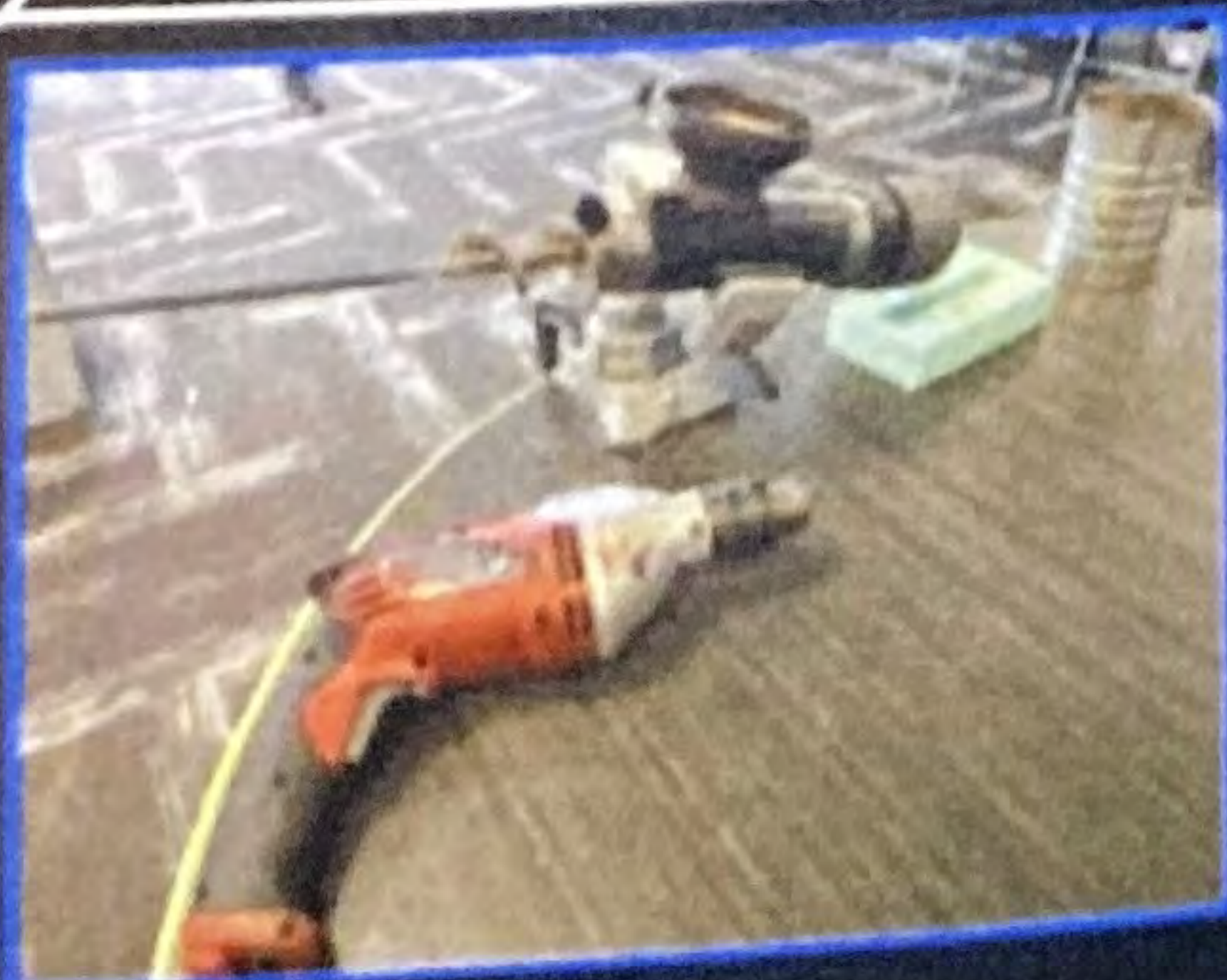
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CAD Drawing



3

Prototype



Testing Results

Test #4 and Test #6 were conducted using a heat source of 200-240°C.

Brick #3

Brick #7



Ratios

70:30 ratio of sand to plastic made our Brick #3 sturdy and stiff, but with too much plastic waste, at too high of a temperature, making it inefficient. The 80:20 ratio had similar problems, but was more efficient. The 90:10 ratio was the best, as we still had a sturdy brick, with minimal plastic.

Automation

Our drill can be set up to work with an arduino to turn forwards AND backwards. In the future we strive to automate the entire process with the press of a button. The automation process will not be affected by lesser gravities, similarly to the rest of our design.

NEXT STEPS/ FUTURE PLANS

Compactness

Making the prototype move in unison.

Automation

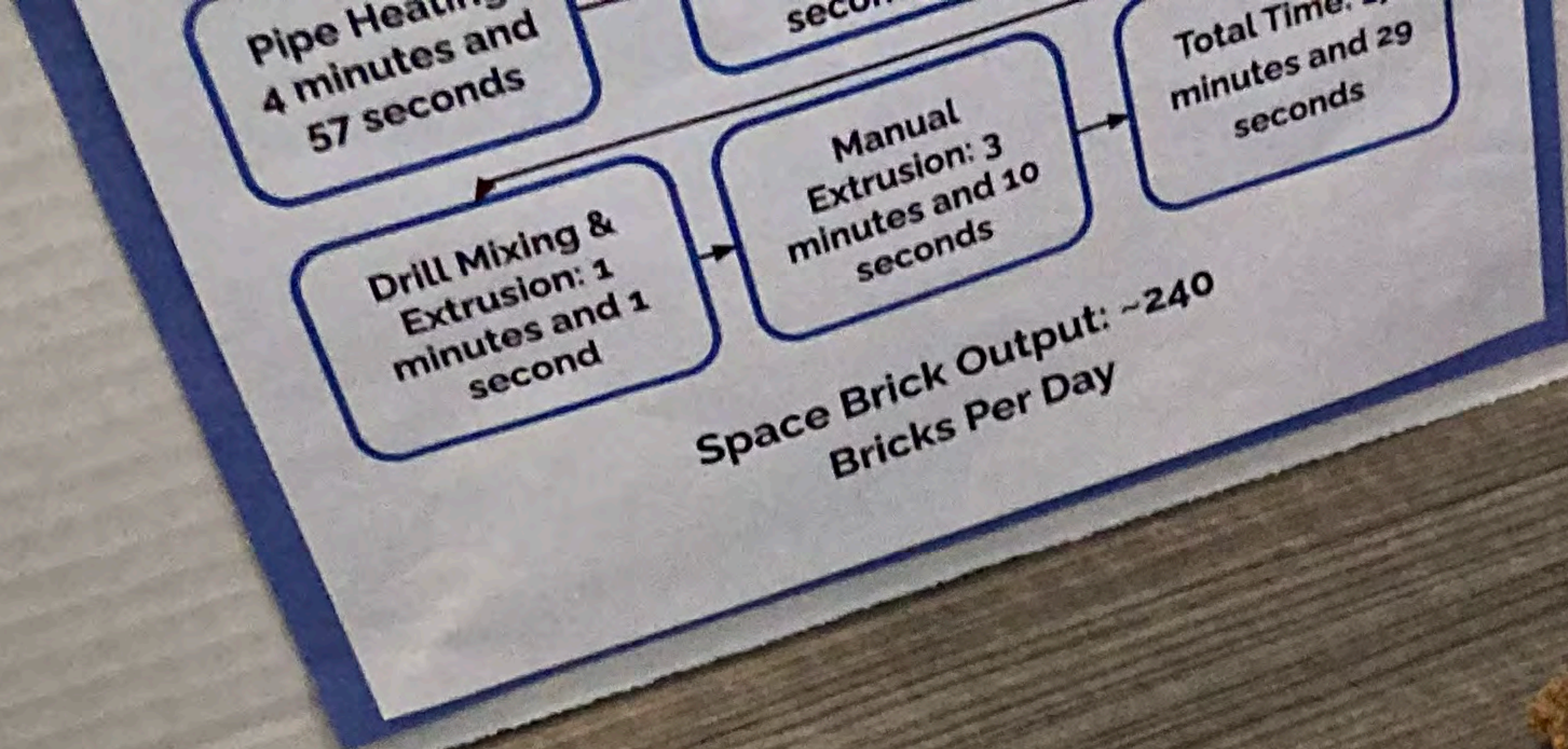
Fully integrated Arduino program to automate the process.

