Team 517
Sample On-Boarding and Orientation

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Senior Design Team 517

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Software Engineer

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Power Systems Engineer

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Joshua Jones
Robotics Engineer

Matthew Schrold
Test Engineer

Special Thanks

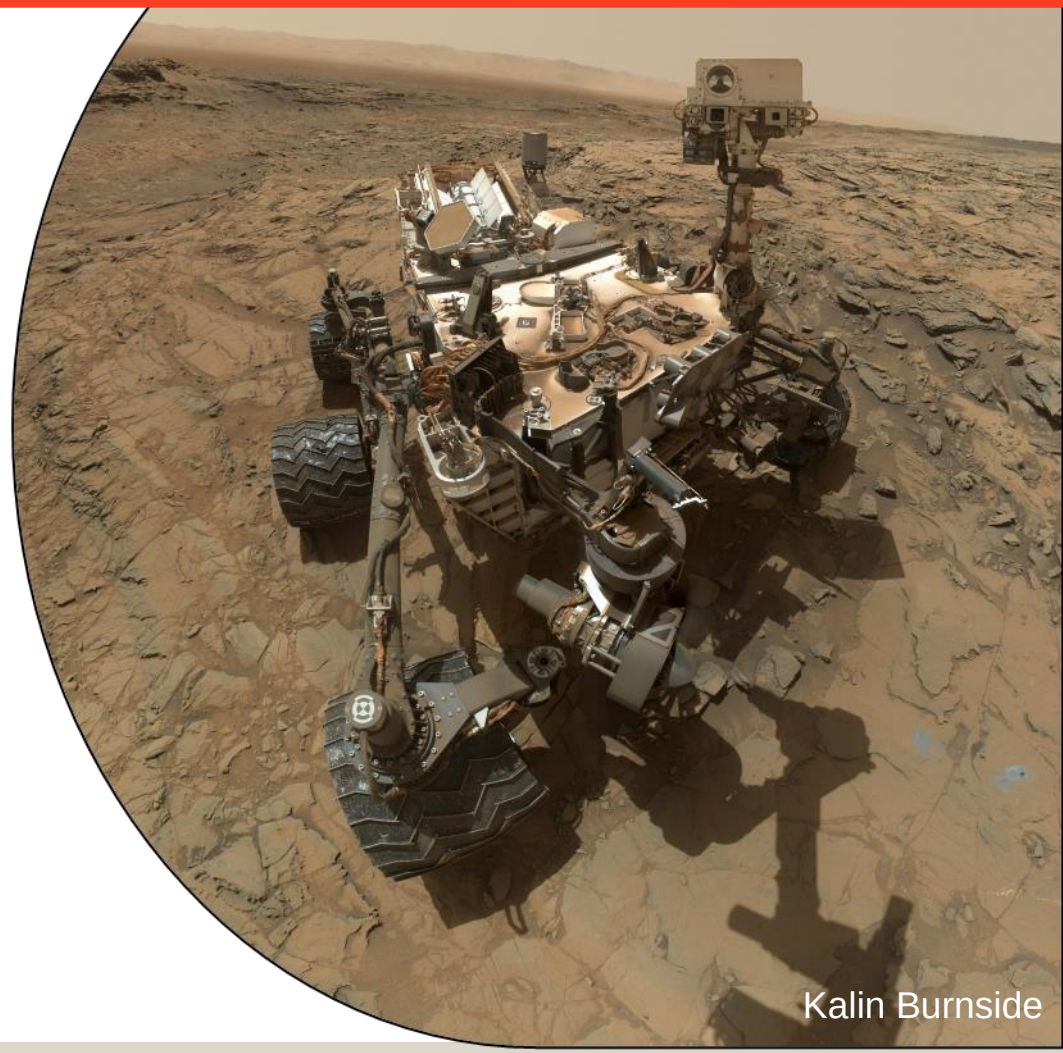
Angela Jackman
Sponsor

Dr. Camilo Ordóñez
Advisor

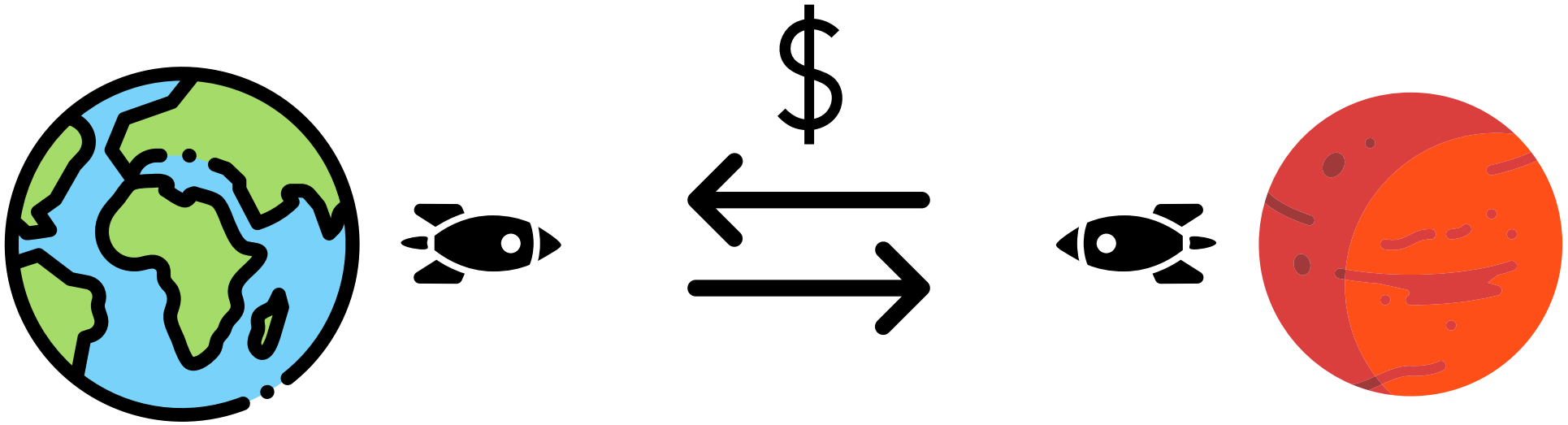
Kalin Burnside

Objective

The objective of this project is for our device to onboard a sample from the environment, manipulate it so that all necessary tests on the sample can be performed, then store acceptable samples



Background



The most expensive variable in space transportation is mass. Reducing weight of cargo reduces the cost.

