UF Herbert Wertheim College of Engineering
UNIVERSITY of FLORIDA

Department of Mechanical and Aerospace Engineering

BioVibes

EML4502 Mechanical Engineering Design III Spring 2023

Group 645V

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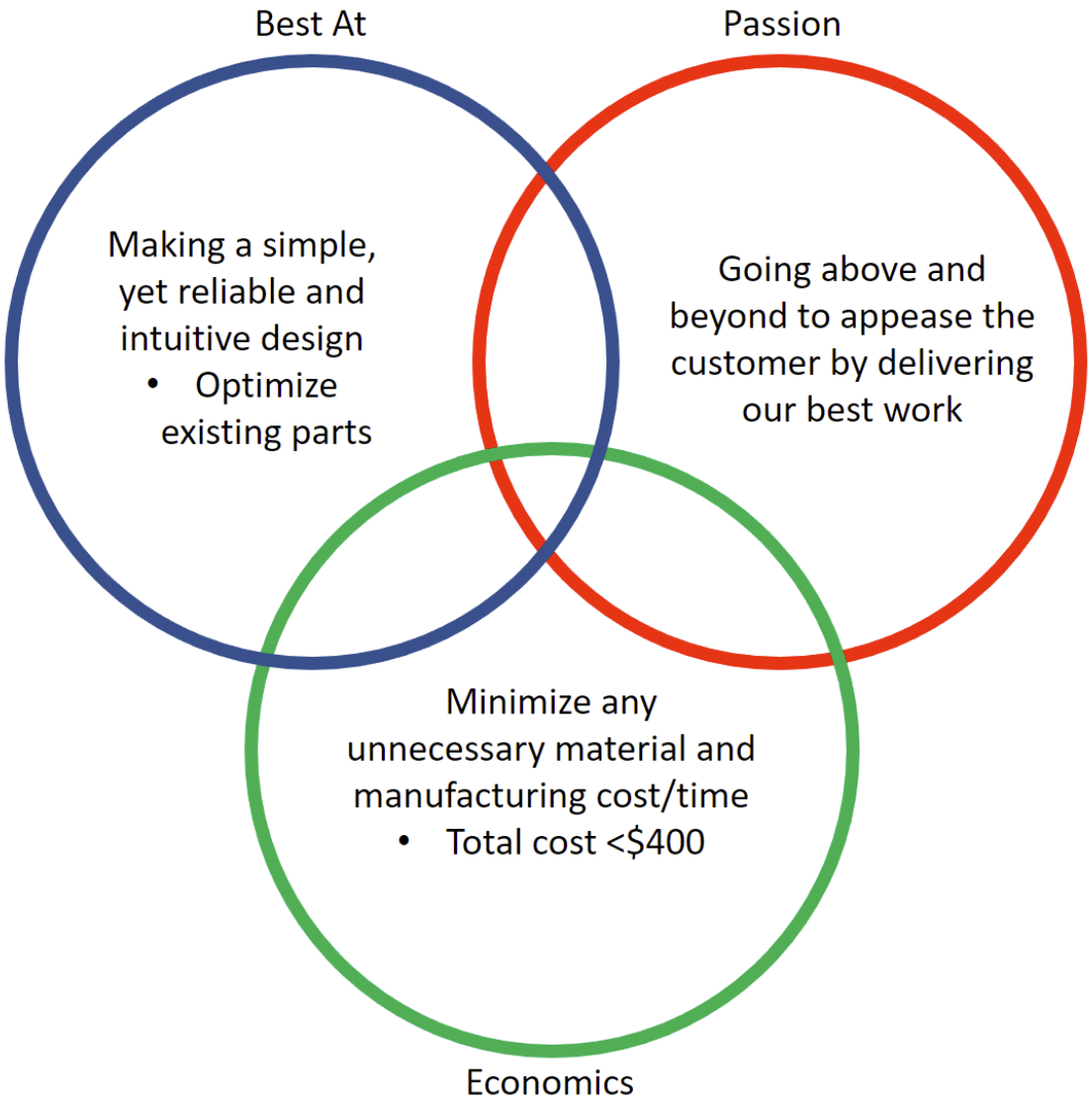
Outline Table of Contents

Page Number

Introduction

BioVibes

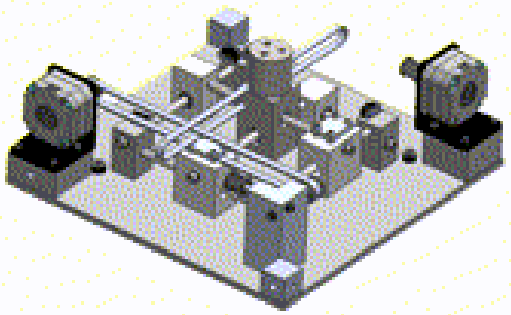


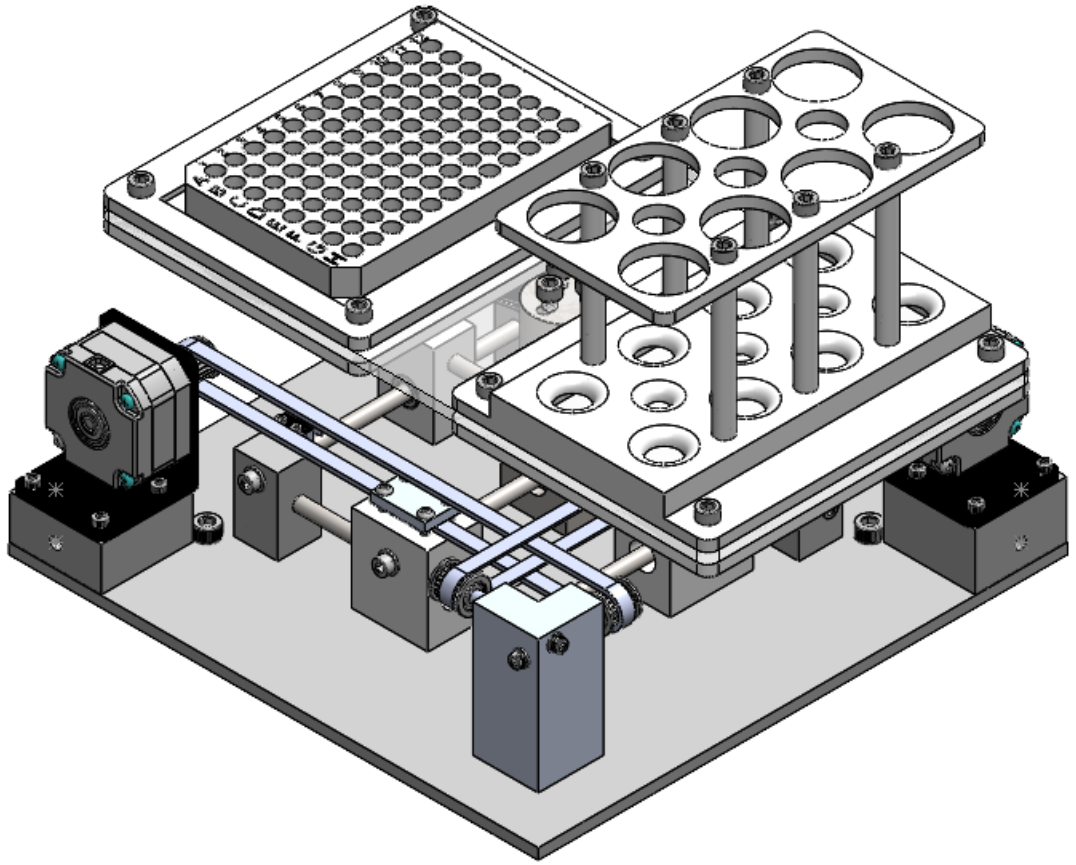
Product Specs

- Max Speed: 350 RPM
- Weight: 10 lbs
- 345 mm x 267 mm x 187 mm (width includes UI)
- IPX-5 Water resistant
- Runs on standard 12V power
- Holds up to 11 vials of various size
- Can hold a 96 well plate
- Aluminum and 3-D printed plastic construction