Connectivity

Redesign the molds to allow the brick to connect smoother and more efficiently.

FINAL PHASE

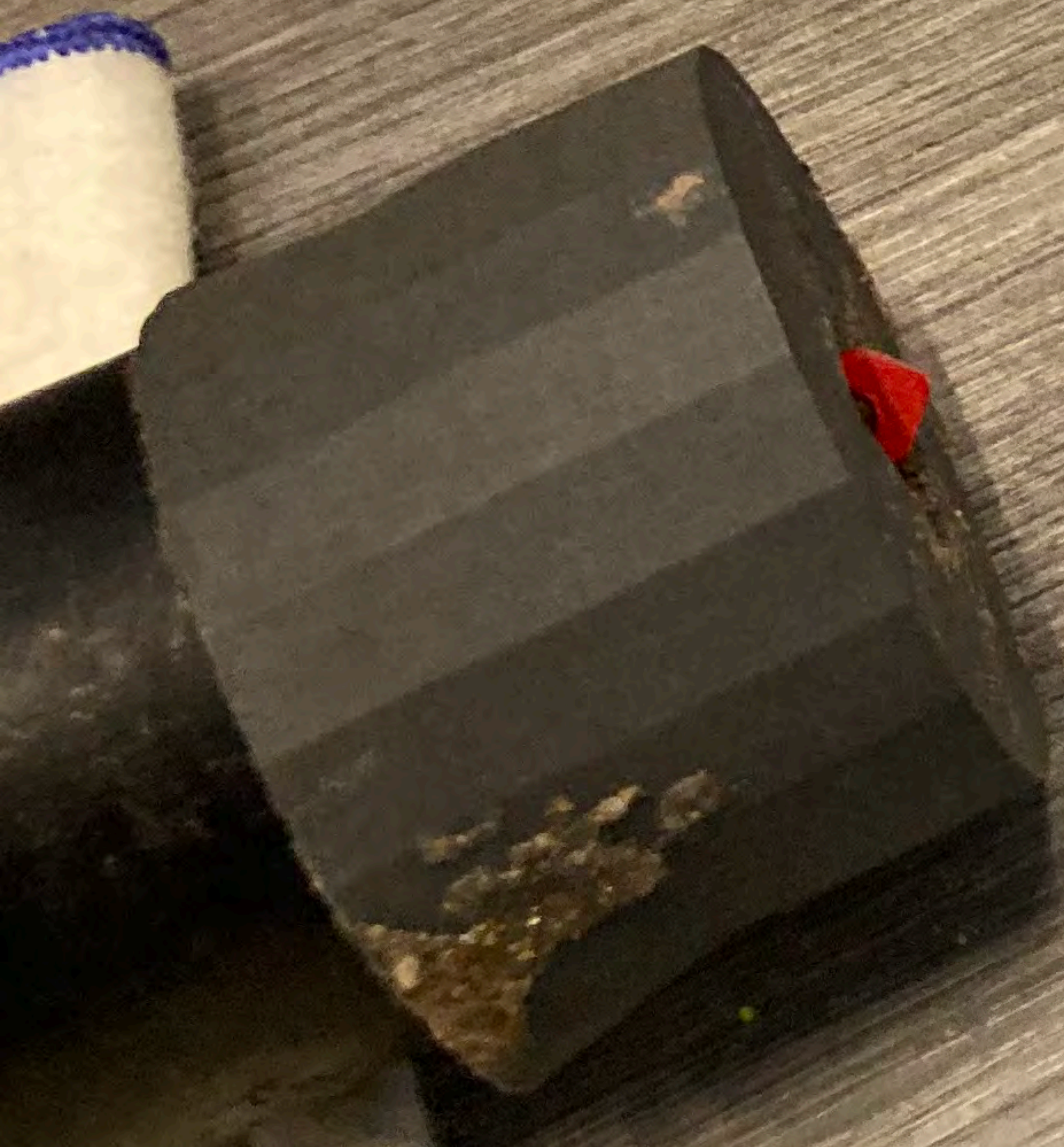
Completely Automated Machine



design the molds to allow the brick to connect smoother and more efficiently.
...simulate into the next 1x1x5" brick.
...structure for recycling plastic!



- Pure Sand | 6:4
- Brick #1 | 55:45
- Brick #3 | 70:30
- Brick #4 | 80:20
- Brick #5 | 80:20
- Brick #6 | 80:20
- Brick #7 | 90:10



Progressment.



PLASTIC PROTOTYPE

PIPE

METAL PROTOTYPE

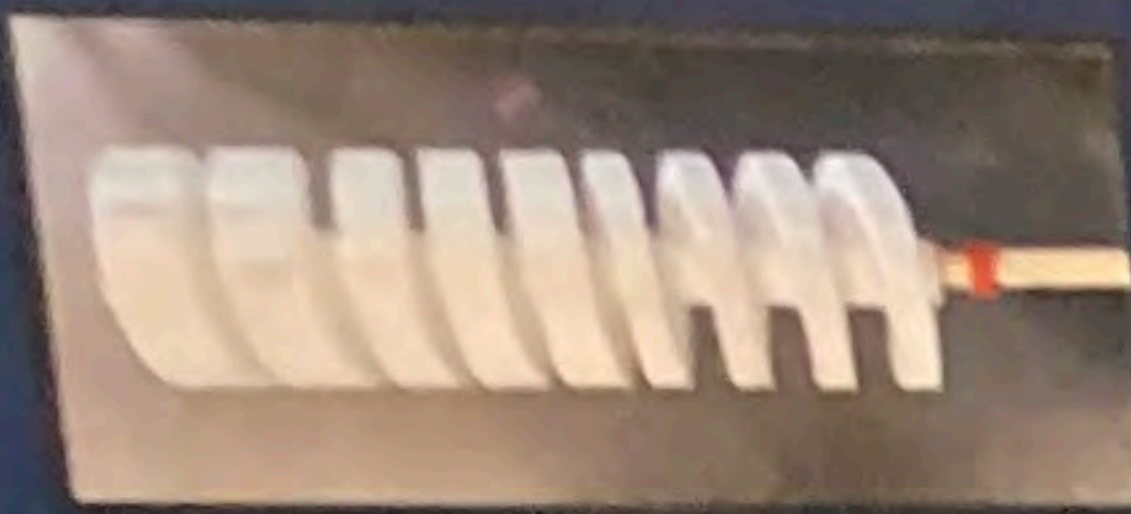
skills

- Make Your Title Pop
- Stabilize Your Trifold
- Get Noticed!



adidas

PLASTIC PROTOTYPE



We used an acrylic pipe and 3D printed parts to construct a prototype.