Our project aims to allow for initial study of samples on Mars to determine if they are worth bringing back.

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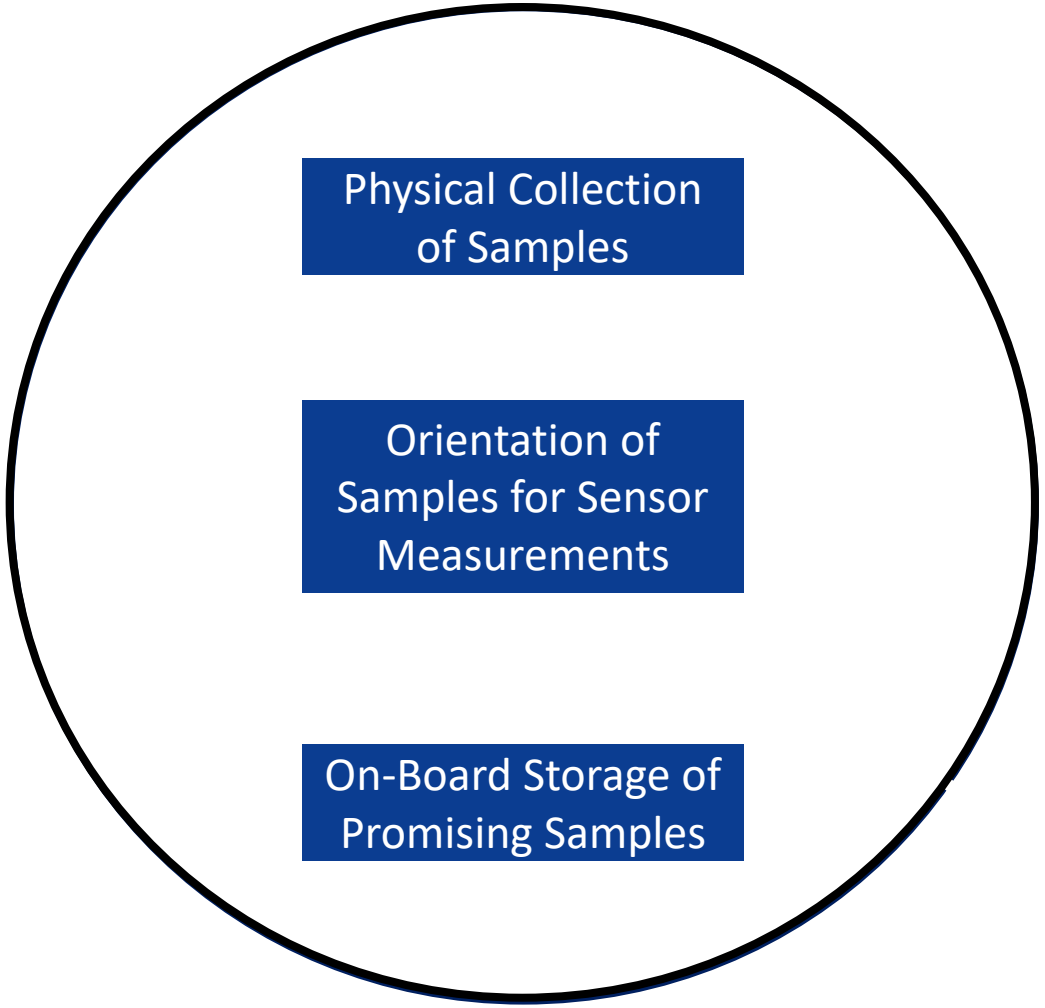
Scope



Power Generation

Transportation

Locating Samples

Sample Return

Sensors

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Customer Needs

Transports the sample on-board

Manipulate the sample for on-board sensors

Store suitable samples on-board

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Customer Needs

Transports the sample on-board

Manipulate the sample for on-board sensors

Store suitable samples on-board

Able to lift sample from surface

Accommodates varying sample sizes

Move the sample on to the rover

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Customer Needs

Transports the sample on-board

Manipulate the sample for on-board sensors

Store suitable samples on-board

- Allow stationary sensors access to any surface location on the sample
- Be able to hold sample in front of stationary sensors
- Allow time for testing to be performed

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Customer Needs

Transports the sample on-board

Manipulate the sample for on-board sensors

Store suitable samples on-board

Store samples in a suitable separate location

Prevent cross contamination of samples

Only store suitable samples

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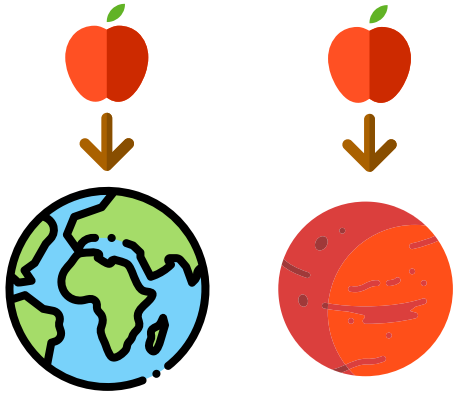
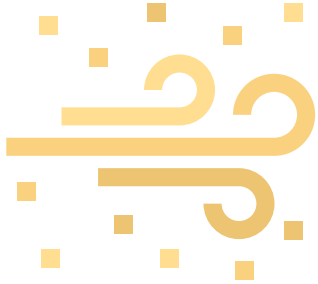
Unique Design Challenges



Gravity Differences



Martian Dust

Cross-Contamination

Temperature Variations

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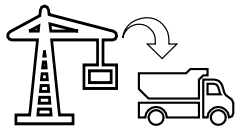
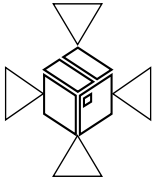
Matthew Schrold