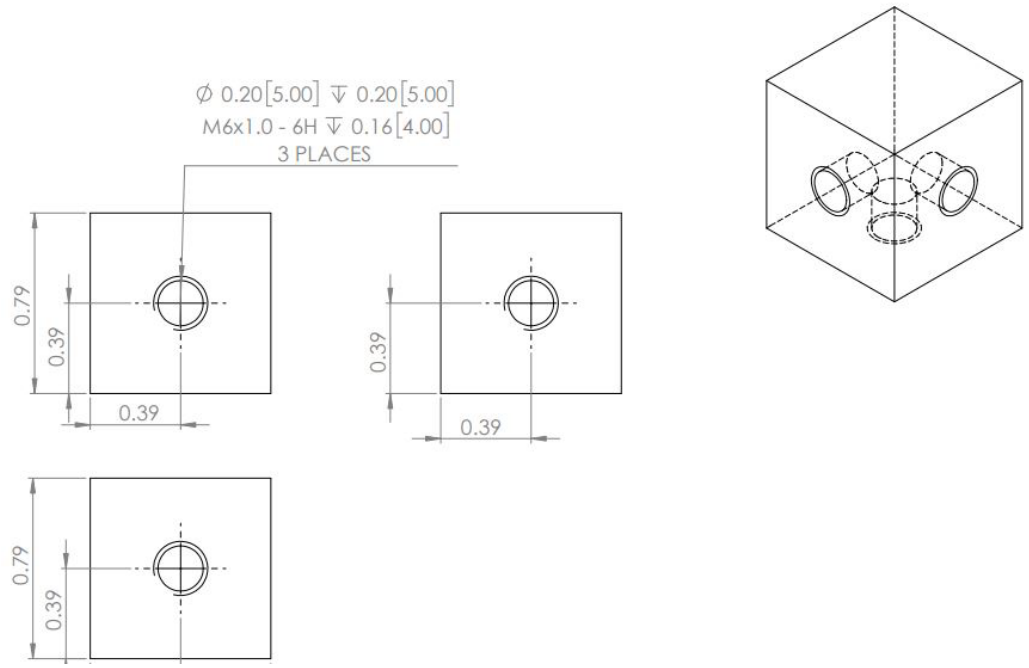
Prototype CAD Model

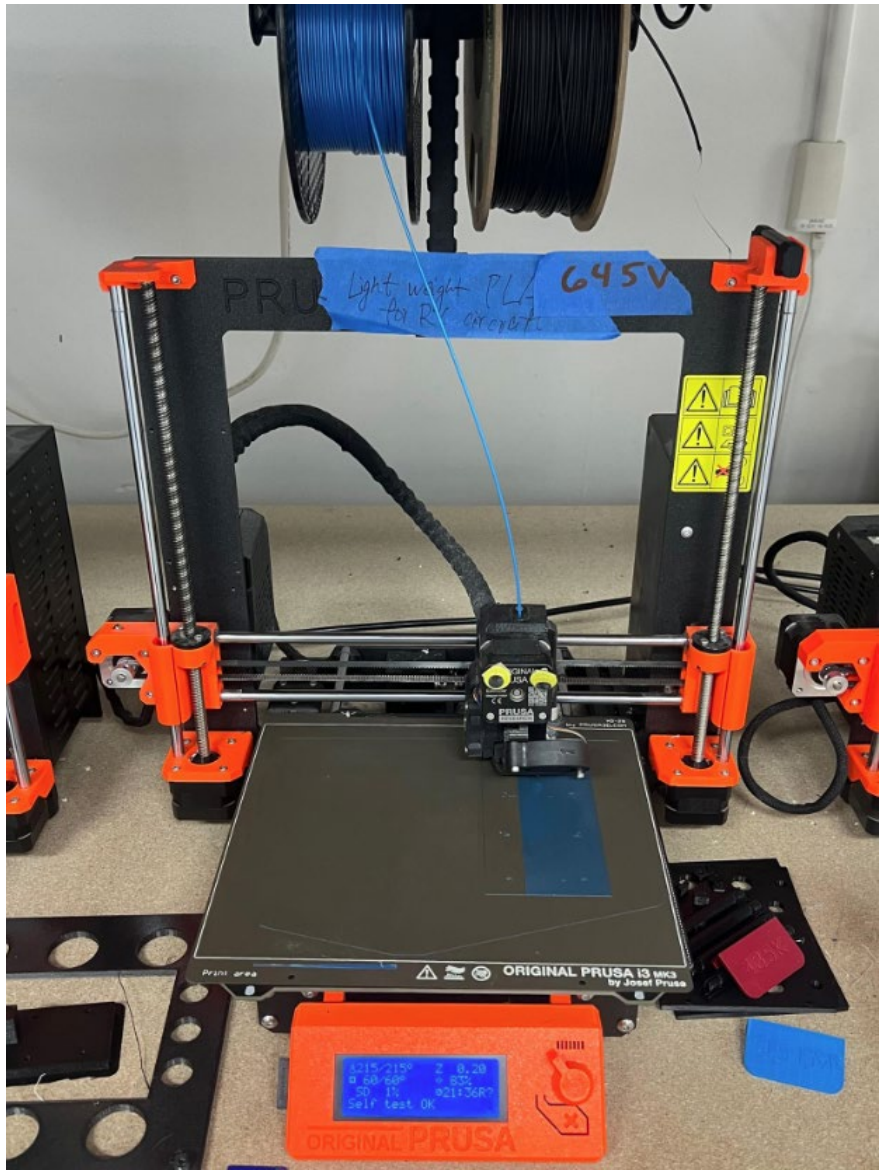
- Belt driven design
- Machined aluminum parts





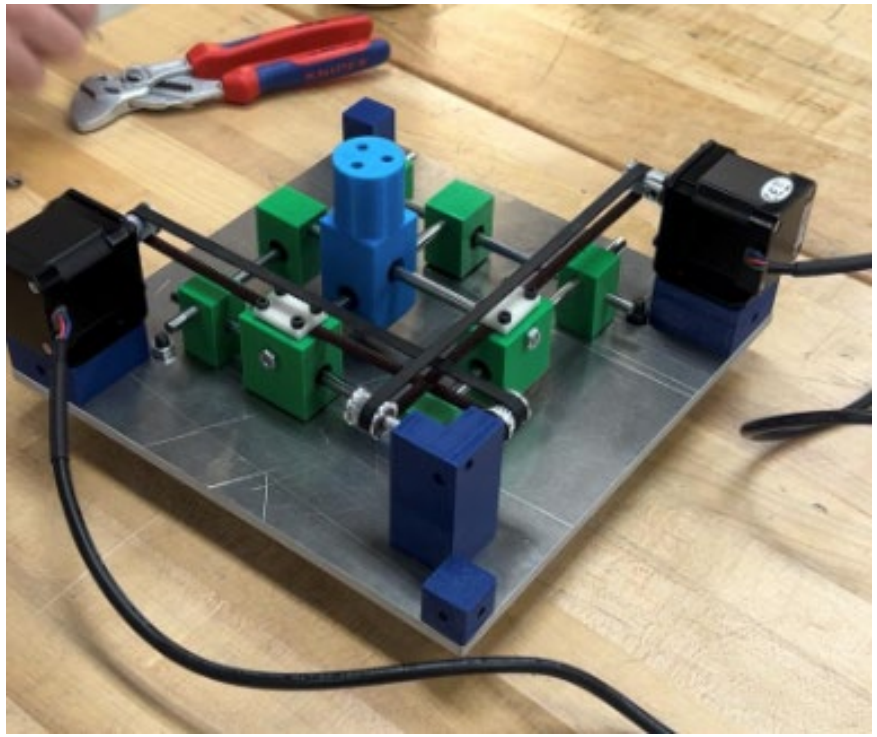
Fabricating Parts

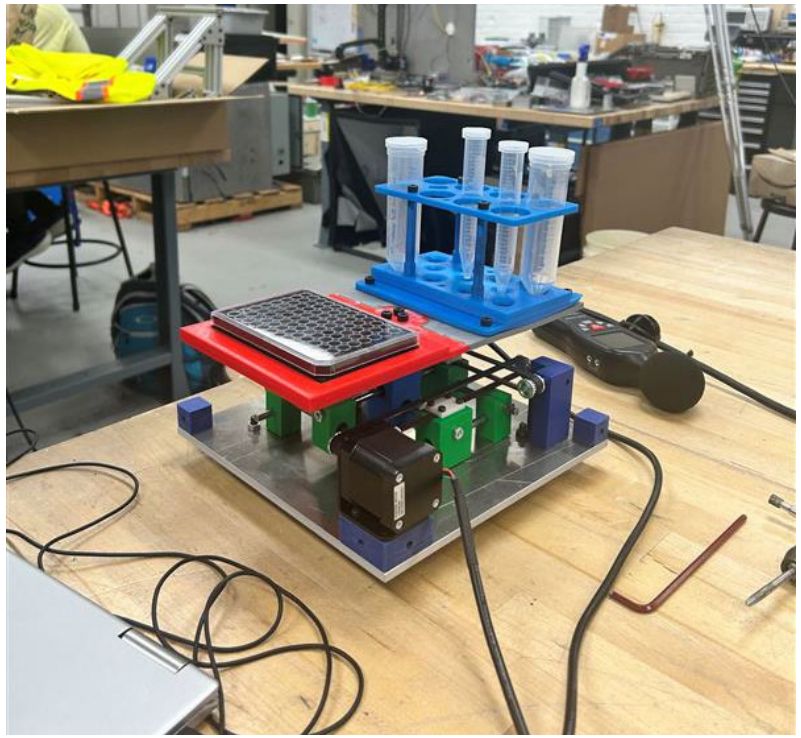




Physical Model

- Prototype phase
- 3D printed plastic parts
- Aluminum baseplate
- Stepper motors
- Rubber belts





Analysis of Design Specifications

Motor Calculations:

$$V_{ave} = \omega A$$

$$V_{ave} = 750\frac{rev}{minute} * 2(5)\frac{mm}{rot} * 1\frac{min}{60s} = 125\frac{mm}{s} = 0.125\frac{m}{s}$$

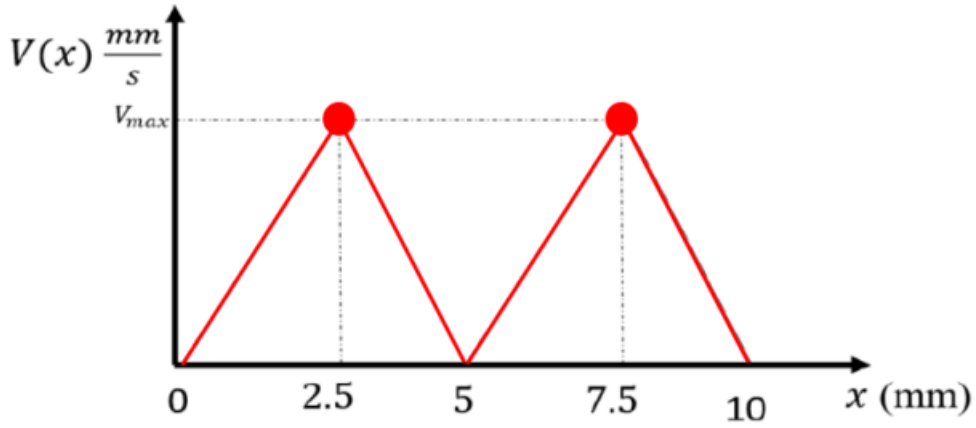
$$V_{ave} = \frac{1}{10}\int_0^{10} V(x)dx = \frac{1}{10}[0.5 * 5V_{max} + 0.5 * 5V_{max}]$$

$$V_{max} = 0.125\frac{m}{s} * 10 * \frac{1}{5} = 0.25\ m/s$$

$$a = \frac{V_f - V_i}{\Delta t} = \frac{V_{max}}{0.05 * 0.25} = 20\frac{m}{s^2}$$

$$F = m * a = 0.5\ kg * \frac{20\ m}{s^2} = 10\ N$$

$$T_{needed} = \frac{F}{g} * d = \frac{10\ N}{9.81\frac{m}{s^2}} * 5\ cm = 5.10\ Kg - cm$$

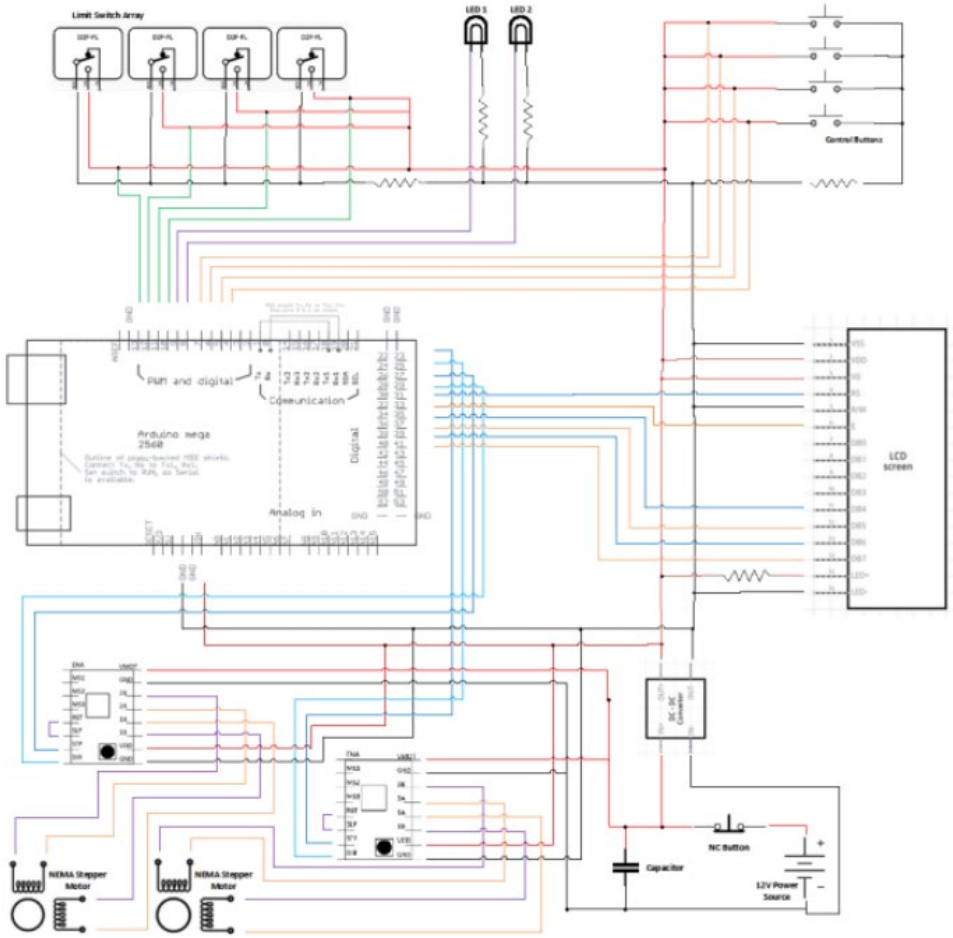


Velocity v Displacement during shaking motion.

