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CMU CUBESAT - MINI SATELLITE

ONGOING

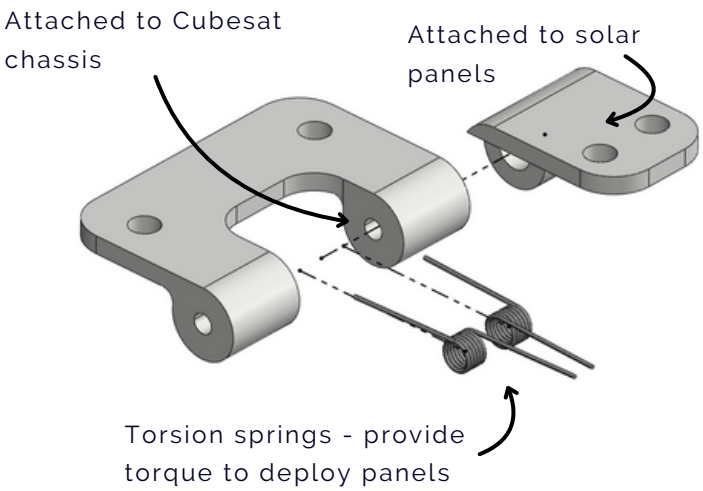
What?

- CubeSats are a class of nanosatellites that use a standard size and form factor
- There are two concurrent versions of this satellite (Argus 1 & 2), due to be launched Fall 2025

How?

- Argus 1: Designing a deployment mechanism for solar panels in low-earth orbit
- Argus 2: Developing modal and stress analysis models for CubeSat structure in ANSYS

V1



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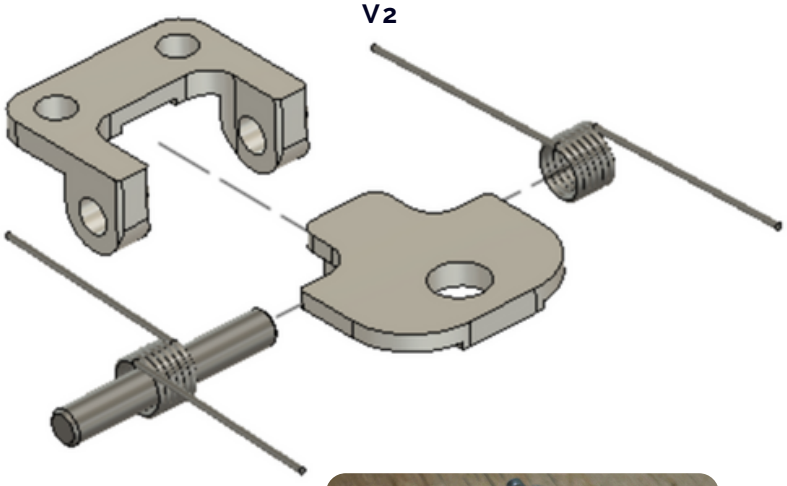
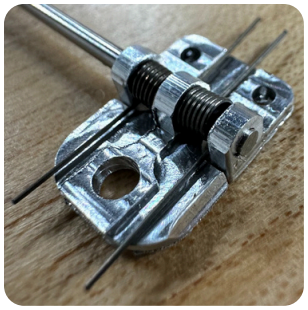
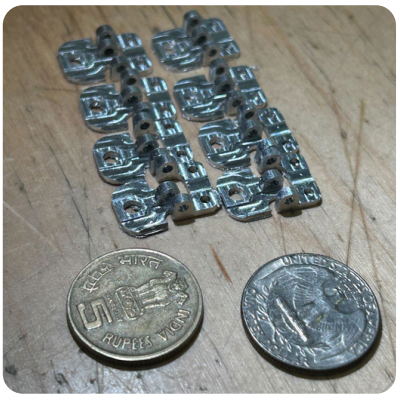
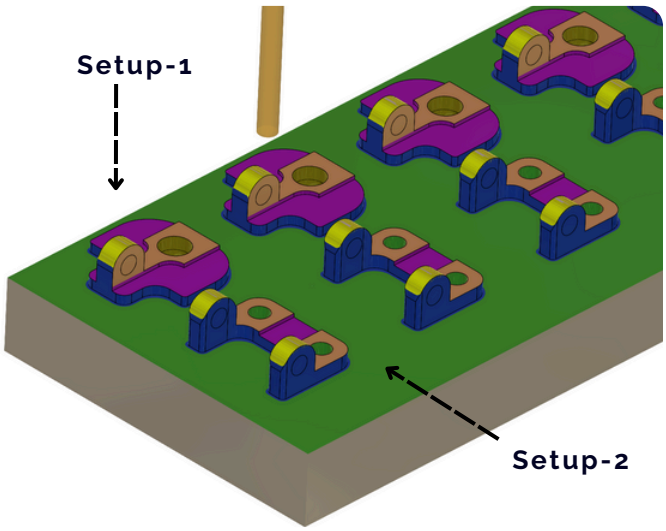