Targets and Metrics



Onboard

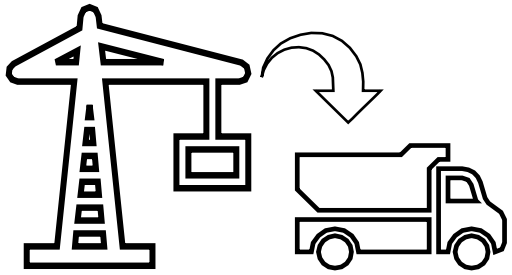
Orient



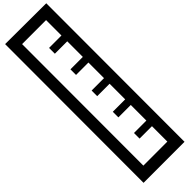
Store

Matthew Schrold

Targets and Metrics



Onboard

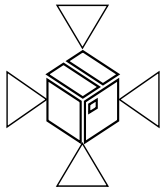


Key Targets

Pick up a sample from up to 50 cm away from the rover

Orient

Move the sample on to the rover within 1 cm of the testing equipment



Store

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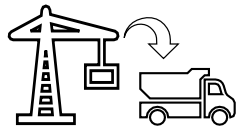
Targets and Metrics



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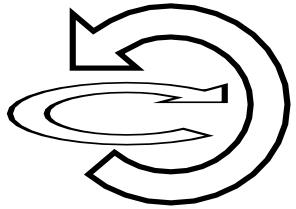

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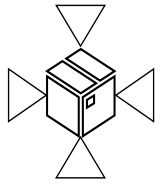
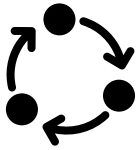


Store

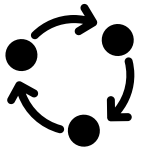
Key Targets

Position the sample in front of on-board stationary sensors

Stabilize sample so that there is 0° of rotation during testing



Rotate the sample 360° about two axes to expose the whole surface area of the sample to the sensors



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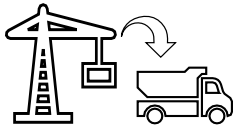
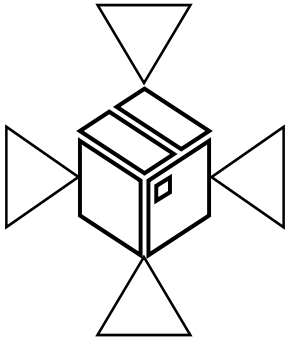
Targets and Metrics



Onboard

Orient



Store

Key Targets

Store 10 samples in an onboard storage unit

Individual storage units are sealed to allow 0% of sample surface area exposure

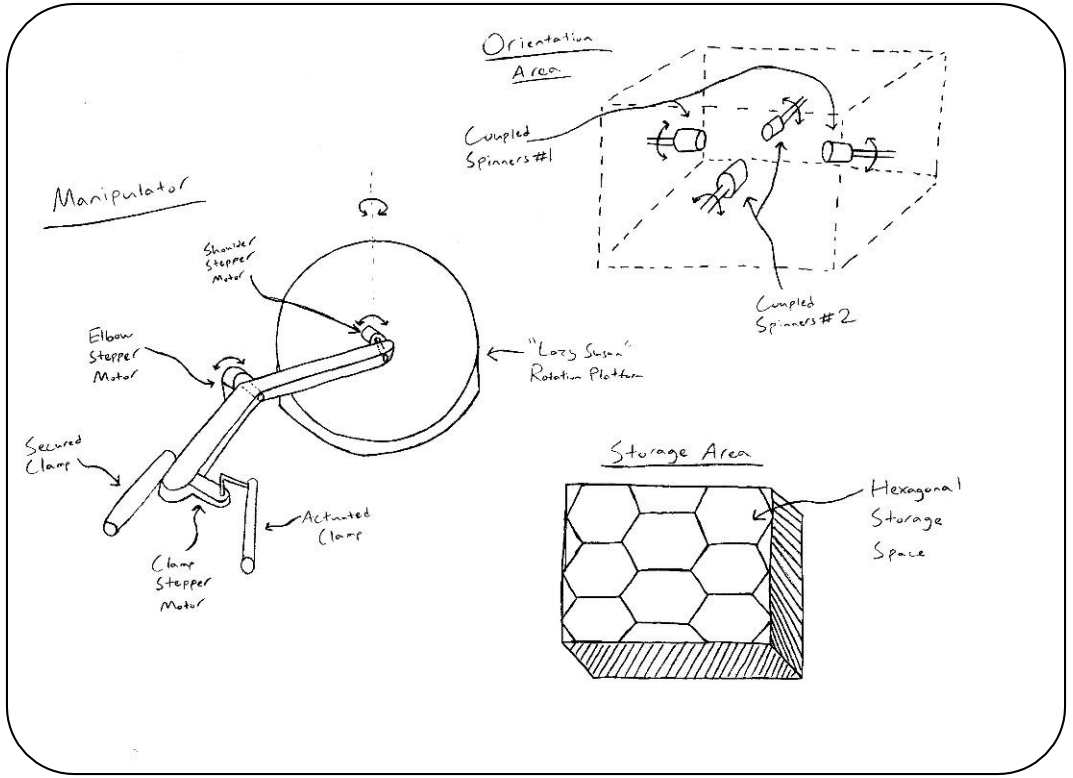
Samples will remain stationary during transport

Matthew Schrold

Design Concepts

Selection Criteria:

- Mass
- Precision of rotation
- ✗ Accommodates various sample sizes
- Stability
- ✓ Storage (Volume and prevent cross-contamination)
- Precision of arm movement