Electronic Design

KEY COMPONENTS:

- Arduino MEGA
- A4988 Stepper Motor Drivers
- Nema 17 Stepper Motors
- Shaker pattern controlled with buttons
- Potentiometers for velocity and radius of motion
- LCD Screen for UI

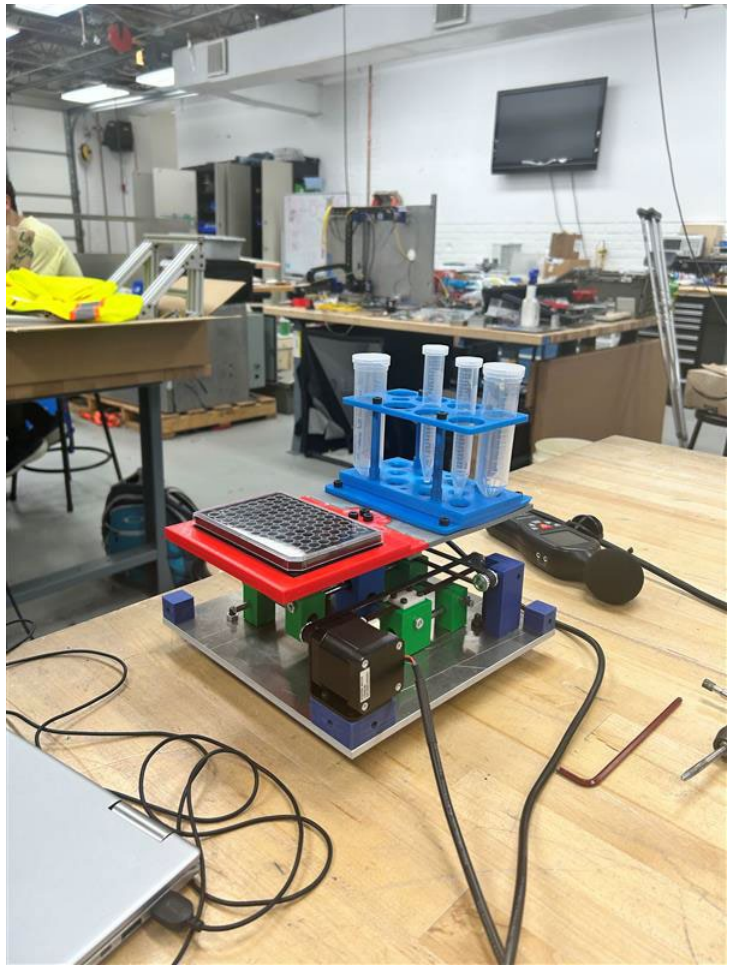


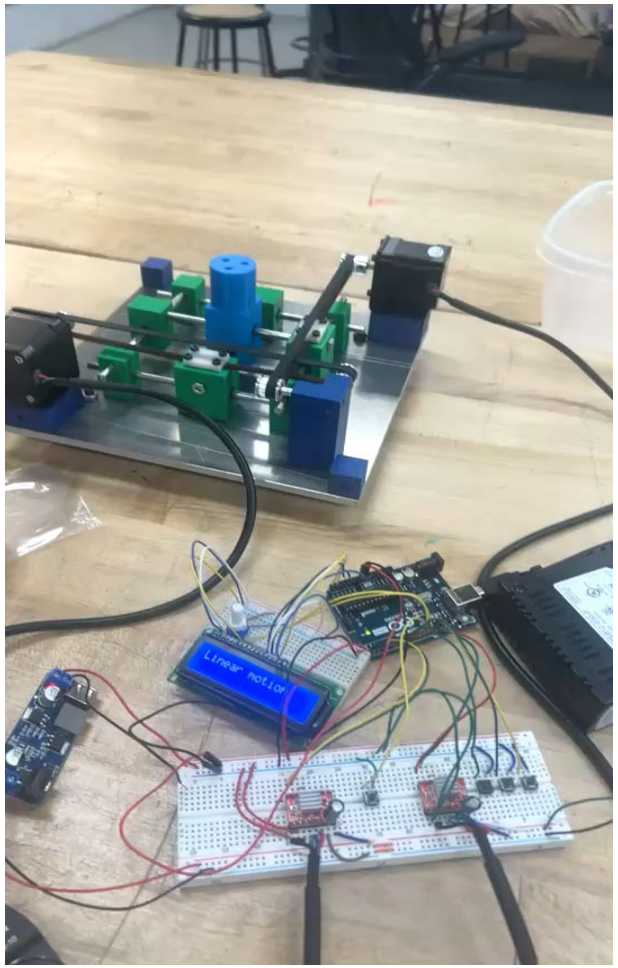
Shaker Demonstration

Shaker table moves in three distinct patterns:

- Linear ⟷
- Orbital ⟳
- Double Orbital ∞

Max Speed = 350 RPM

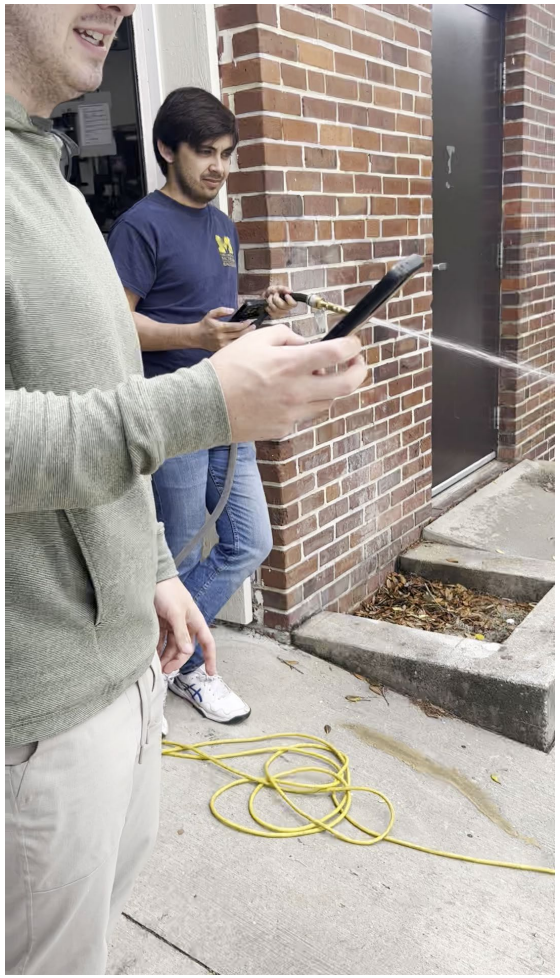




Water Infiltration Test

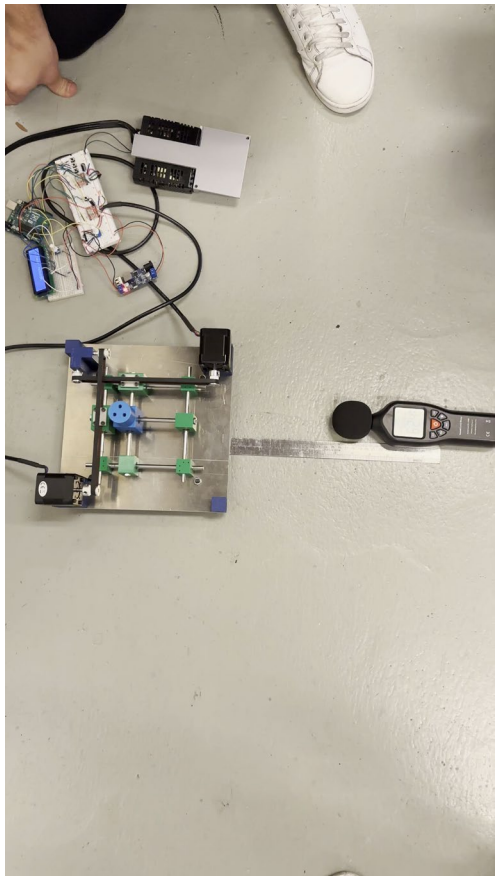
- IPX-5 Rated Water Resistant
  - Protected against low pressure water stream

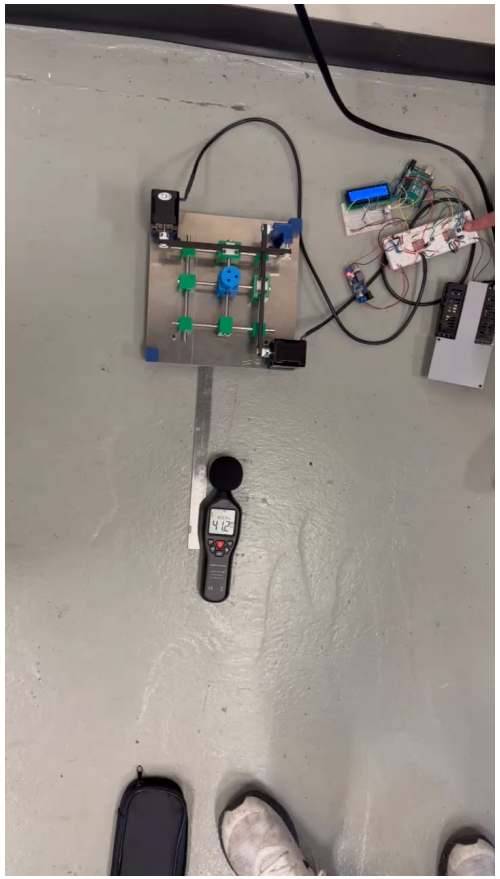
- Functional during & after water dousing
  - 4-minute active test
  - 20-minute standby test