Testing of the prototype was based on how well particulates are mixed by our auger design.



For each test, we changed the size of the particulates. We used sand and sawdust; the sawdust was sifted to obtain finer particulates. One test was done with sand and wax to simulate the difference in density between the lunar regolith and plastic.

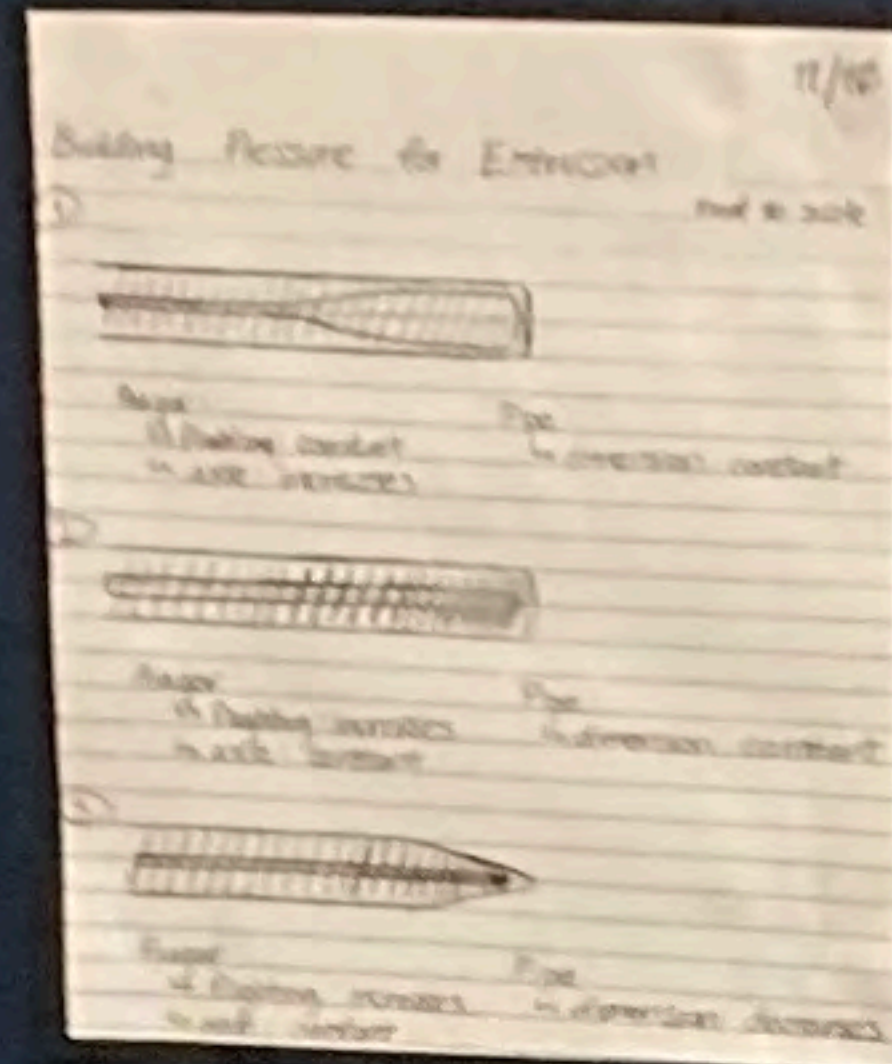
These tests highlighted that large particulates would get caught in between the auger flights. Smaller particulates mix together well for our auger design. The observations of the test with the sand and wax indicated that although a few of the particles combined together, a greater quantity of heavier density particles lingered in the pipe.

The designed auger mixes small particulates effectively, however larger particulates often jam in between the auger flights.

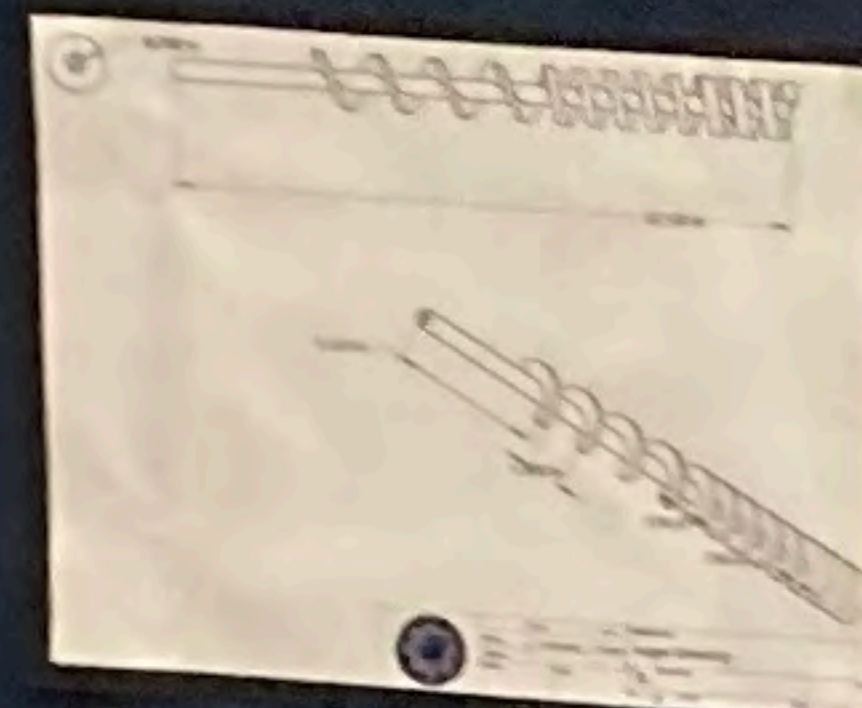
The cost to manufacture a plastic prototype is relatively low with its weight being reasonably low.

The hopper design has only one intake making it inefficient when loading particulates.