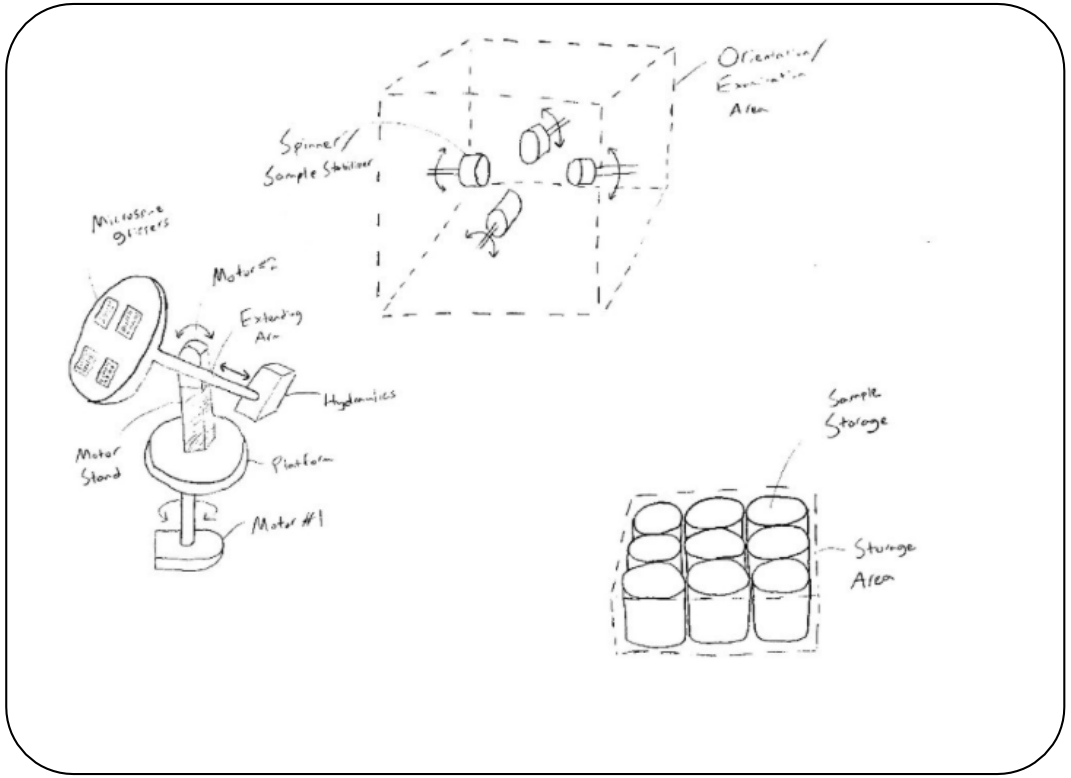
The Claw

Matthew Schrold

Design Concepts

Selection Criteria:

- Mass
- Precision of rotation
- Accommodates various sample sizes
- ✓ Stability
- Storage (Volume and prevent cross-contamination)
- ✗ Precision of arm movement



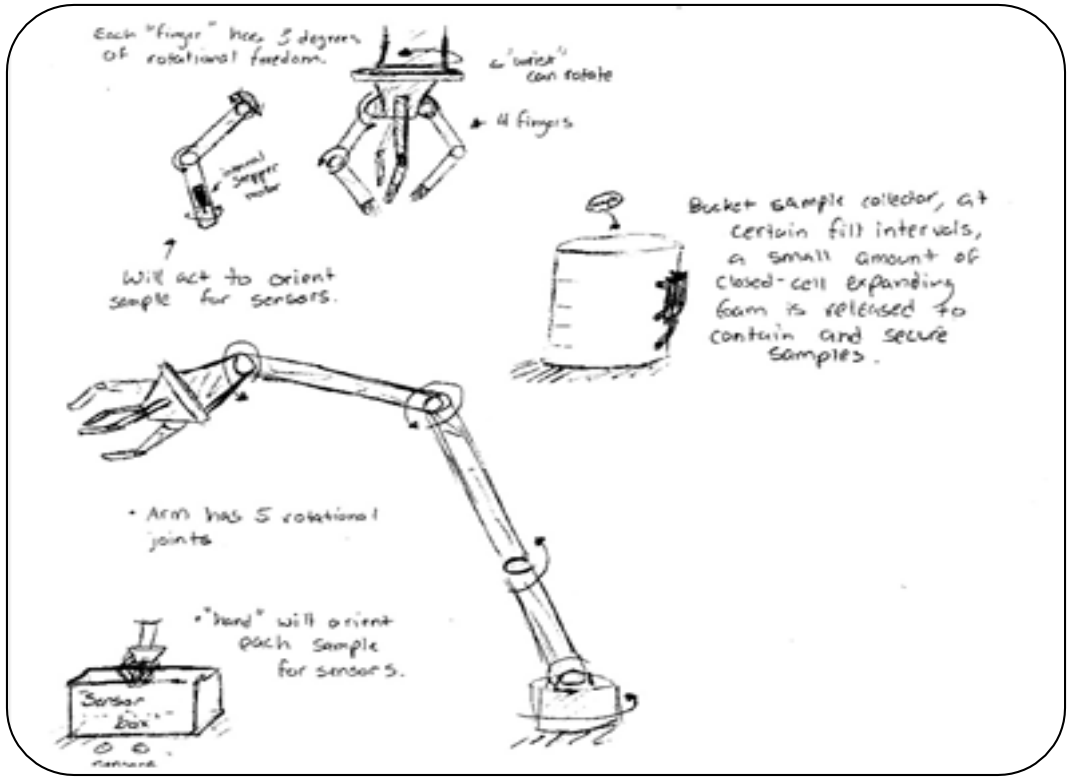
The Micro-Grip

Matthew Schrold

Design Concepts

Selection Criteria:

- ✓ Mass
- ✓ Precision of rotation
- ✓ Accommodates various sample sizes
- Stability
- ✗ Storage (Volume and prevent cross-contamination)
- Precision of arm movement