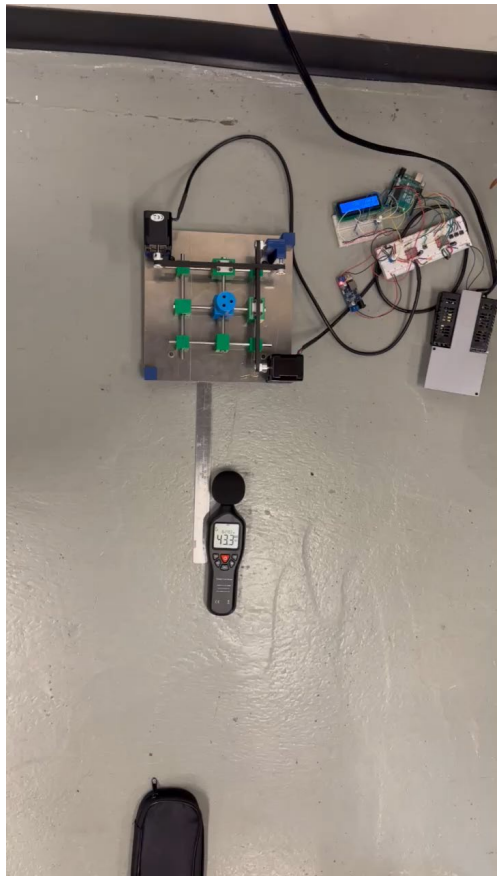


Acoustic Test

- Quiet Operation
- <60 dB in any direction

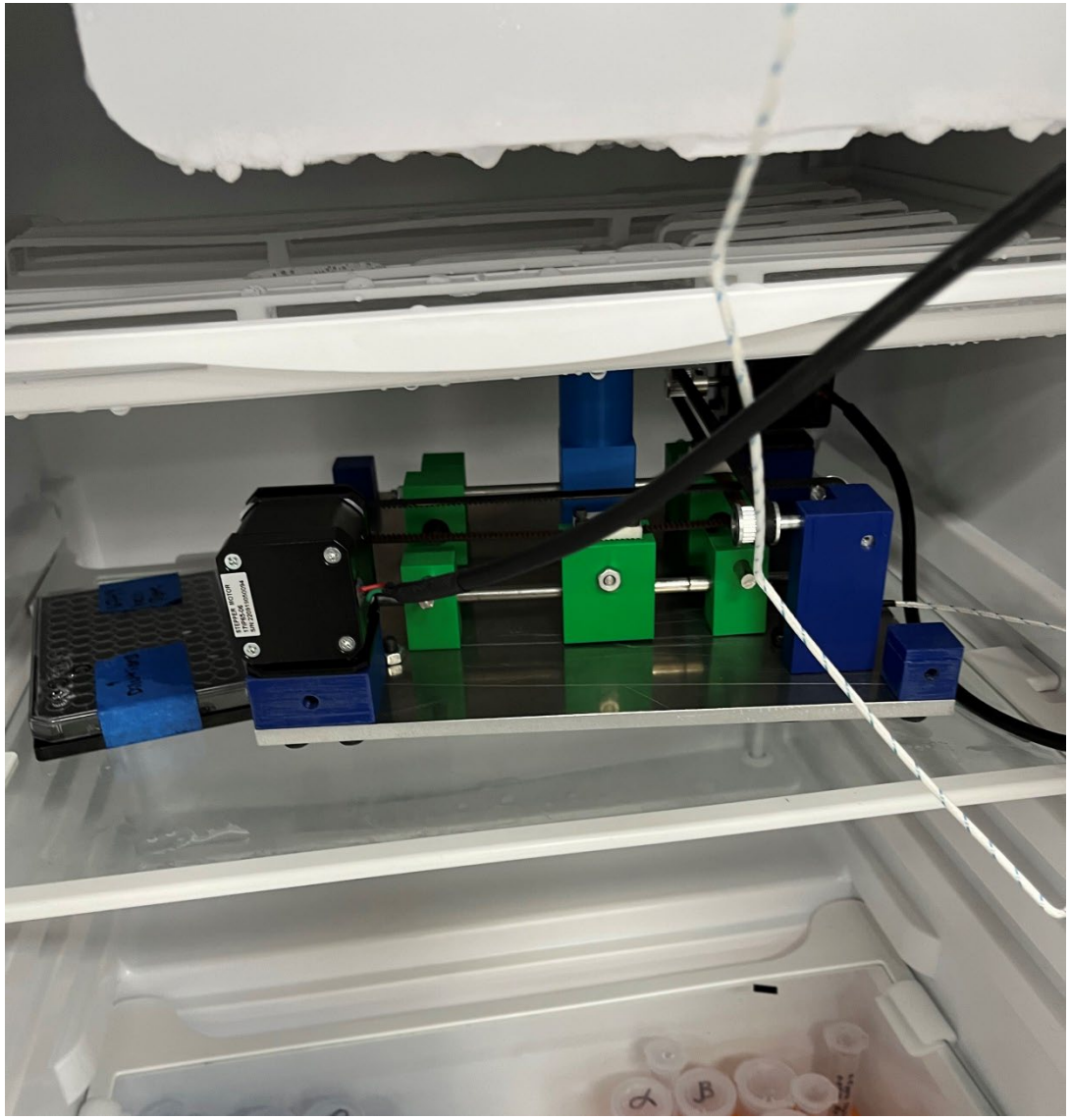






Cold Soak Test

- Shaker table cooled to at least 4° C
- Cold soak for 90 minutes
- Operate at 6 RPM with double orbital and linear patterns



Overclock & High Temperature Test

Overclock

- At least 350 RPM
- 10 minute overclock duration

High Temperature Test

- Oven heated to 70° C
- Shaker table placed inside
- Running at maximum speed, the table remains in the oven for 100 minutes

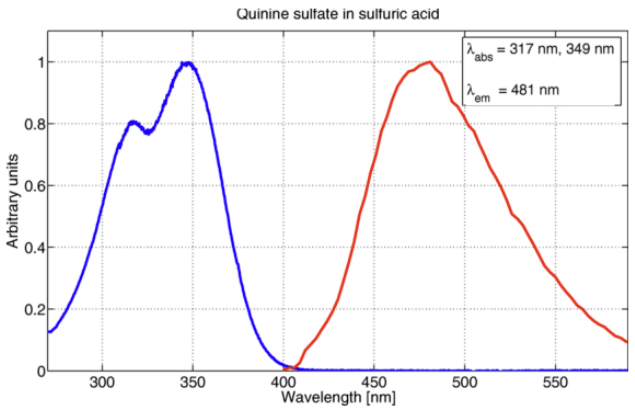
Optical Density & Fluorescent Intensity (ODFI) Test

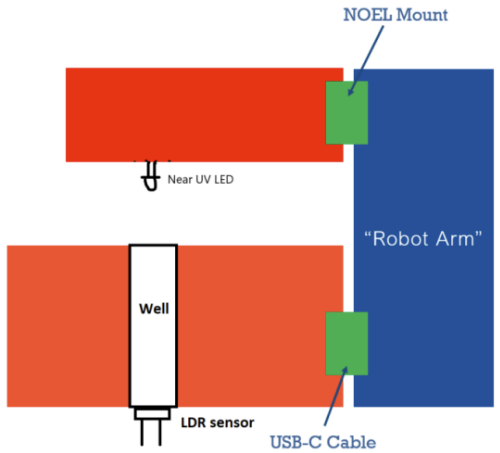
Optical Density Test:

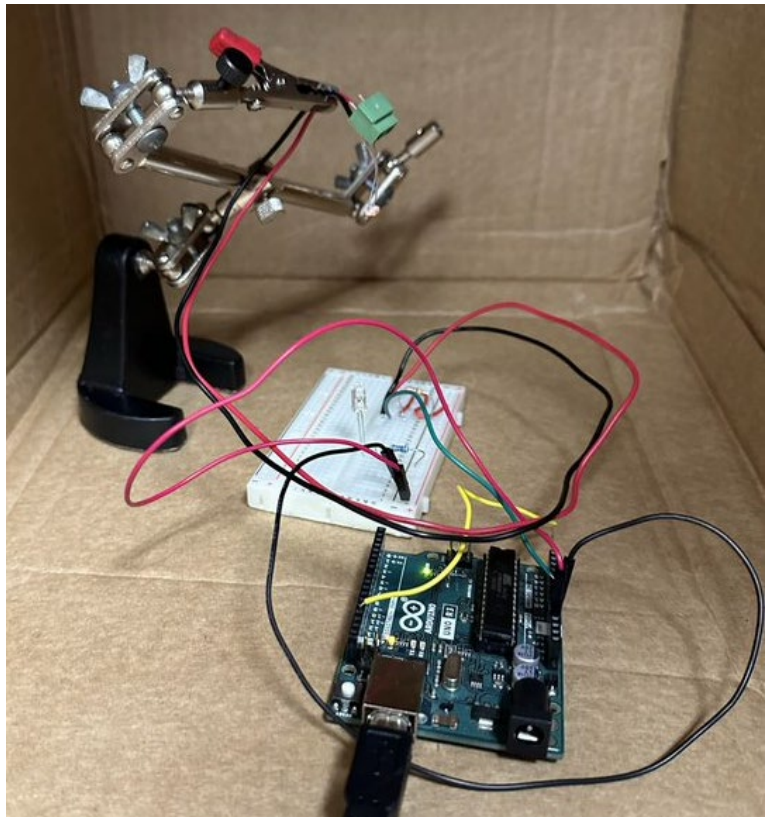
- Milk in various concentrations
- LED & Light dependent resistor

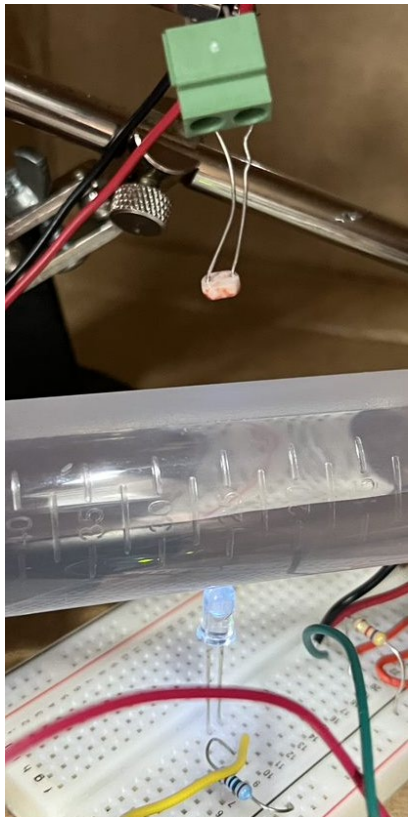
Fluorescent Intensity Test:

- Quinine in various concentrations
- UV LED & Light dependent resistor









Drop Test

Withstand a drop from 75-cm

- Must still be functional after the drop
- Housing or cosmetics can be damaged

Simulated Drop Test

Testing Summary and Conclusions (strengths and weaknesses)

Strengths: Adaptability and Convenience

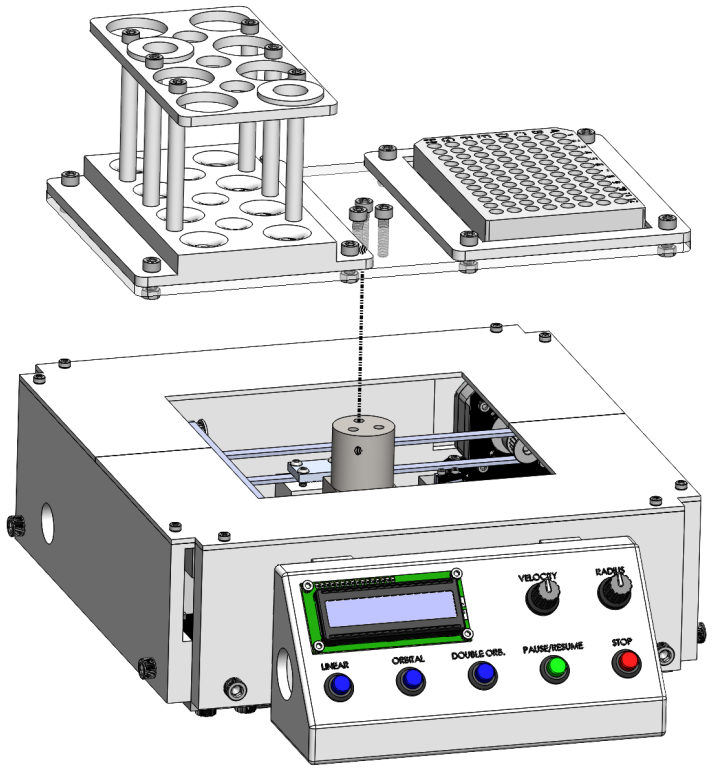
- Waterproofing test
  - OTS parts allowed for reliable waterproofing
- Cold test
  - Resistant motors that can function under extreme thermal loads
- Ease of use test
  - Design was operated and easily understood after initial demonstration
- ODFI
  - Cheap and easily produced, able to accurately measure OD and FI values