PIPE AUGER EXTRUDER



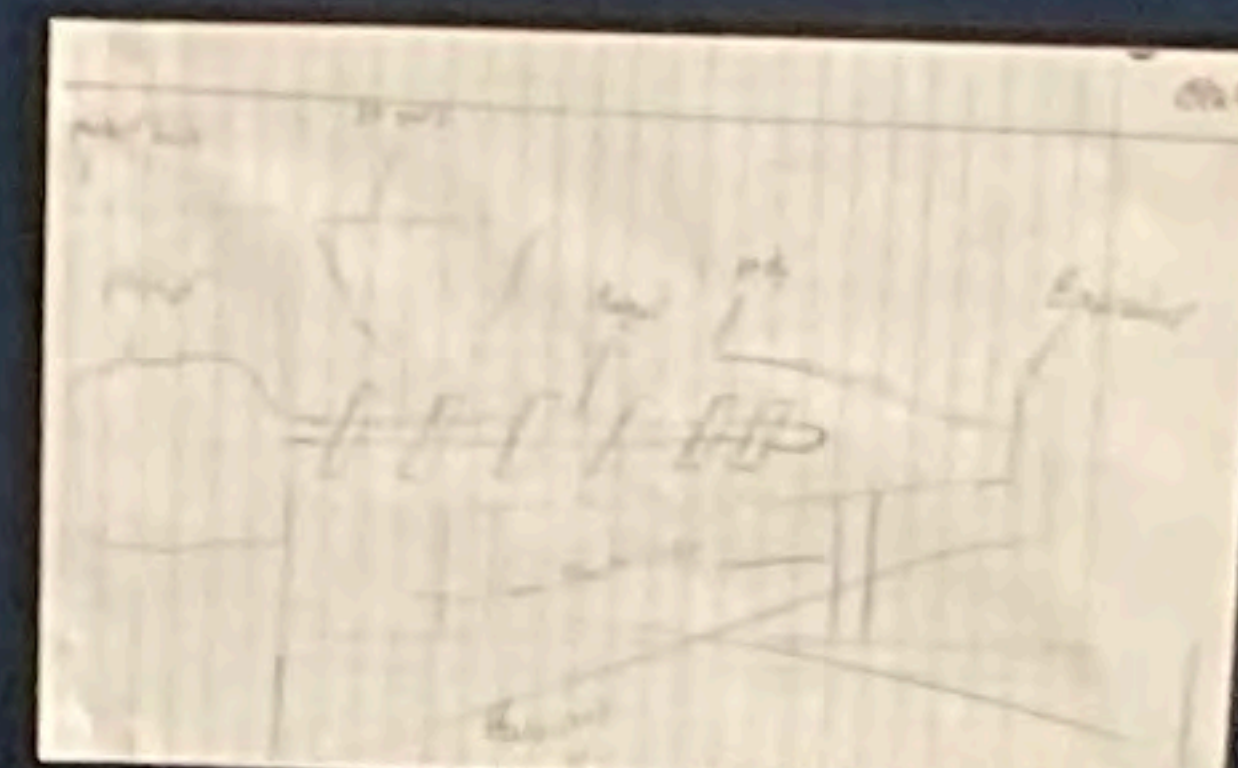
Brainstormed methods to compress the lunar regolith and plastic mixture in the machine.



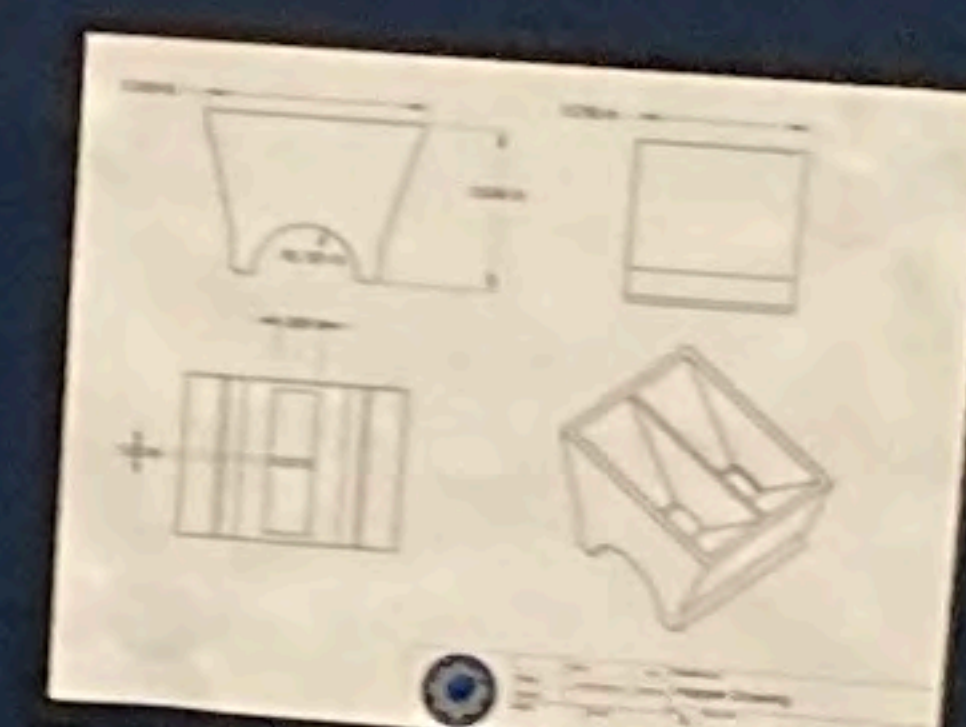
CAD drawing of an auger with decreasing flighting length adhering to the brainstormed ideas.

Given our limited resources, we could not obtain the materials we desired for the final machine. If we had the resources, we would ideally want silicon carbide for the pipe and titanium carbide for the auger and the other components.

GALLATIN HIGH SCHOOL
CODY W, CHRISTIAN M,
GREYSON W, KENNY T.
GLENN BRADBURY



Initial idea for a basic extruder machine.



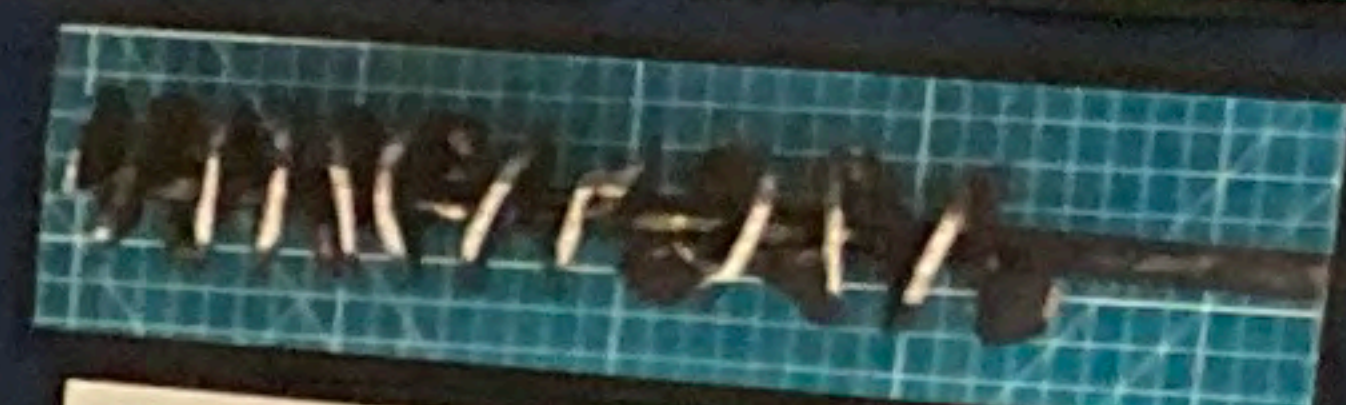
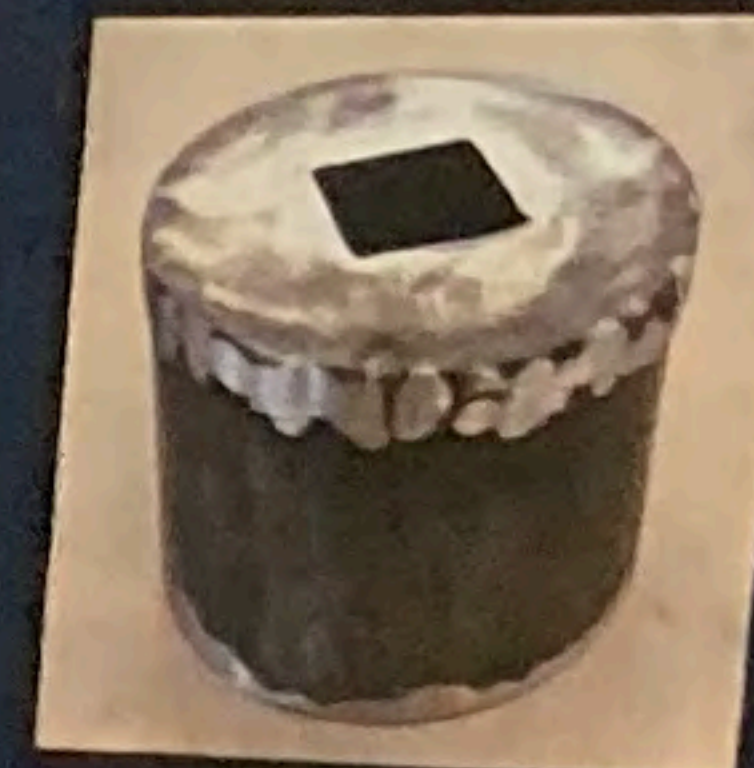
CAD drawing of a double intake hopper to allow two materials to be added at the same time.