The All in Two

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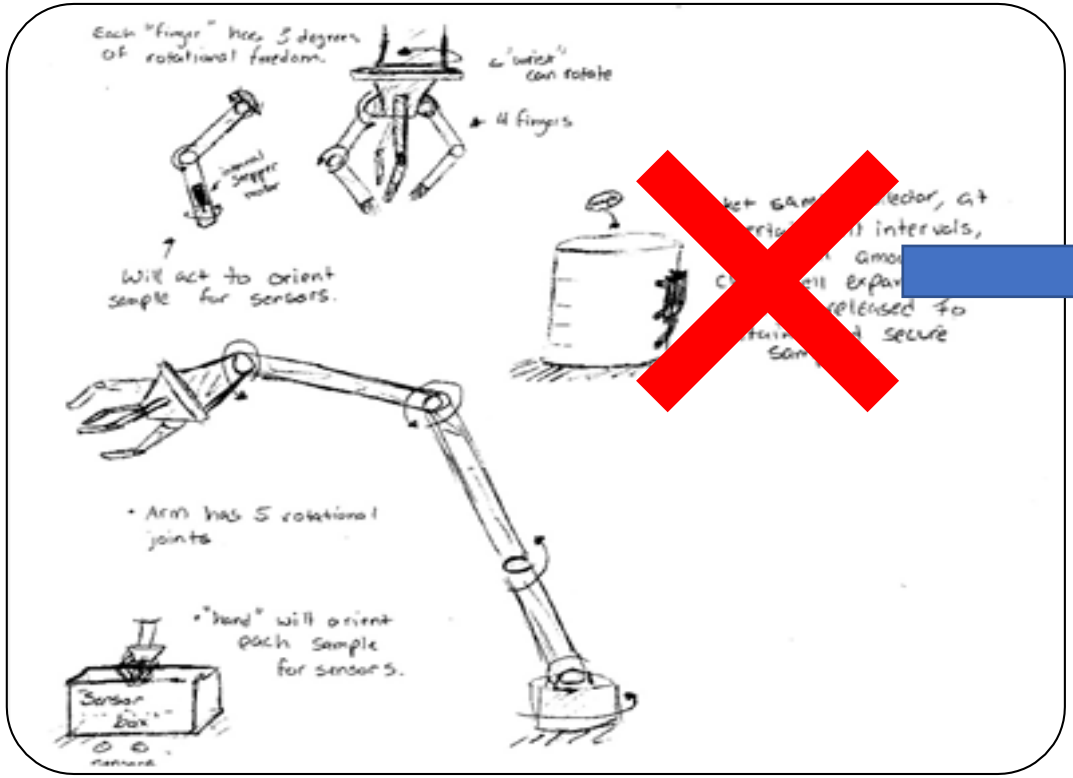
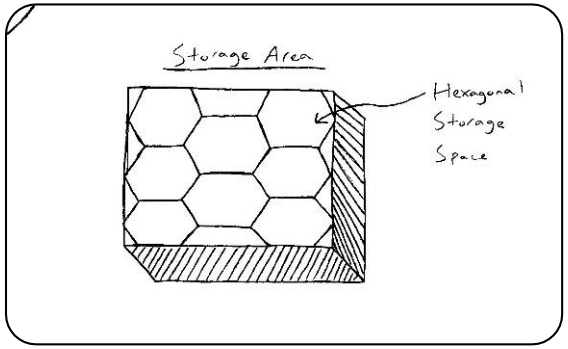
Final* Design





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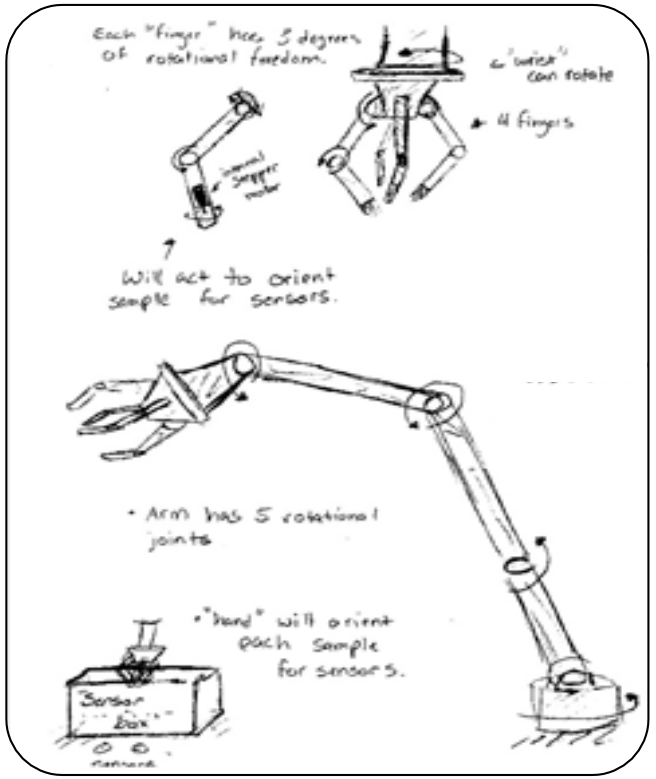
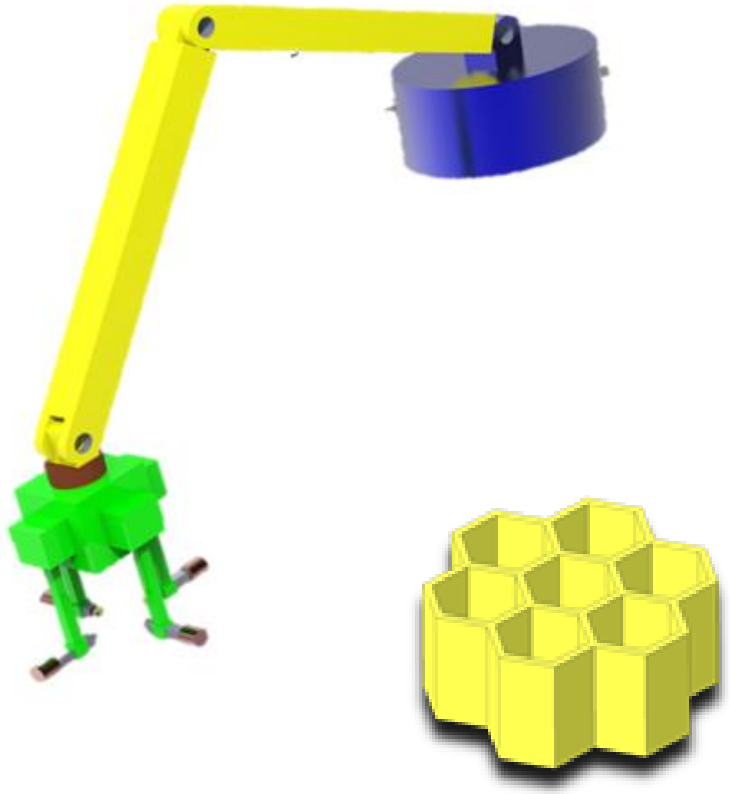
Final* Design



Reduce Complexity



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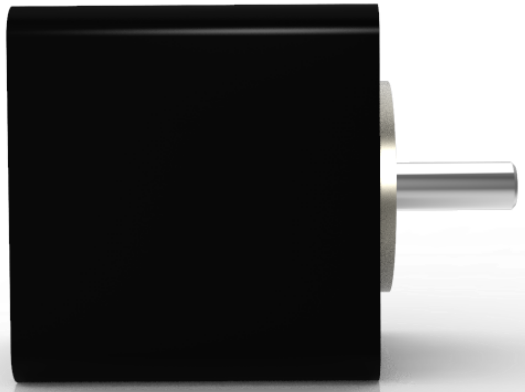
Mechanical Power