Weaknesses: Manufacturing and Supply Chain

- Drop test
  - Plastic parts with minimal strike resistance
- Hot test
  - Lack of manufactured parts led to issues with plastic components melting
- Acoustic Test (further improvements are expected with the proper casing).
  - 3D printed plastic had tolerancing issues leading to vibrations and acoustic feedback

Whole CAD view

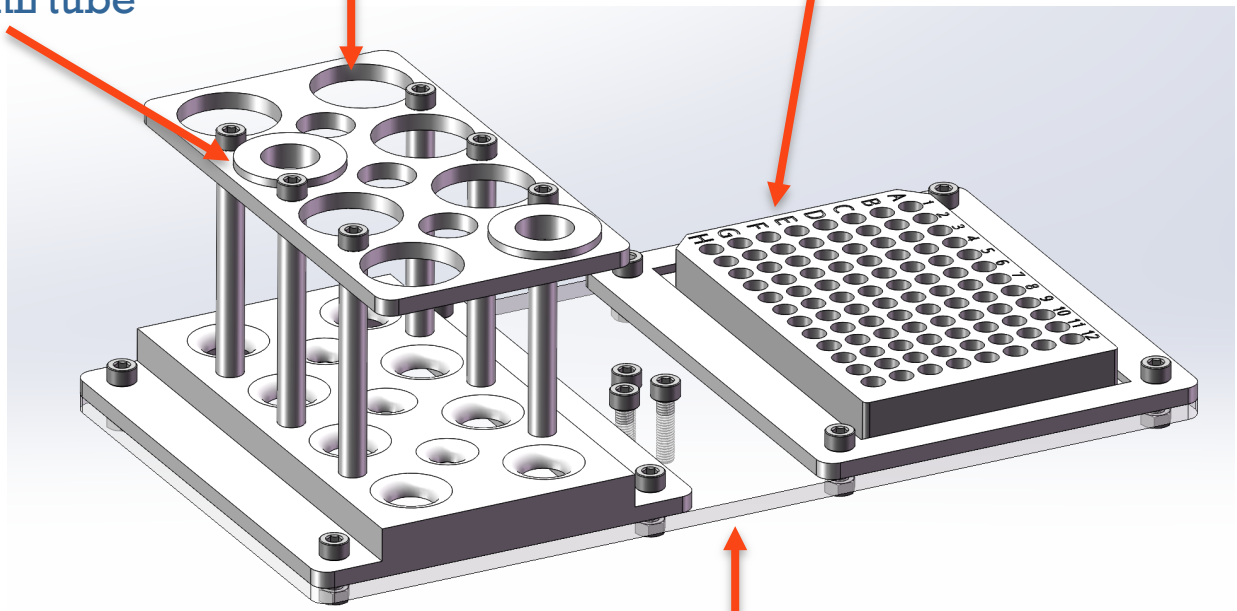
Shaker Plate Pull off and Show



Modular Insert to hold 15 mL tube

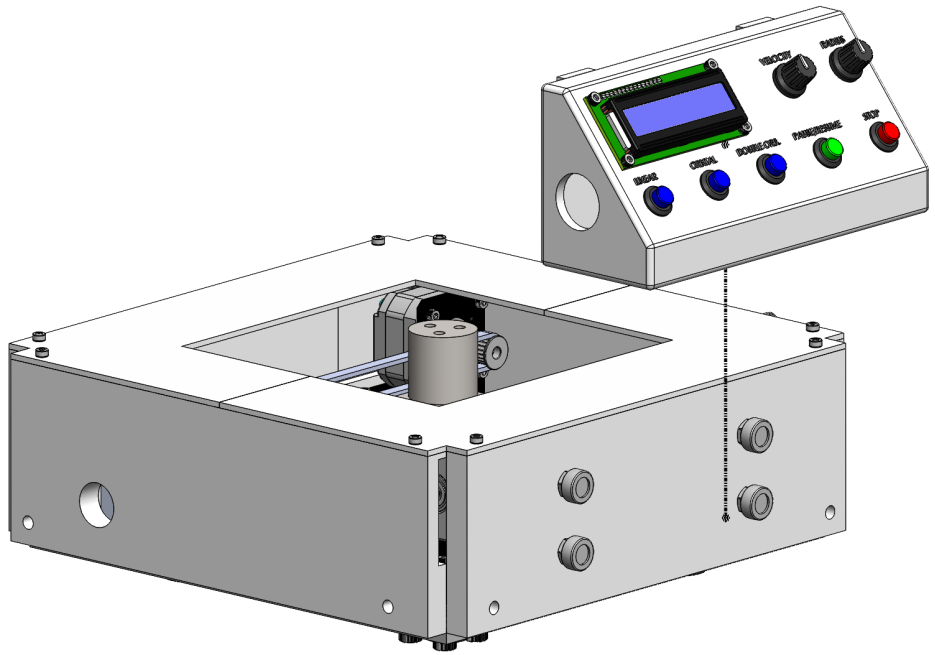
Cutout for 30 mL tube

Shown with 96 well plate (also holds 6, 24, 48, and 384 variants)



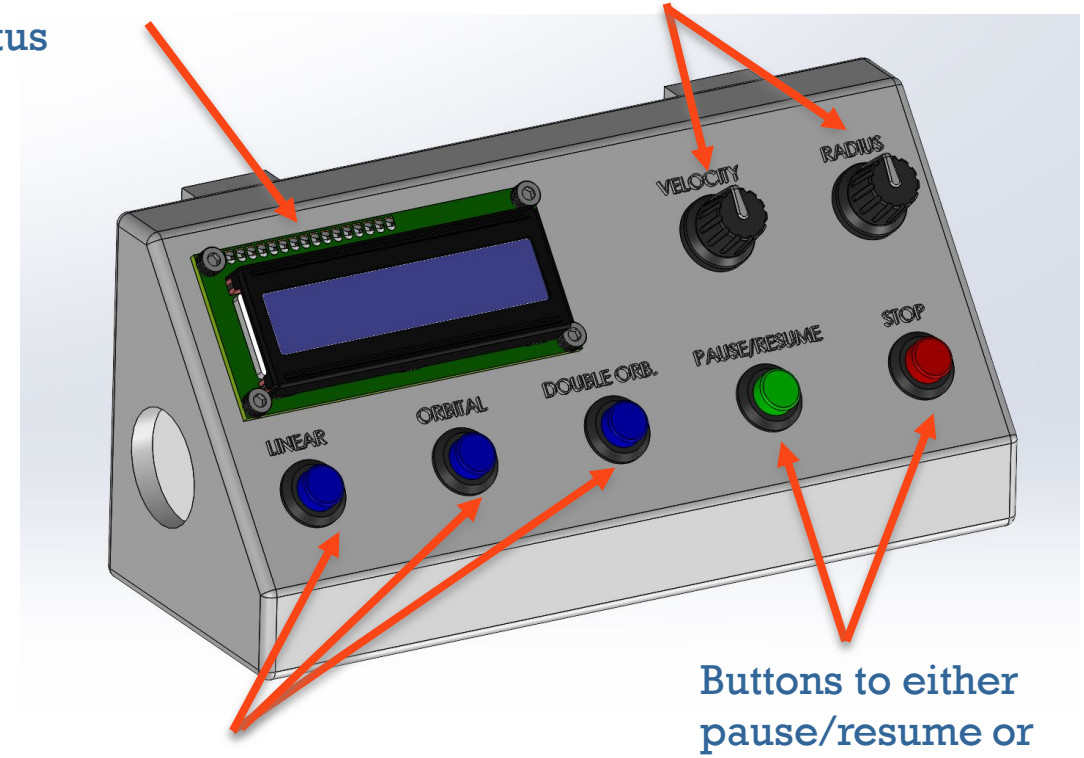
Translucent acrylic bottom plate for OD/FI pass through

UI Pull Off



LCD to display orbital parameters and table status

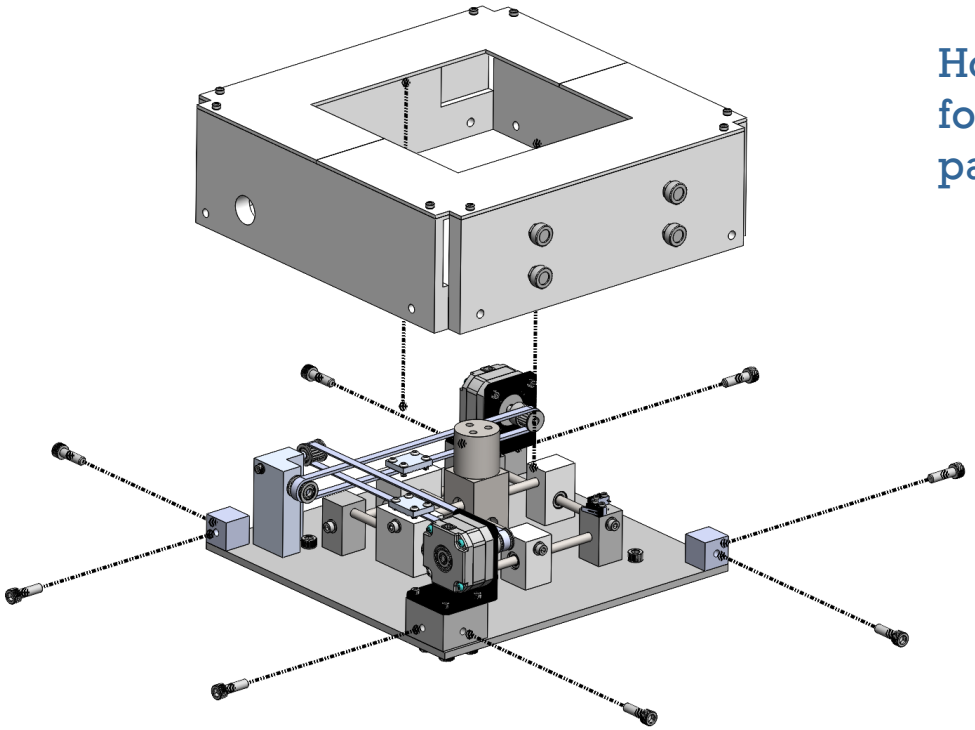
Dials connected to potentiometers to control velocity (rpm) and radius (mm)