Silicon Carbide was chosen because it is cheap, relatively thermally conductive, and hard enough to resist abrasion from lunar soil. Additionally, it is naturally dark in color allowing it to absorb sunlight.

Titanium Carbide was chosen because it has a high melting point of 3,140°C and is hard enough to resist abrasion from lunar soil.

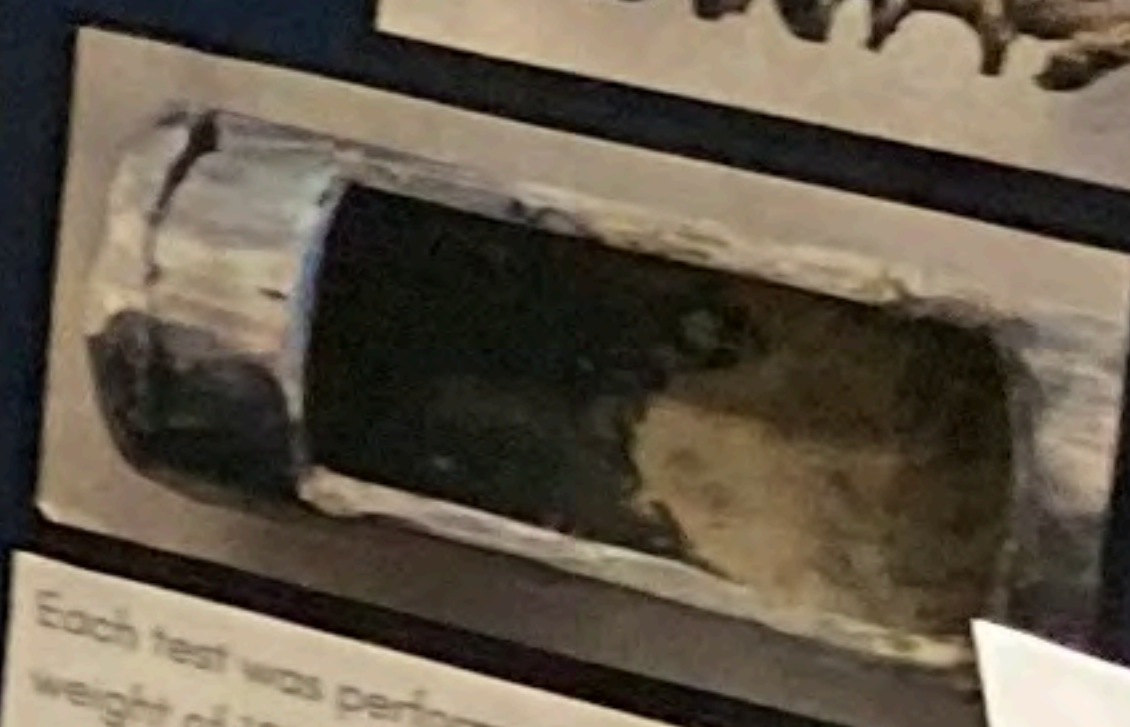
Traditional clay bricks contain chemical compounds like Silica, Alumina, Iron Oxide, Magnesia, and Lime; these chemicals are also found within lunar regolith. As a result,

METAL PROTOTYPE



We used steel parts to make components like the pipe and auger. Additionally, we 3D printed a hopper to construct a prototype.