DC Geared Motors
- Encoder feedback
- High torque, low RPM
- Brushless (low temperatures)



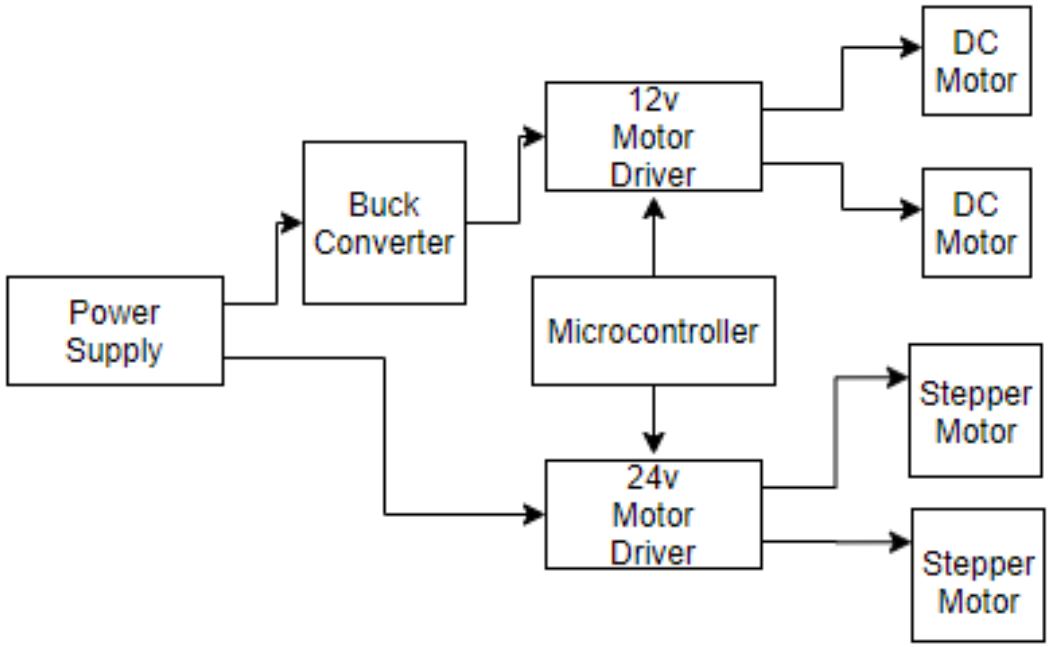
Stepper Motors
- High precision
- Small footprint
- Easy Control

Joshua Jones

Electrical Power

Block Diagram of Power System

- The power supply is provided by the rover
- Buck converters drop input voltage for the motor drivers
- A microcontroller is connected to the communication channels of the drivers
- Motor drivers drive the motors connected to them



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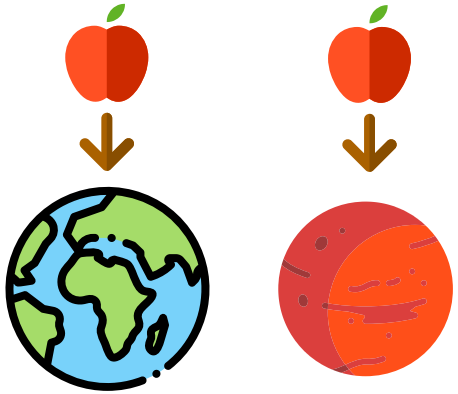
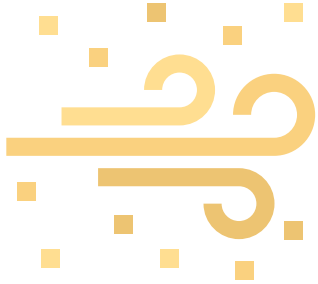
Unique Design Challenges

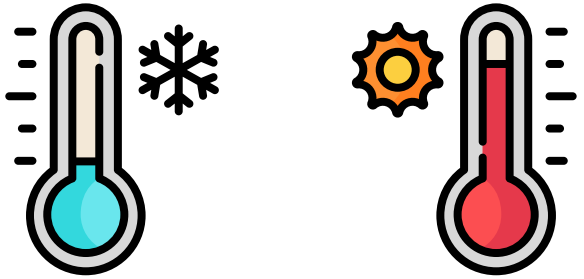


Gravity Differences



Martian Dust

Cross-Contamination



Temperature Variations

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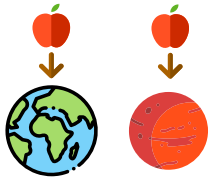
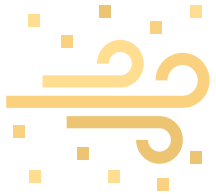
Unique Design Challenges





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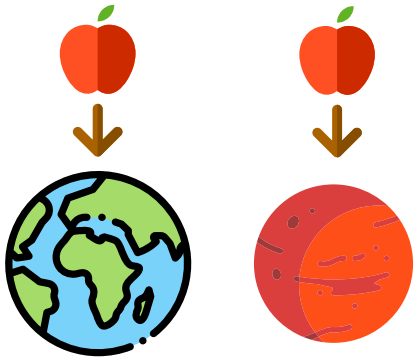
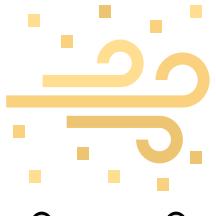
Unique Design Challenges





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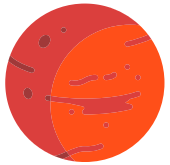
Gravity Scaling

Dynamic Scaling using differences in gravity.

g = 9.81 m/s^2 Weight = 100 kg



g = 3.73 m/s^2 Weight = 38 kg

Effects on:

- Equations of motion derived to represent the robotic system
- Controller utilized to command the actuators onboard