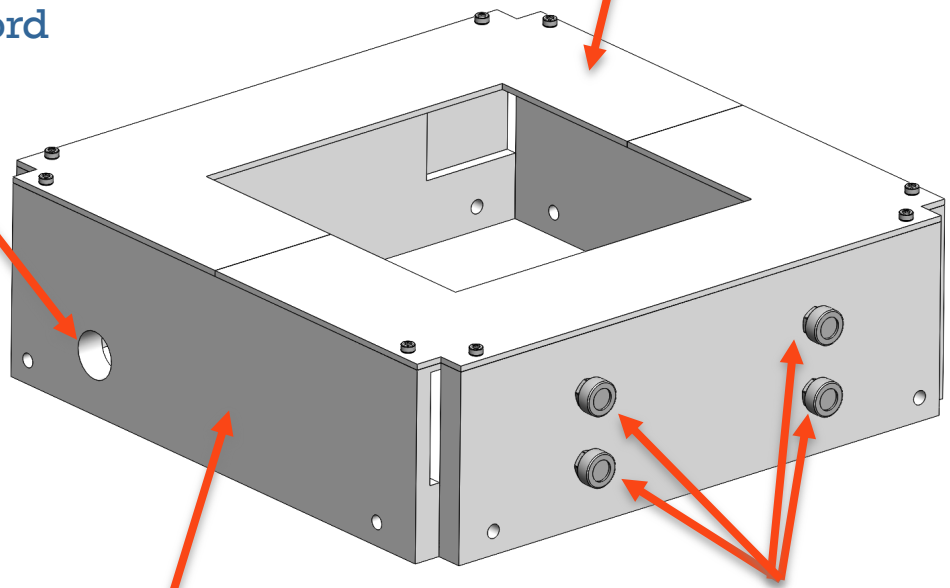


Buttons for simple and intuitive orbital pattern control

Buttons to either pause/resume or emergency stop

Housing Pull Off





Lid composed of two identical ABS parts

Hole to attach gland for umbilical cord pass through

Housing is composed of four ABS walls

Sliders mounted on one wall to attach removable UI

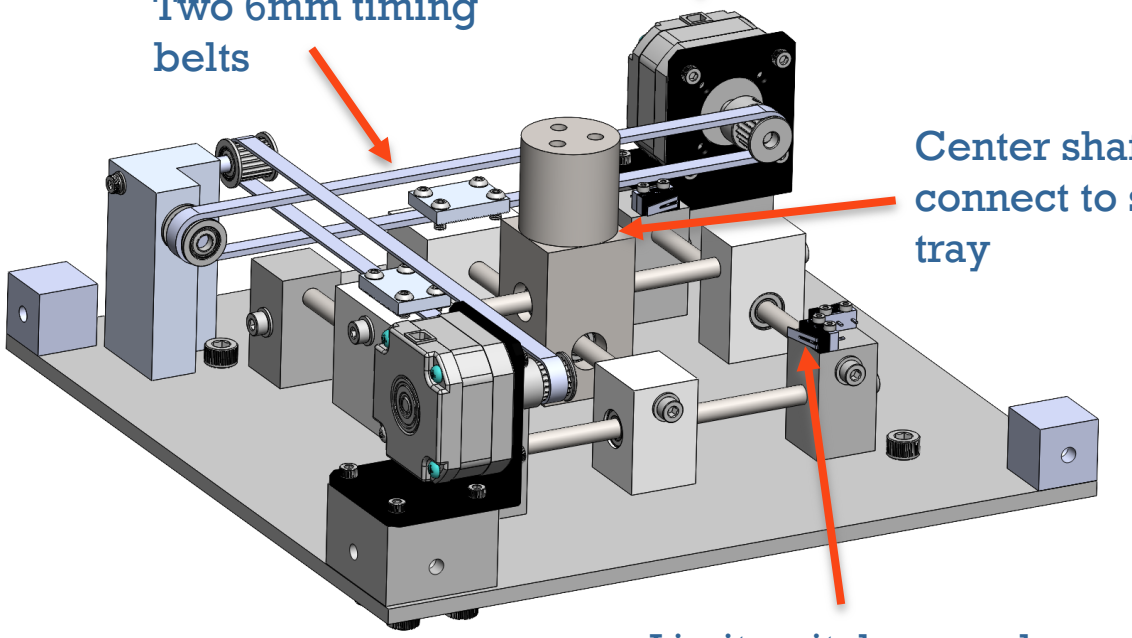
Motors and Rails subsystem

Two Nema-17 stepper motors used to drive motion

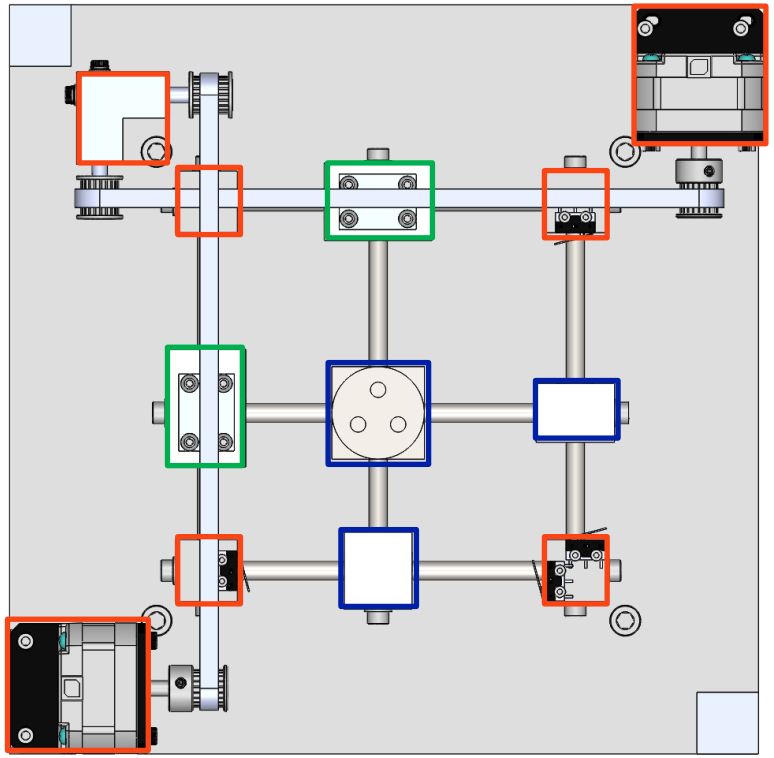
Two 6mm timing belts

Center shaft to connect to shaker tray

Limit switches used for calibrating center shaft location



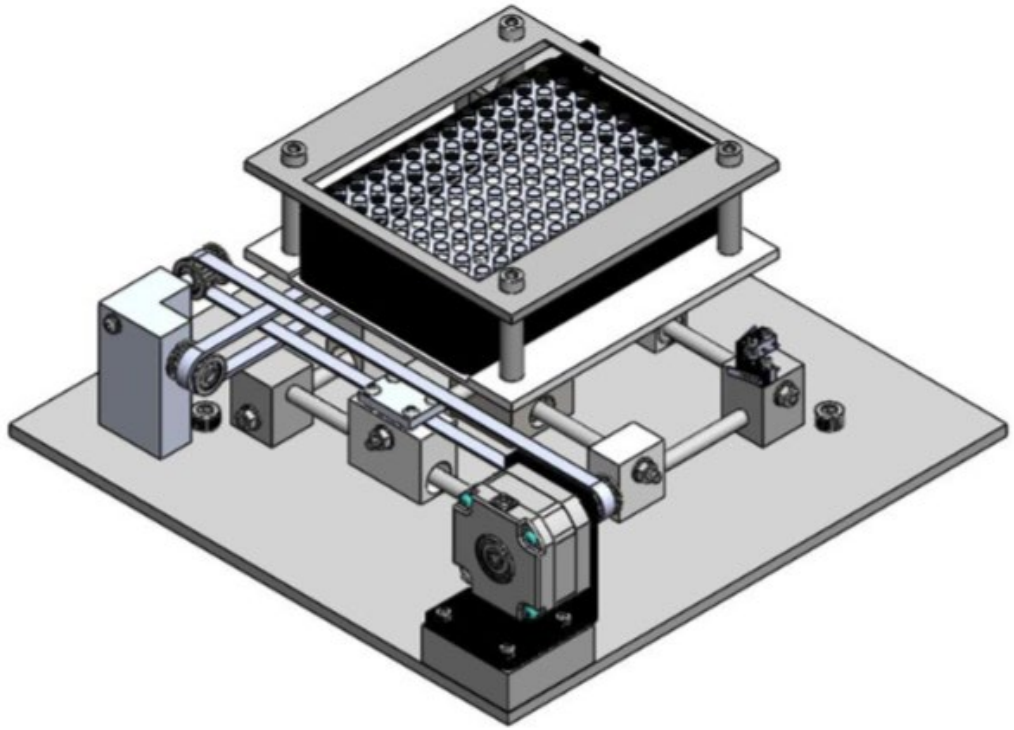
Parts in blue are floating/movable, parts in red are anchors



Design Evolution

Changes:

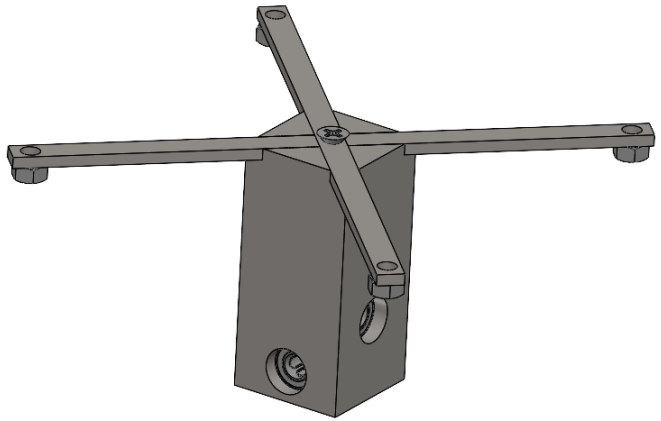
- Increased height and overall size of manufactured parts
- Updated well plate & tube tray design
- Higher power motors
- Water Resistance
- Housing

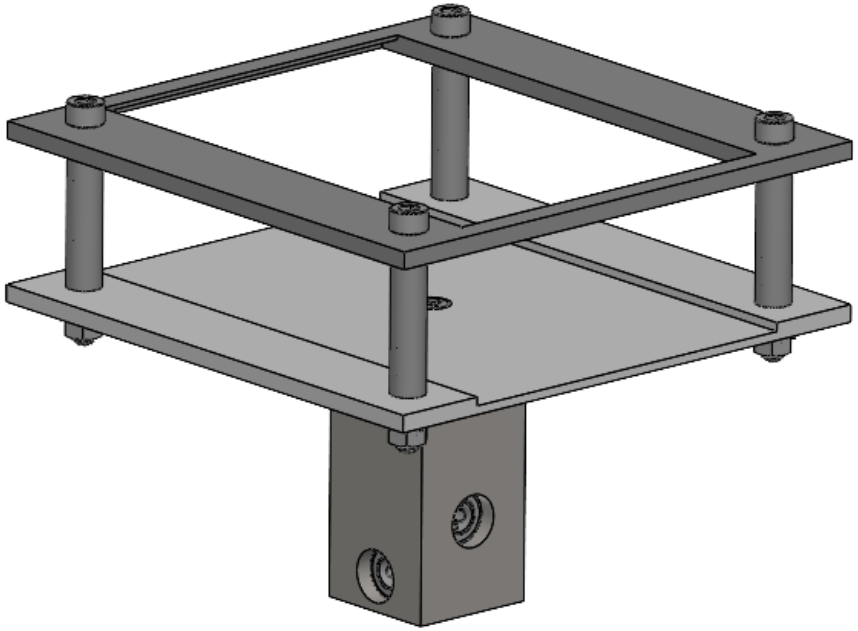


Old Shaker Tray Design

Modifications needed:

- Only accommodates for one well plate
- Difficult to manufacture
- Remove X-arm supports
- Replace Philips head fasteners