DESIGN

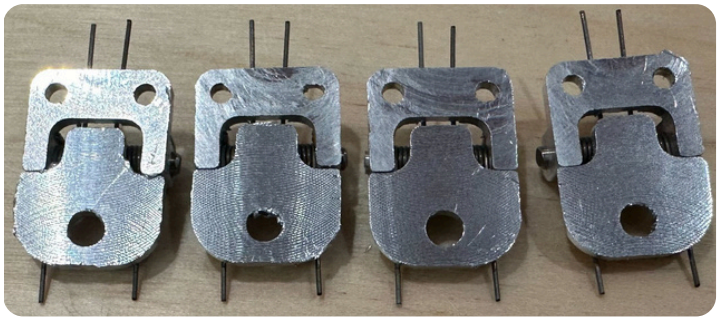
- Designed in **Fusion360**
- Implemented **DFMA** techniques to optimize for 3-axis machining
- Iterated over multiple versions to increase torque by **200%** and decrease volume by **40%**
- Calculated boundary conditions to select off-the-shelf components to reduce costs and lead-times



CAM - 3 Axis Machining (2 setups)

MANUFACTURING

- Manufactured hinge components using 3-axis CNC Milling
- Minimized setups and machining time using **CAM** (Fusion360)
- Programmed multi-part CAM setup to increase manufacturing speed by **16x**



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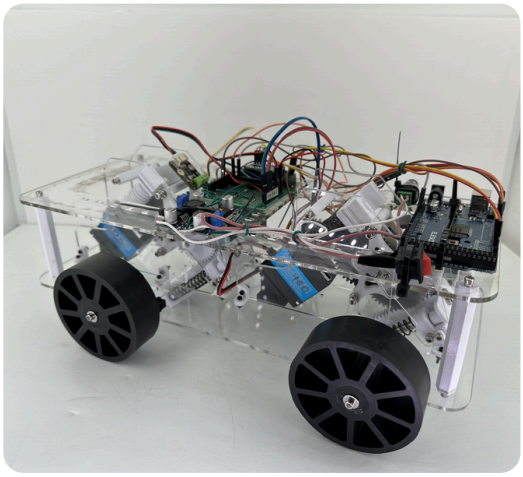
HOPPER - A JUMPING ROBOT

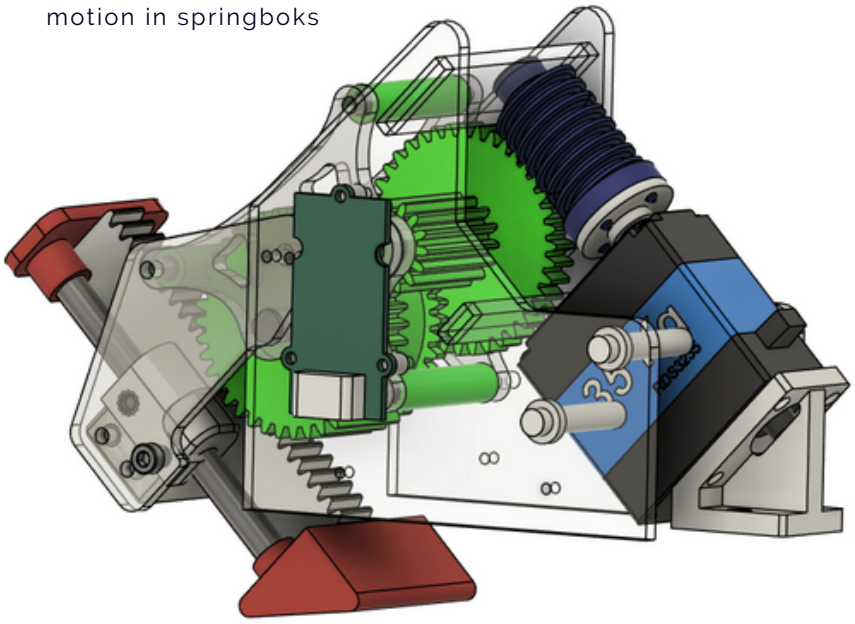
What?