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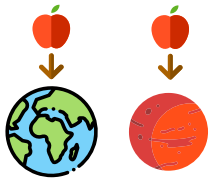
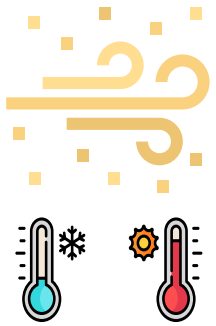
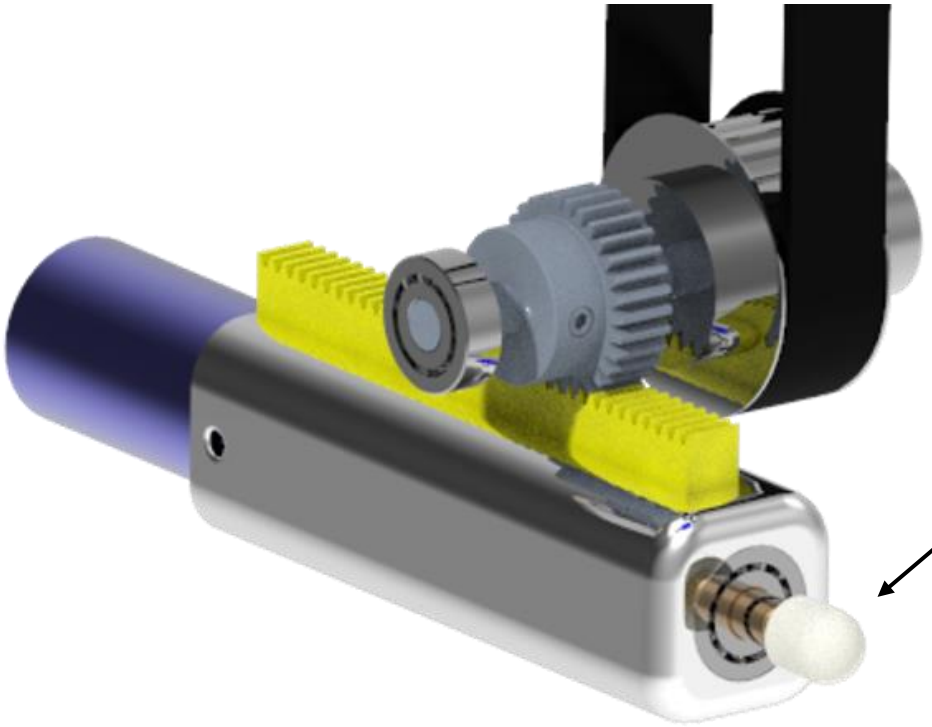
Unique Design Challenges





Cross-Contamination



Silicon Tips are replaceable via mechanism located on storage unit

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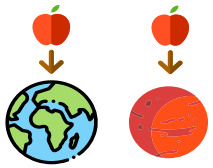
Unique Design Challenges



Martian Dust

Accordion Boot

Flexible accordion seals will prevent dust from getting inside moving parts

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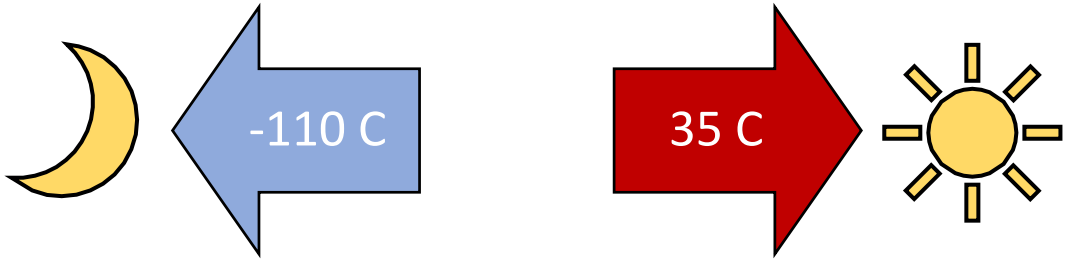
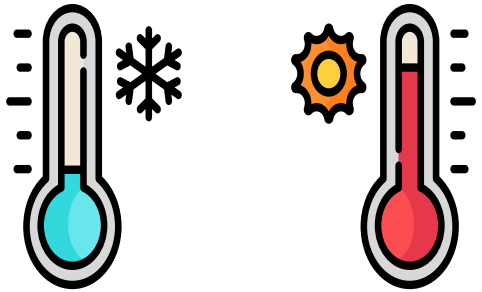
Unique Design Challenges

Temperature Variations



Material	Yield Strength [MPa]	Coefficient of Thermal Expansion [1/K]*10^{-6}	Density [kg/m^3]
Aluminum 2024	324	24.7	2780
Aluminum 6061	276	25.2	2720
Magnesium AZ31B	260	26	1770



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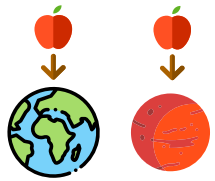
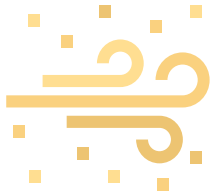
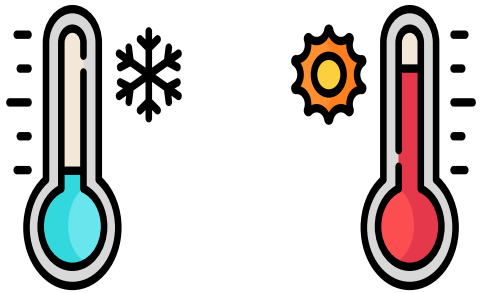
Unique Design Challenges







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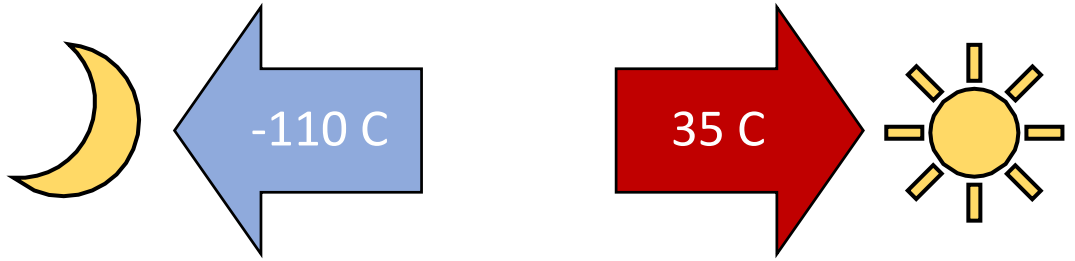