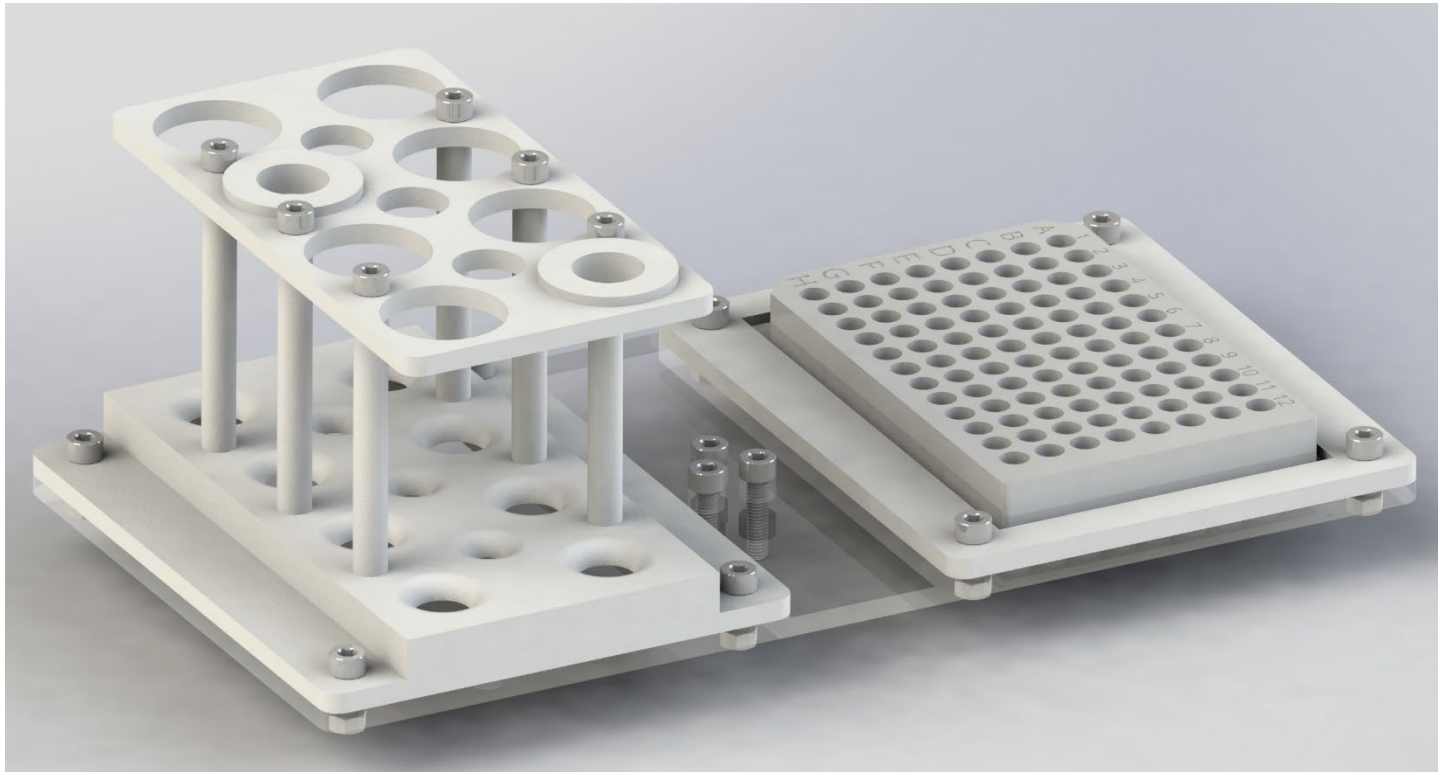




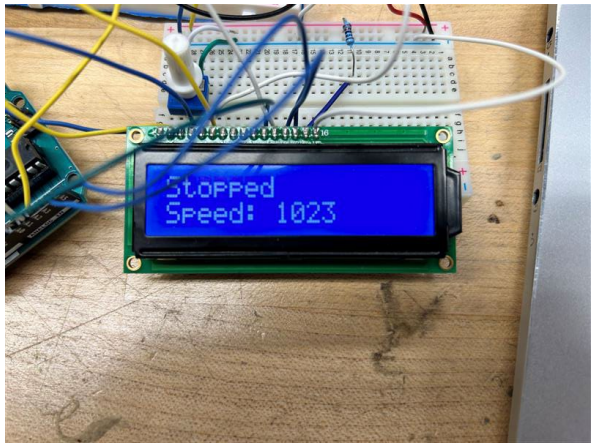
Updated Shaker Tray Design

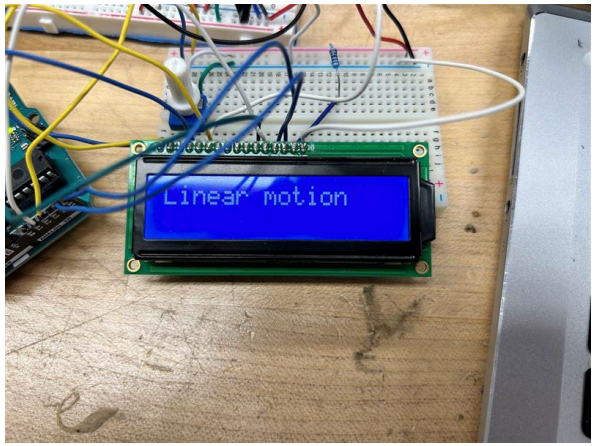
Features:

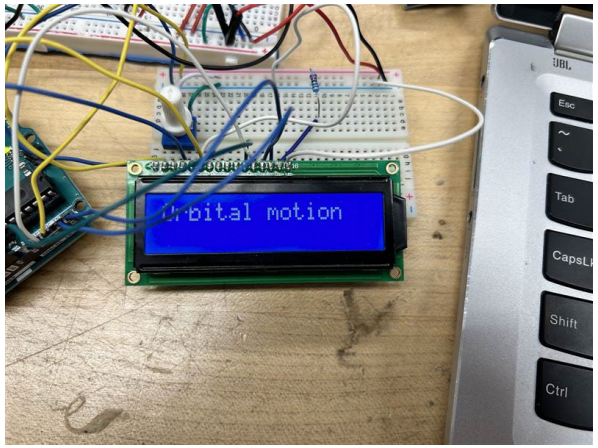
- Holds a well plate and conical tubes simultaneously
- Accommodates for well plate models: 6, 24, 48, 96, and 384
- Accommodates for eight 50 mL and three 15 mL conical tubes
- Modular inserts used to hold smaller sized tubes

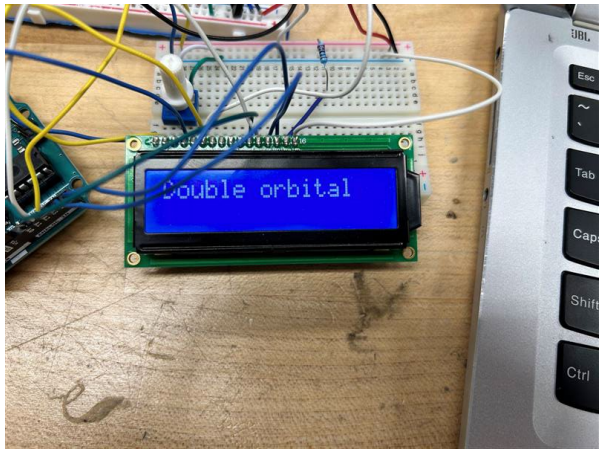


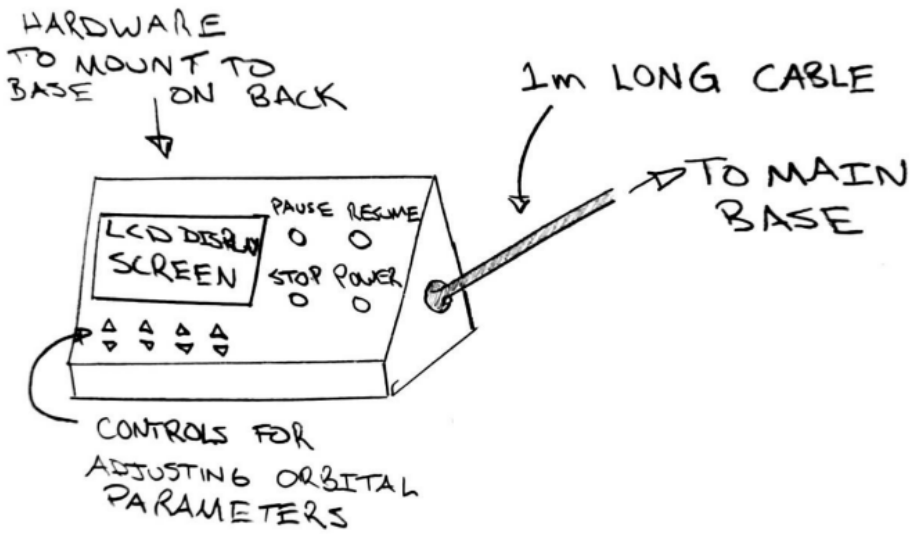
Old User Interface Design









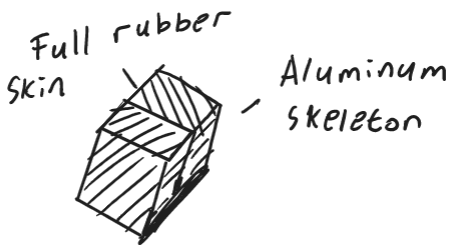


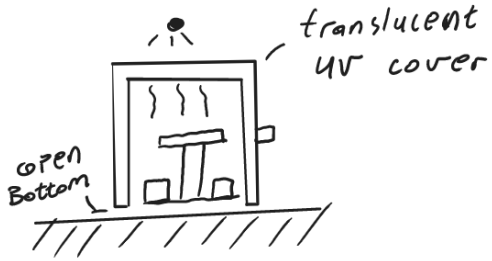
Updated User Interface Design

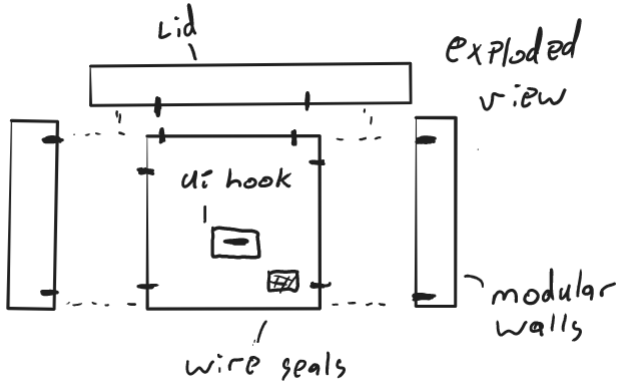
Features:

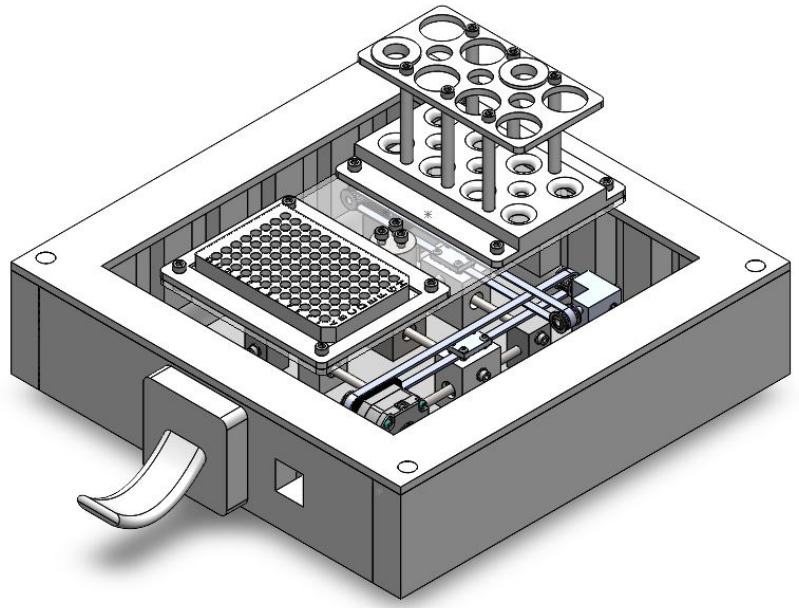
- Removable from shaker table unit
- Wired ambilocal cord allowing user to operate from a meter away