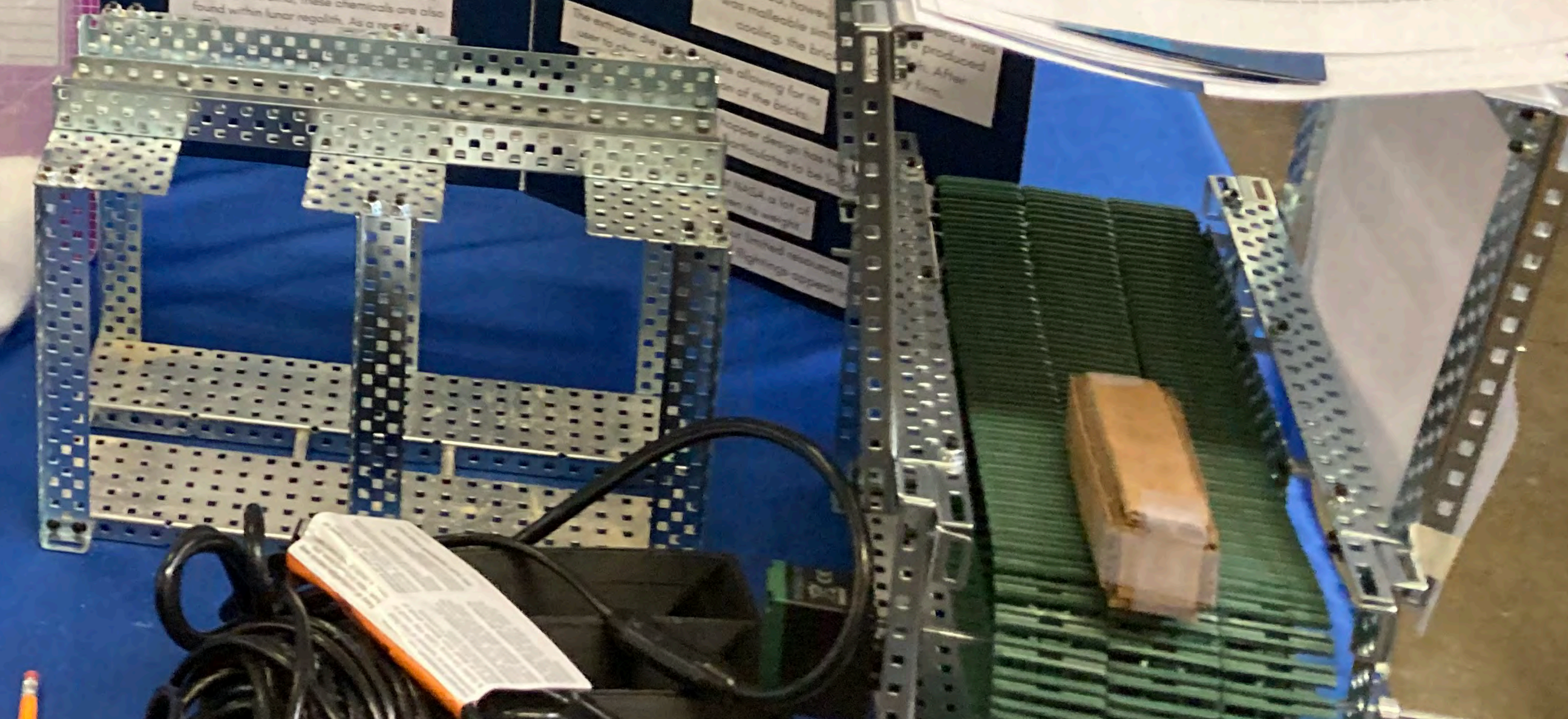
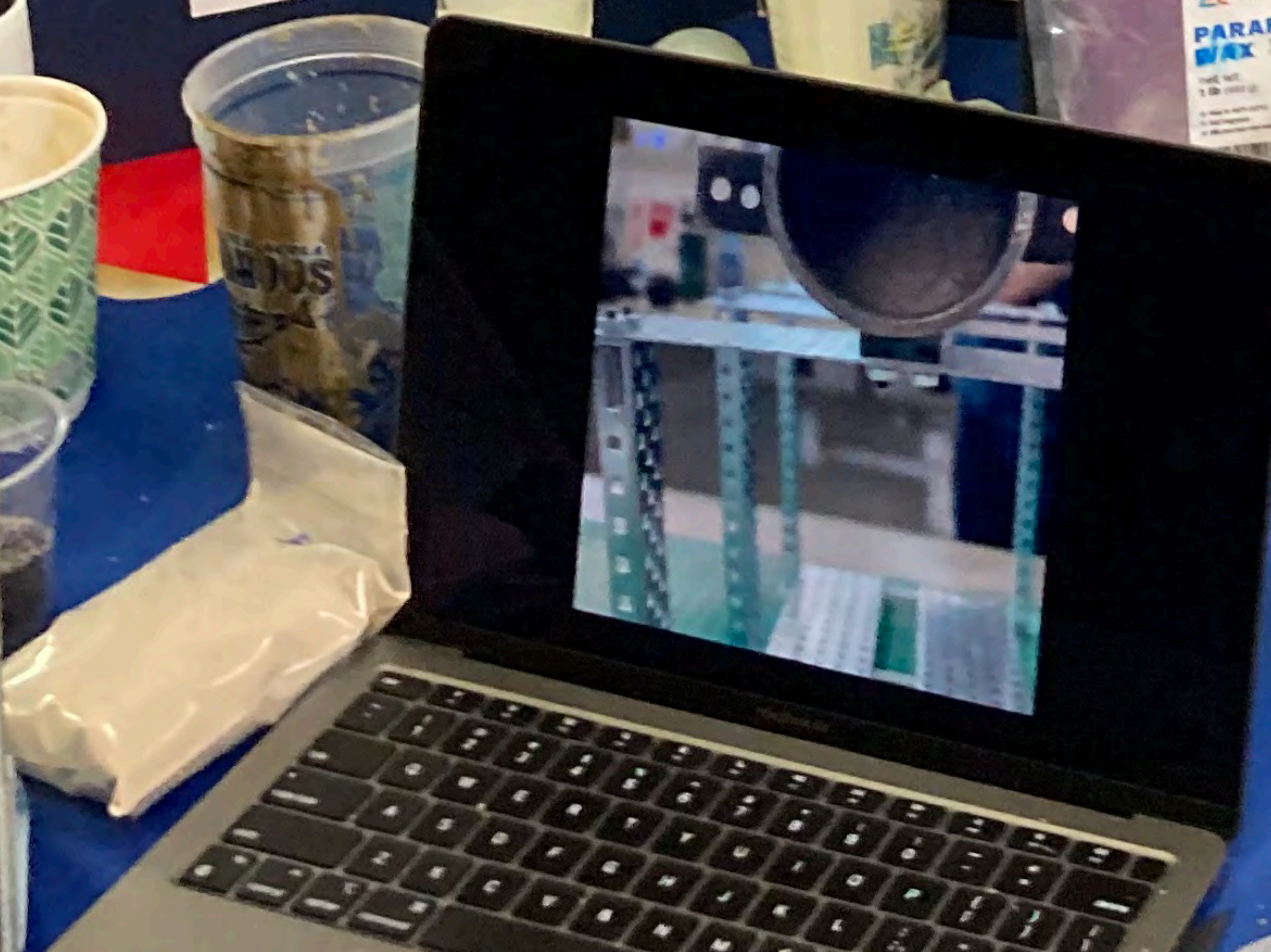
Testing of the prototype was based on mixing, compression, and extrusion of a sturdy brick.



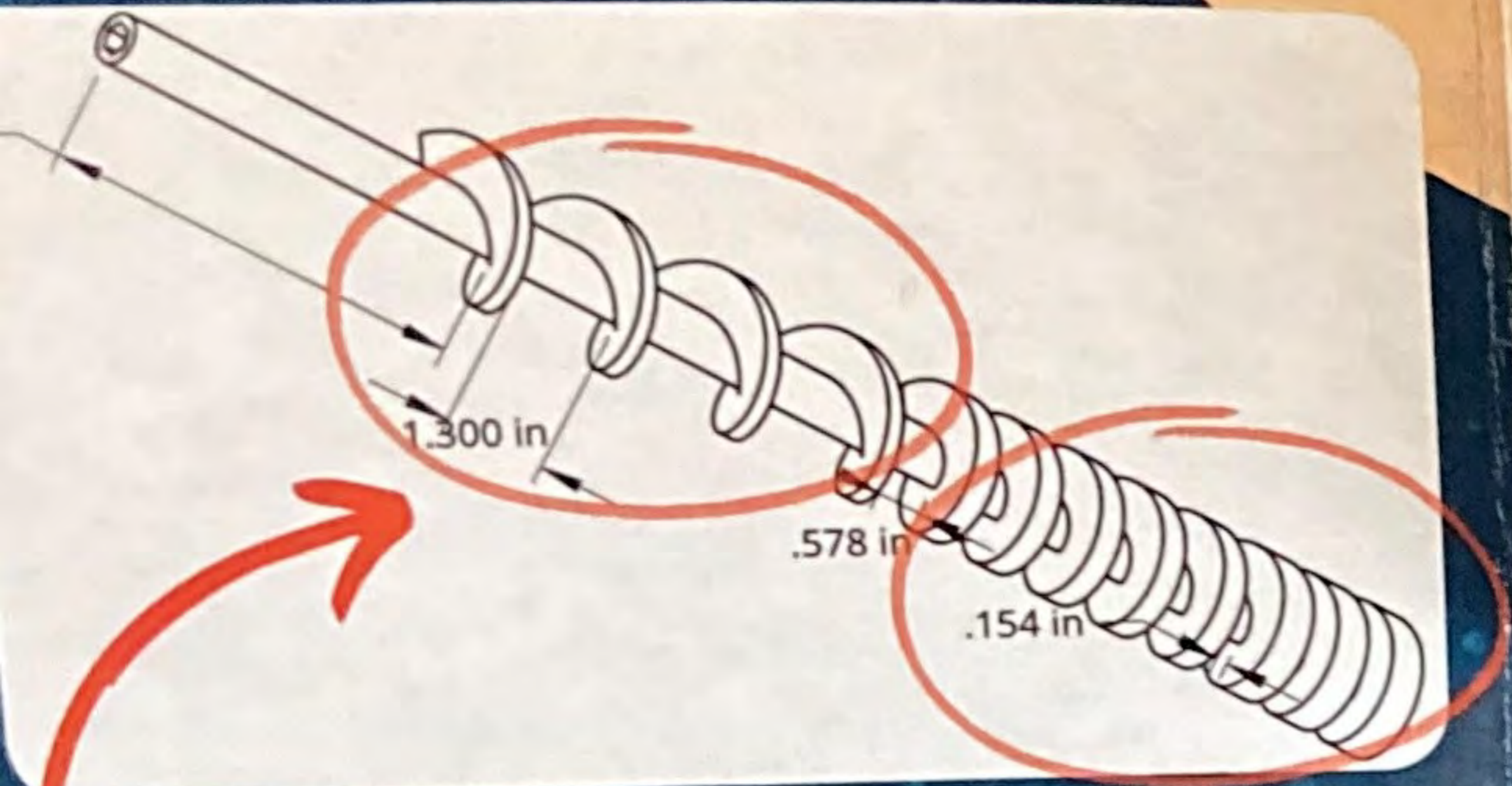
Each test was performed with a constant weight of 150 grams; the ratio between fly ash and paraffin wax was altered between each test. The auger was initially rotated by a motor, but issues arose leading to the auger being rotated by hand.