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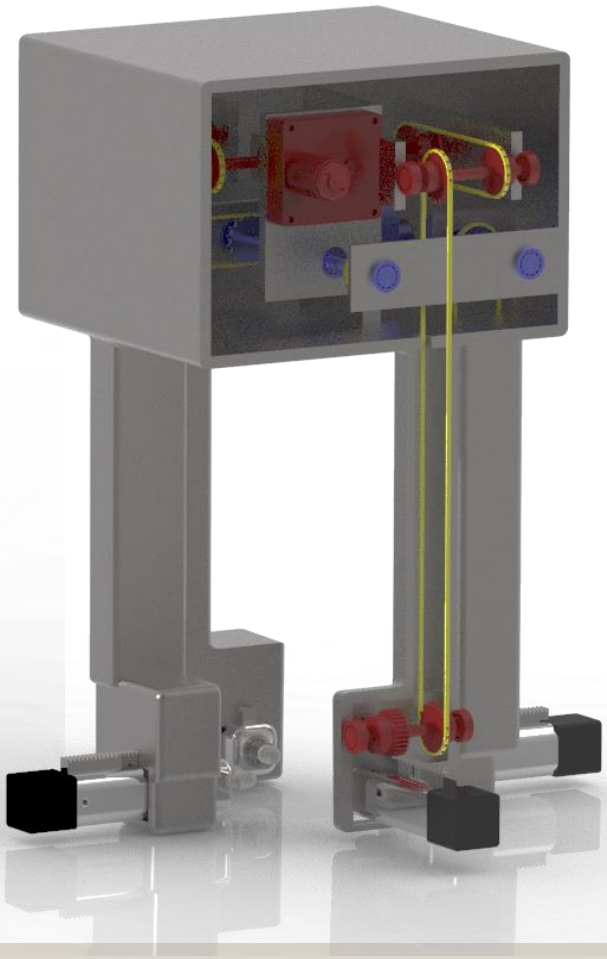
Current Design



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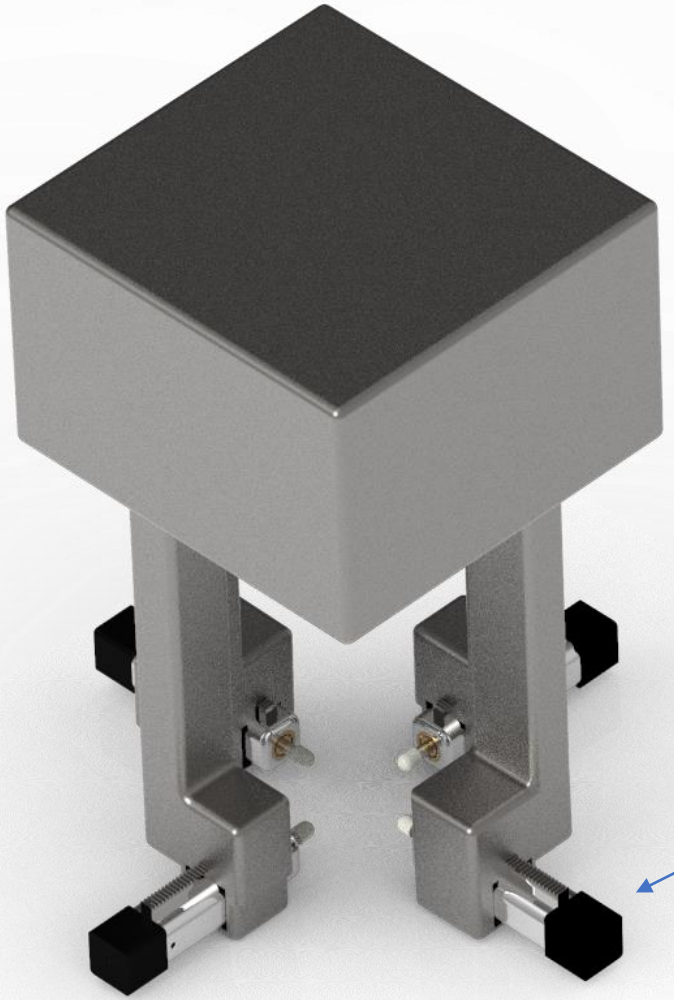
Current Design



Rotational connection to arm is still being developed.

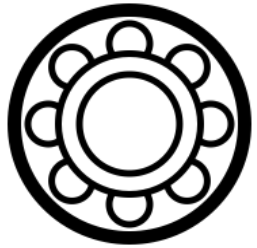
Accordion Boot will be used for seal around fingers.

Joshua Jones

Current Work

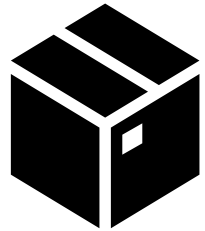
Stress Calculations

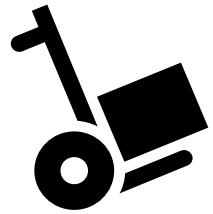
- Calculating stresses acting on gears and bearings throughout the end effector



Ordering Parts

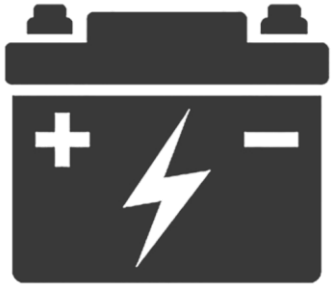
- Received items from first order
- Bringing materials to the machine shop with design drawings





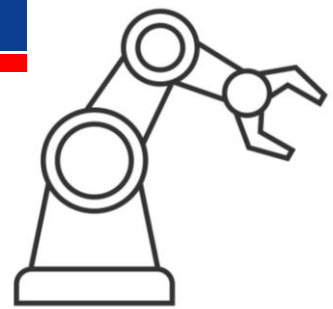
Battery Integration

- High power density
- Battery management systems



Inverse Kinematics

- Developed the 3D inverse kinematics for the robotic arm



Joshua Jones

Future Work

Outer Shell for End Effector	Finalize Other Designs	Order Parts	End Effector Prototype
• Complete outer shell to encase the end effector inner mechanism	• Finalize arm design, CAD, and drawings • Finalize storage design, CAD, and drawings • Initial programming structure • Initial wiring diagrams	• Compile a list for final parts order • Begin 3D printing outer shell component	• Assemble final build • Finalize wiring • Finalize programming • Troubleshoot final build
3/2/2020 - 3/6/2020	3/2/2020 - 3/23/2020	3/9/2020 – 3/23/2020	3/9/2020 - 4/13/2020

Joshua Jones

Team 517
Sample On-Boarding and Orientation

March 5, 2020

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