Old Housing Design





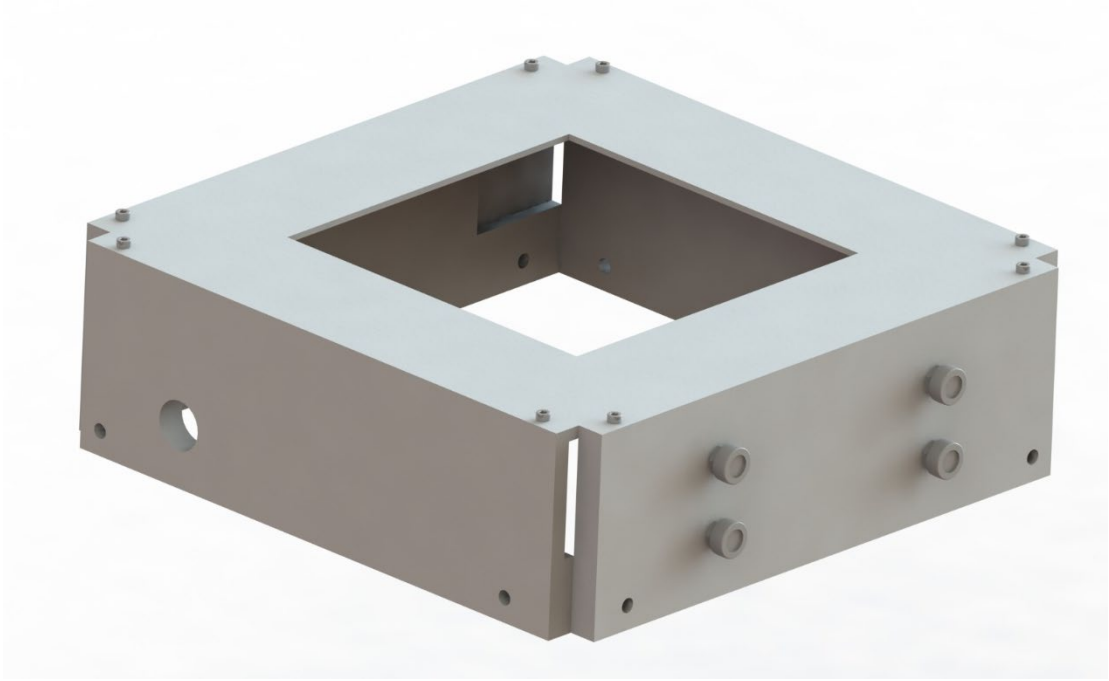




Updated Housing Design

Features:

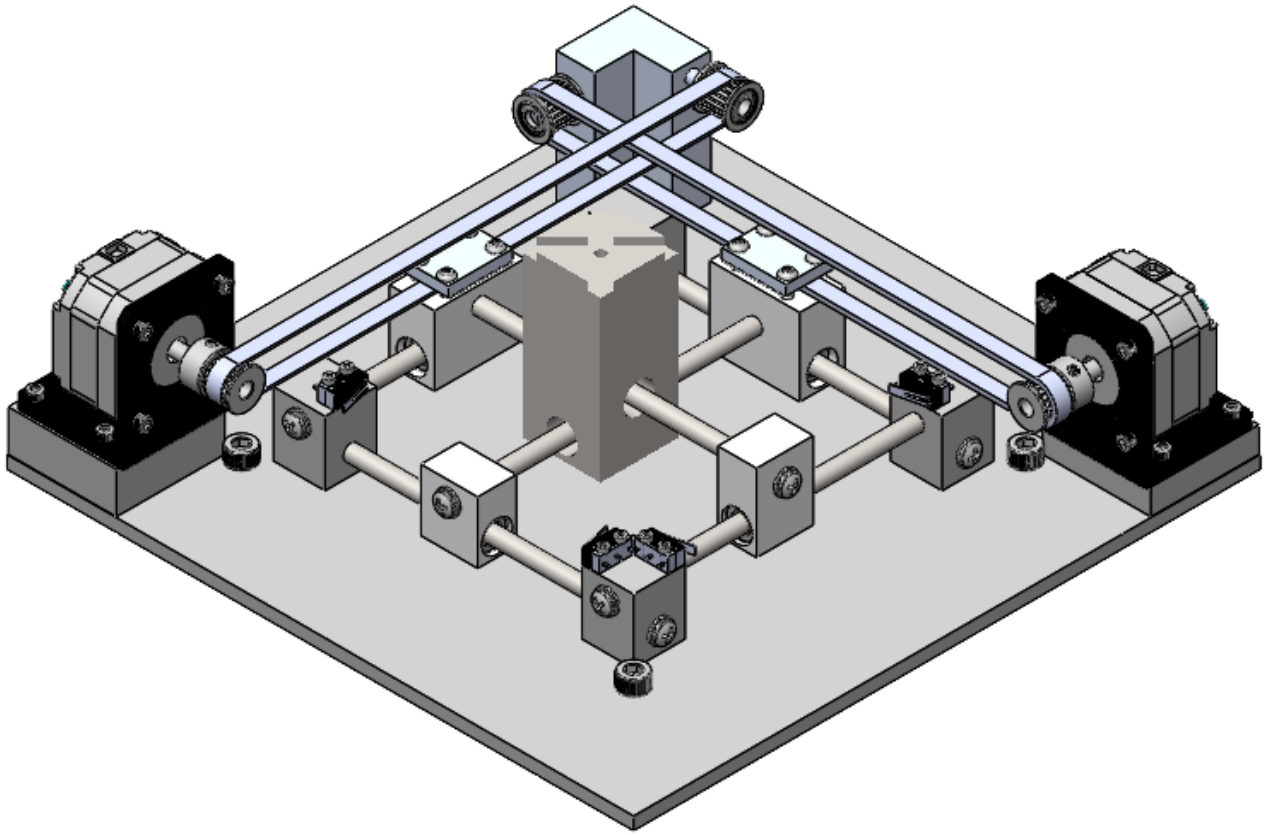
- Modular and easily replaceable components
- Attaches directly to shaker baseplate subsystem
- Lowers acoustic profile
- Made from ABS plastic for cheap manufacturing



Old Motors and Rails Design

Modifications needed:

- Increase overall dimensions of mounting blocks to account for 1 major diameter around each hole
- Many part dimensions adjusted to be made from nominal dimension stock
- Replaced all Phillips head fasteners with hex head fasteners



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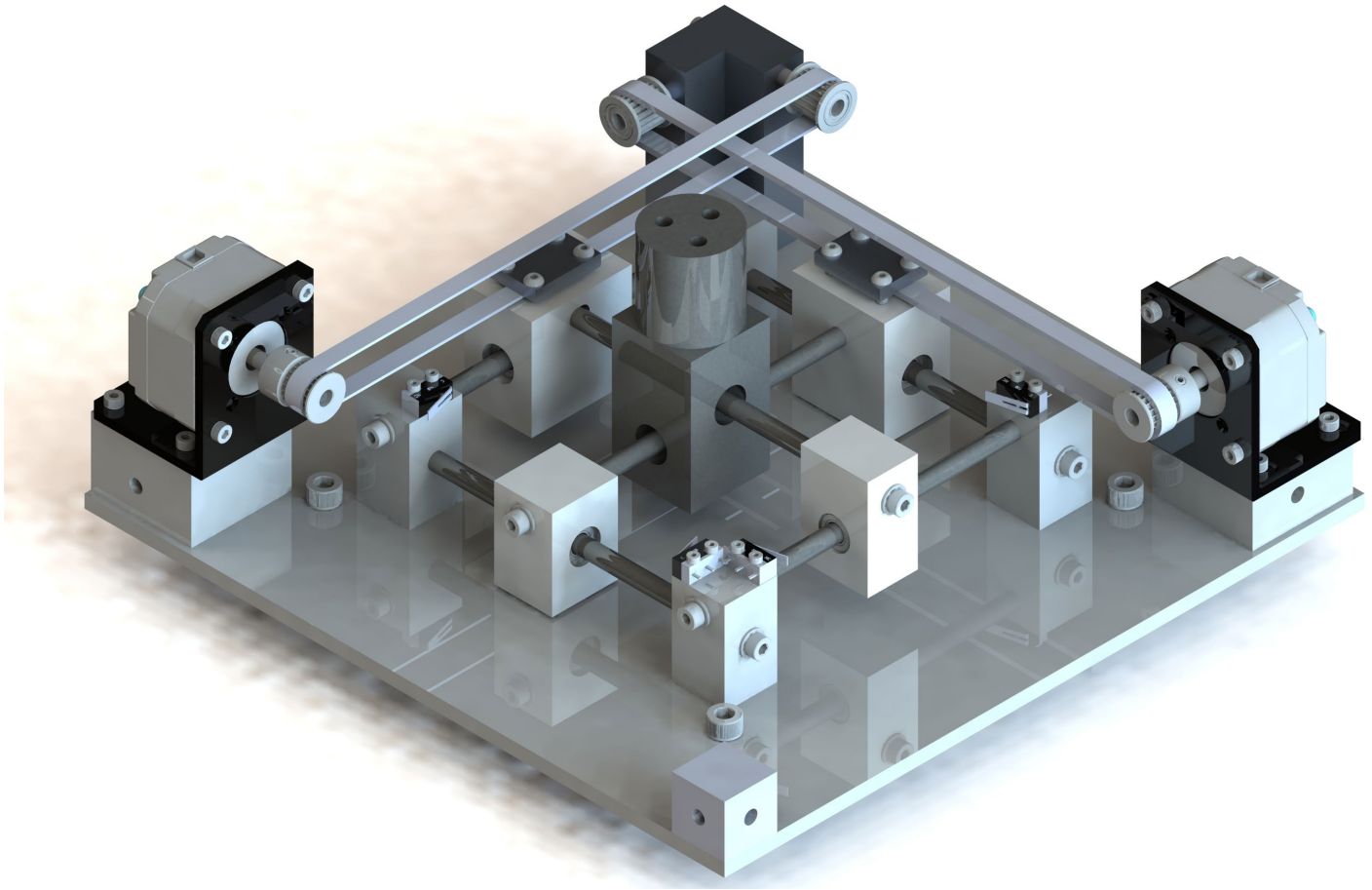

Cost Summaries

Type	Cost
Mechanical System Assembly	$267.45
Stepper Motors	$54.80
Electronic Components	$294.34
Manufacturing Costs	$75.50
Total	$690.09

Summary of design benefits

1. High-speed performance
2. Compact and lightweight
3. Versatile and adaptable
4. Robust construction
5. Water-resistant design

Summary of design benefits

6. Easy power source compatibility
7. Customizable shaker patterns
8. Informative LCD screen
9. Reliable and high-quality components, easily replacement
10. Rigorously tested

Thank you!

Questions?