- Hopper is a small, bio-inspired jumping robot
- It was built towards testing and validating whether jumping is more energy efficient than wheeled locomotion, when navigating through uneven terrain
- The bioinspiration : pronking motion in springboks

Results

- Increased gear ratio by **10x** by integrating worm wheel
- Robot demonstrated a maximum jump range of **159mm**, with a mass of **1.05 kg**
- Robot demonstrating a Cost of Transport of **80.92**



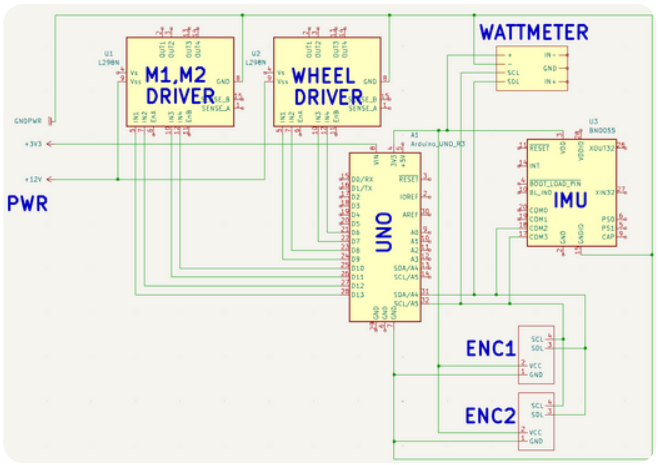


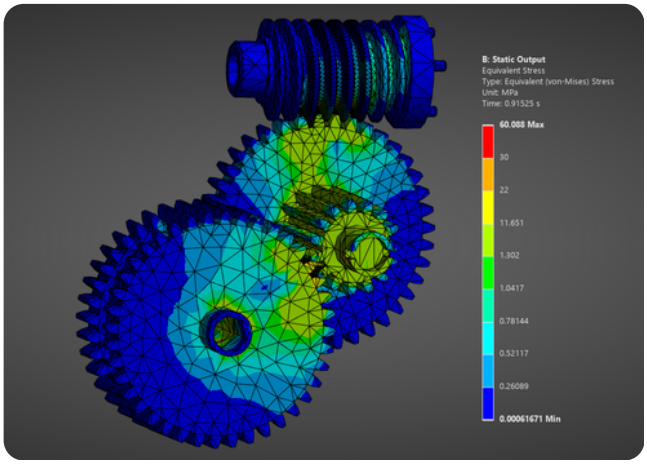
DESIGN

- Redesigned gearbox from compound spur to worm wheel geartrain in **Fusion360**
- Prototyped gearbox using rapid prototyping (**FDM 3D Printing**)

MECHATRONICS

- Selected and integrated positional sensors, power systems (converters, battery), micro-controller and actuators for the system
- Designed electronics layout in **KiCAD** for data signals and power





ANALYSIS & FEA

- Plotted equations of motion in **MATLAB** to determine co-relation between robot parameters and motor specs
- Calculated system dynamics based on **equations of motion** to determine motor parameters
- Used loads from system dynamics in **ANSYS Mechanical** to determine stresses in gear train

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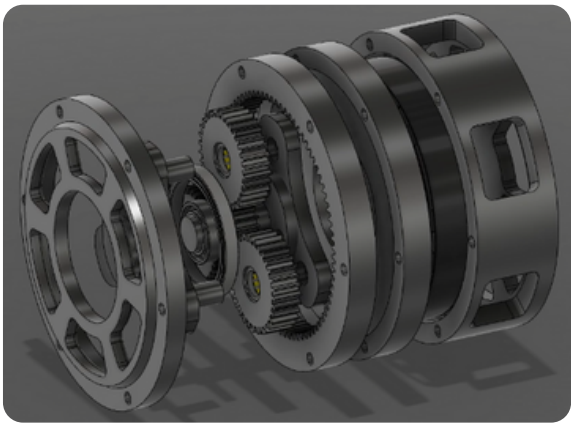
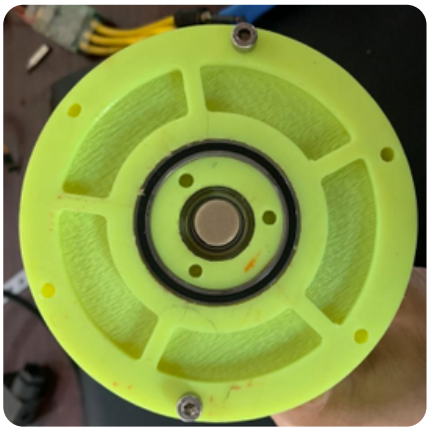
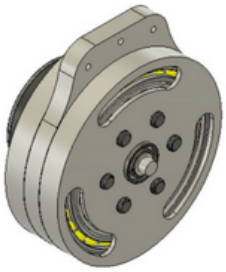
PLANETARY GEARBOX