From these tests, we face some issues concerning jamming in between the auger flights. The hopper design has only one intake making it inefficient when loading particulates.

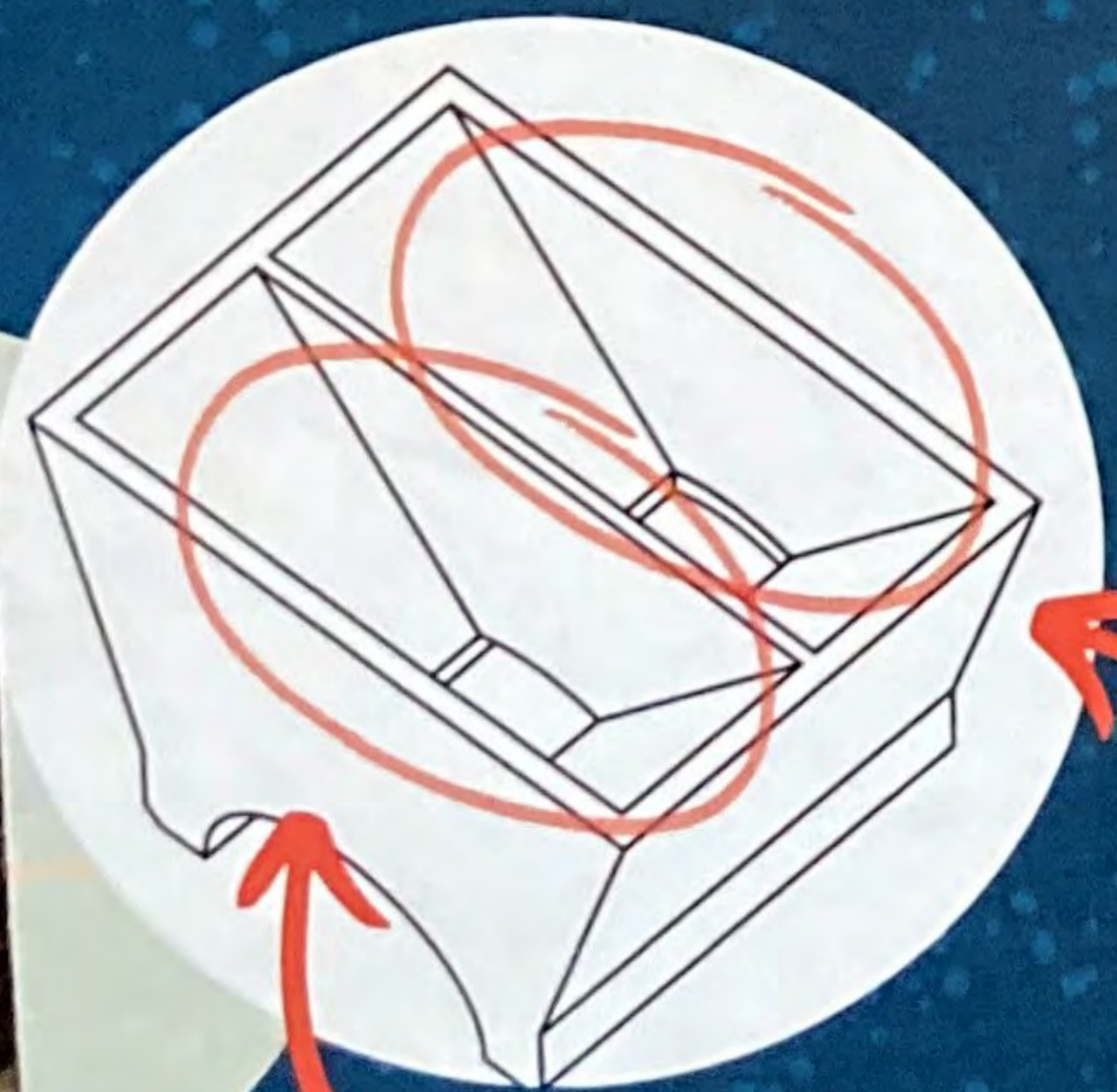
The hopper design has only one intake making it inefficient when loading particulates.



AD MODELS



Individual sections
for mixing and
compression



Separate intakes
for plastic and
lunar regolith

FLIGHT-READY HARDWARE MATERIAL

Silicon Carbide:

Pipe

Titanium Carbide:

Auger, Hopper, Backplate,
Extruder Die

PIPE AUGER EXTRUDER

GALLATIN HIGH SCHOOL

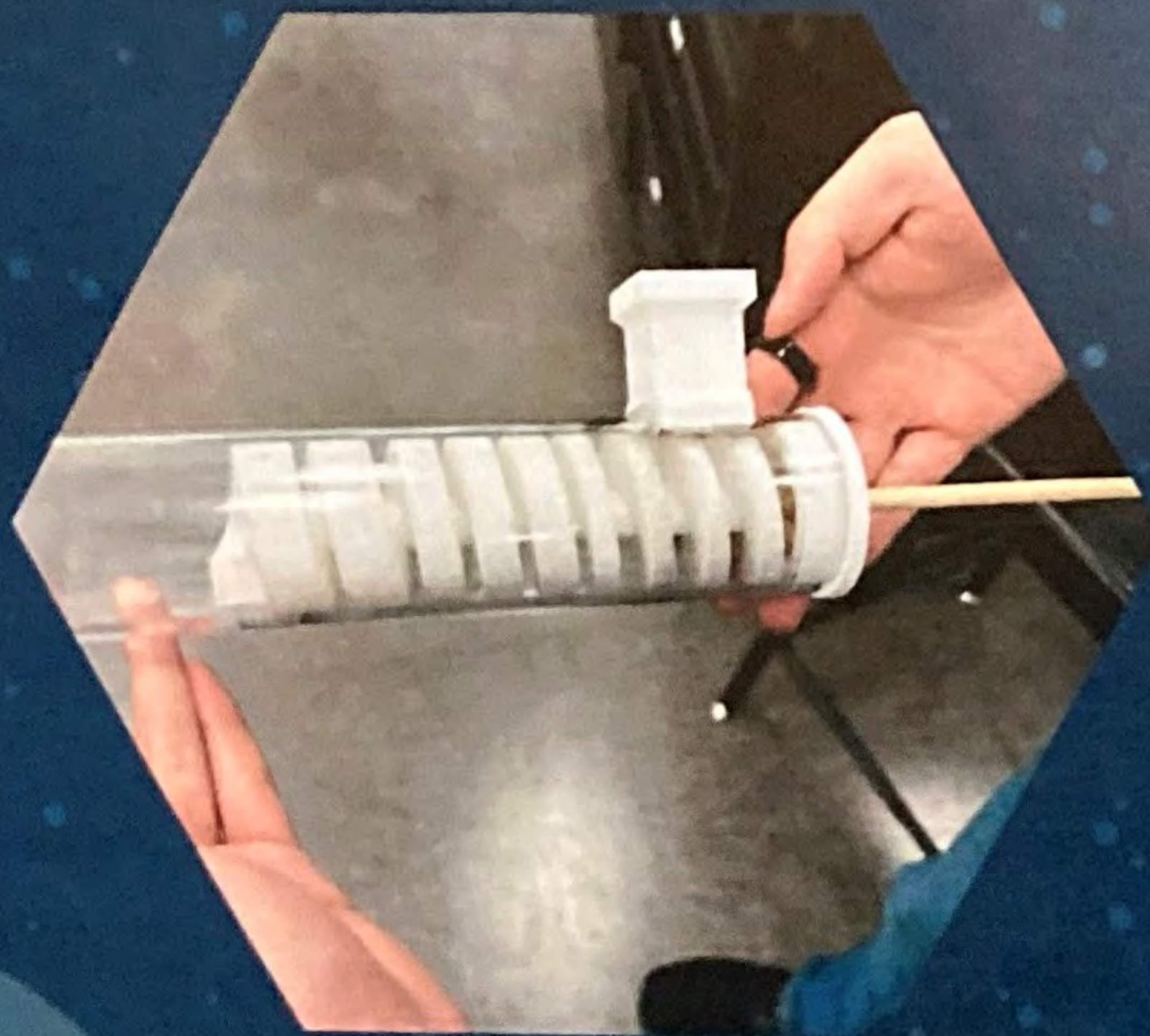
CODY W, CHRISTIAN M,
GREYSON W, KENNY T.

GLENN BRADBURY

PLASTIC PROTOTYPE

Components:

3D printed auger,
hopper, and backplate.
Clear acrylic pipe.

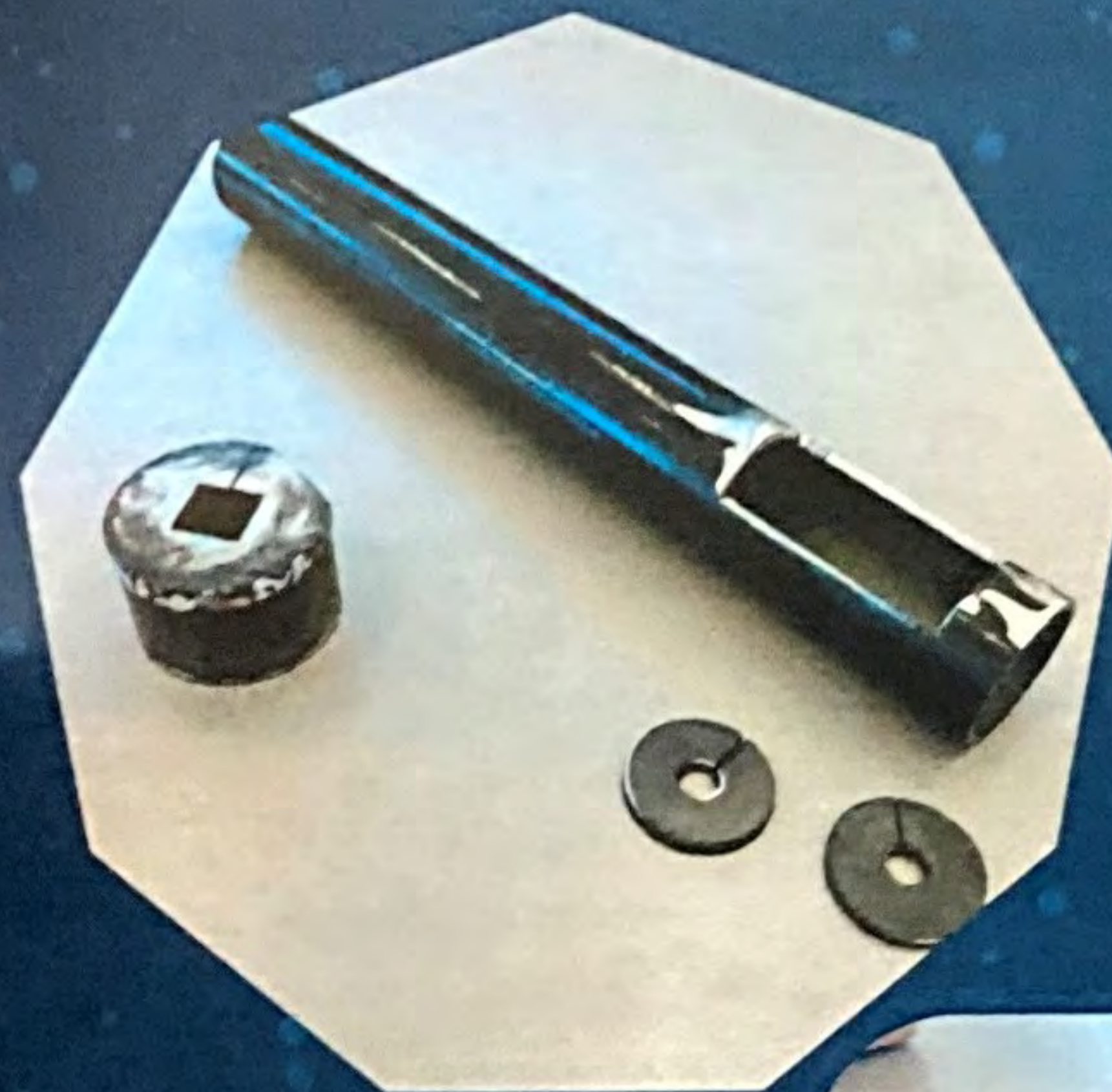


This prototype has certain limitations, including the inability to heat the pipe, the lack of an extruder die, and the fact that it is not to scale.

METAL PROTOTYPE

Components:

All parts are made of steel. Auger flighting bent with a jig



Some limitation of this prototype include its weight and the fact that the components are not made with ideal materials

TESTING

Plastic Procedures



Pour each proportioned particulate one by one and mix by auger

Results

The auger mixing portion works well; small particulates mix evenly, larger particulates clog the auger.



Metal

Procedures

Pour each proportioned fly ash and paraffin wax into the auger via hopper



Results

A full brick was not extruded, but the paste that was extruded was malleable similar to play doh