Cycloidal Gearbox

Planetary Gearbox

What?

- Designed and prototyped a single-stage **planetary gearbox** for developing a proprioceptive actuator for a quadruped robot
- Selected **machine elements** (bearings, bushings, pins, gears) and fasteners based on static force calculations

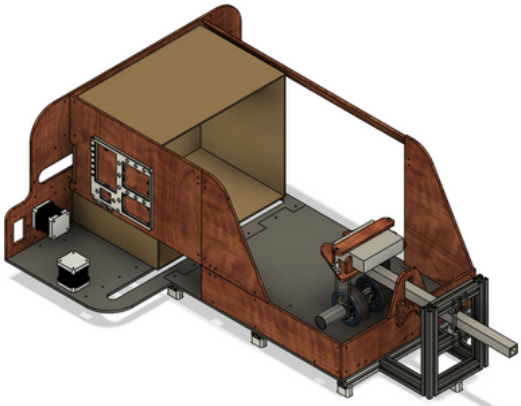
How?

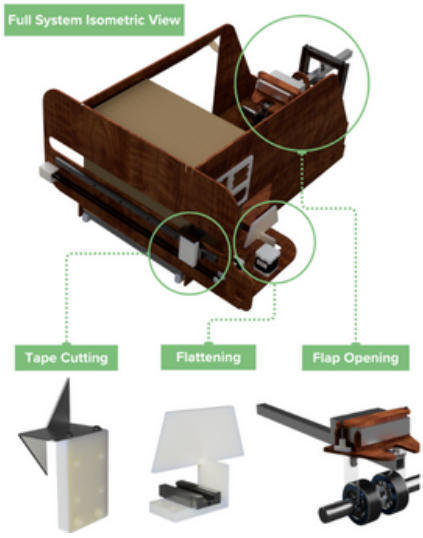
- Used **SOLIDWORKS** to design a parametric assembly to allow for different configurations of gear ratios
- Calculated required output torque by solving **dynamical equations** of motion of quadrupedal robot
- Prototyped gearbox using **FDM 3D Printing**

Results

- Gearbox had a maximum output torque of **14 N-m** with a **6:1** reduction

BOXMANIA - BOX FOLDING ROBOT





What?

- Designed and prototyped a robot that opens, unfolds and flattens cardboard boxes
- Performed **FMEA** to refine design
- Conducted static analysis to determine **motor parameters** (speed, torque)

How?

- Used **Fusion360** to design chassis and components for robot
- Fabricated chassis components using **Laser Cutting** and **3D Printing**
- Applied **DFMA** techniques to minimize number of 3D parts to reduce fabrication lead times

Results

- Robot successfully processed a cardboard box in **25 sec**.
- Improved system reliability to **80%** by applying FMEA techniques

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BUTTERFLY - BUTTER MELTING DEVICE

What?

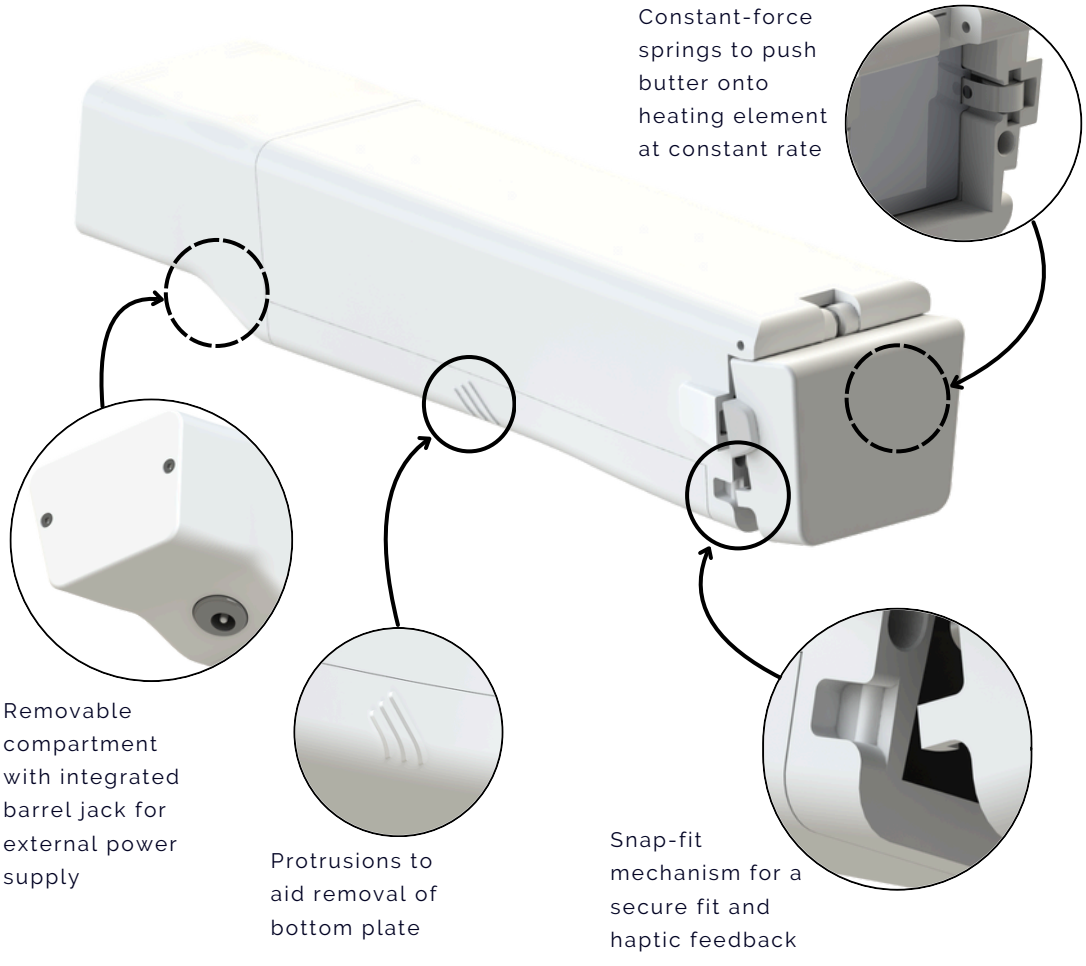
- Butterfly is a device that melts butter, so it can be easily applied to toast
- Advantages:
  - Prevents toast from tearing
  - Prevents toast from cooling due to cold butter
  - Reduces mess

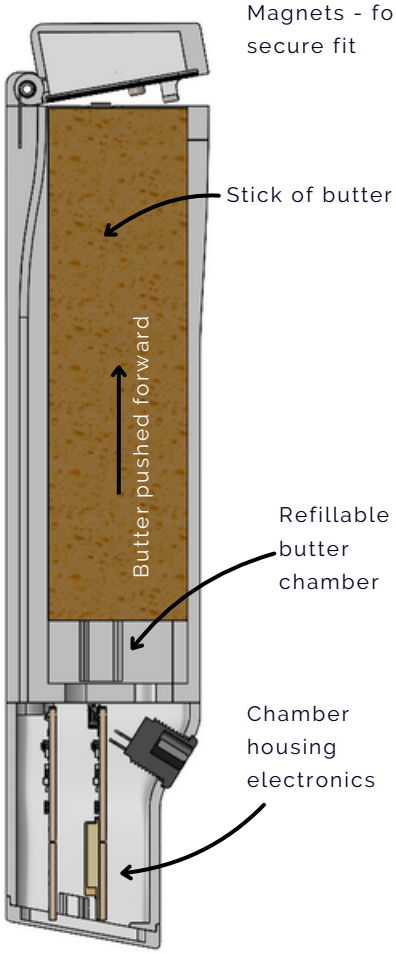
Challenge

- To design an ergonomic and aesthetically pleasing functional prototype of an appliance
- To maximize usability of device by incorporating snap-fits, magnets and springs
- To minimize usage of electronics (actuators, sensors, batteries)

How?

- Produced **3D CAD** models and working assemblies for the device using **SOLIDWORKS** surfacing and plastic design tools
- Designed electronics subassembly incorporating **ESP32**, thermistor and power circuitry
- Fabricated using **rapid prototyping** methods (3D Printing)





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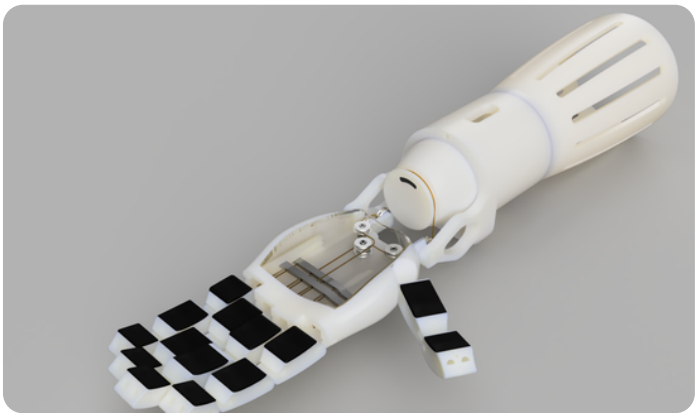
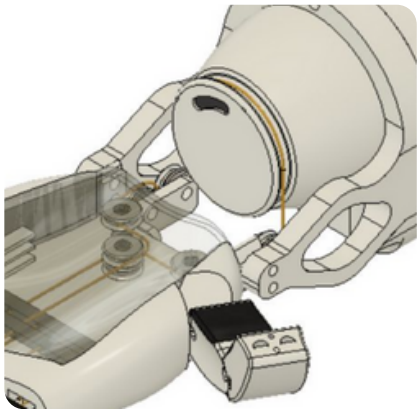
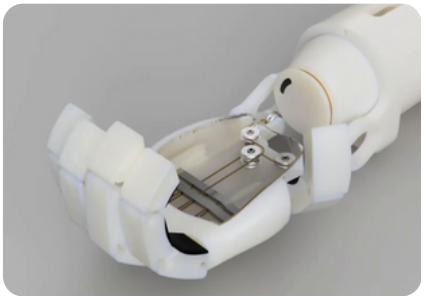
PROSTHETIC ARM

What?

- This device is an affordable, easy-to-manufacture prosthetic arm that converts arm rotation into a grasping motion
- The arm utilizes **leadscrews** and **pulleys** to achieve motion

How?

- Designed **parametric assembly** in **Fusion360**, to allow for different configurations of arm sizes
- Implemented **flat springs** to achieve underactuated grasp

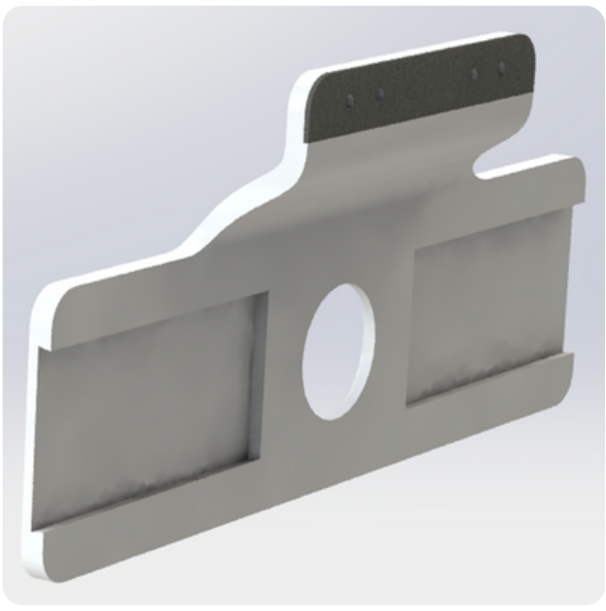
Results

- **1 degree of freedom** drove 5 digit grasping motion, with grip strength sufficient to hold **1kg**
- Patent process for this implementation is ongoing

HIP EXOSKELETON - METAMOBILITY LAB

ONGOING





What?

- The hip-exoskeleton is a human-assistive wearable device that enhances human mobility
- It uses two actuators placed at the hip joint to provide assistive torque during walking

How?

- Integrated IMU sensors to collect 6-axis motion data, by writing Python scripts, using **SPI** and **I2C** communication protocols
- Developed **wiring layouts** and fabricated circuitry
- Designing a mechanism using constant force springs to adjust width of the exoskeleton to allow multi-user compatibility