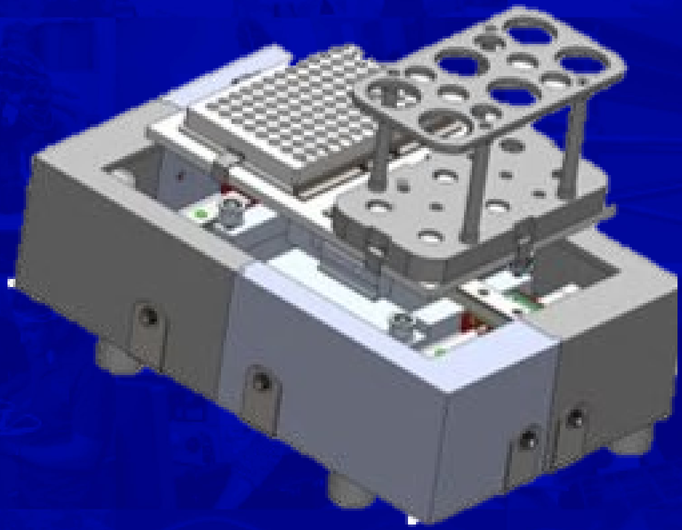
Herbert Wertheim College of Engineering
UNIVERSITY of FLORIDA

Department of Mechanical and Aerospace Engineering

The Microbe Mixers



Group 243D

Michaela Baughn, Hugh Brittenham, Kyle Cunningham, Samuel Falzone, Ricardo Martinez, Darryl Mijares, Thierry Momplaisir, Asher Siddiqui

POWERING THE NEW ENGINEER TO TRANSFORM THE FUTURE

Meet the Team

Michaela Baughn

Hugh Brittenham

Kyle Cunningham

Samuel Falzone

Ricardo Martinez

Darryl Mijares

Thierry Momplaisir

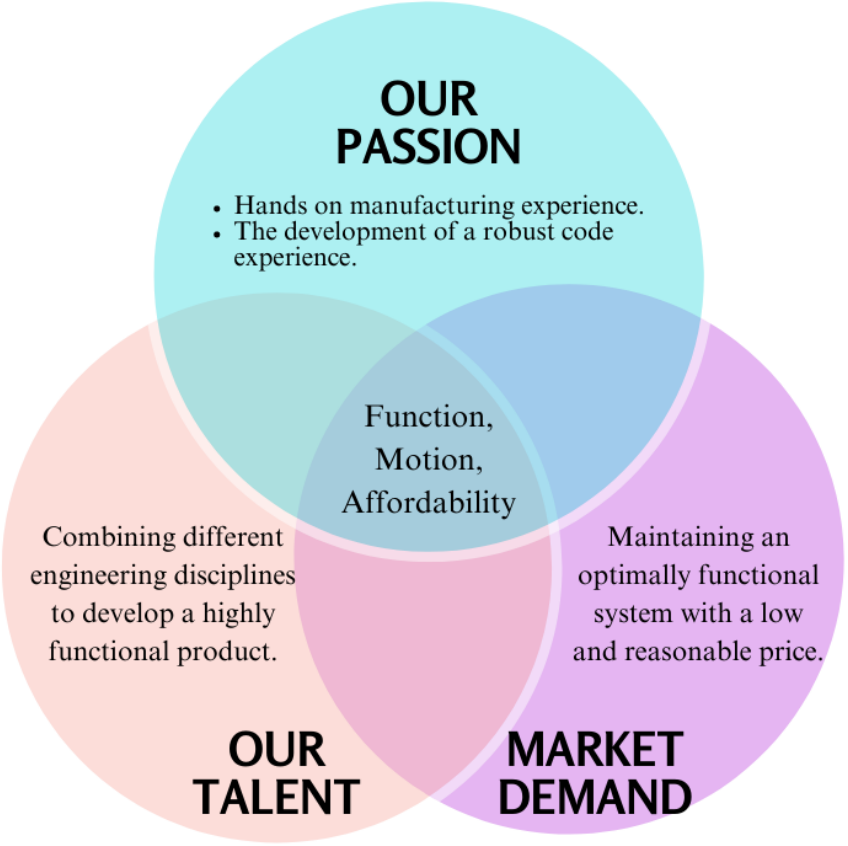
Asher Siddiqui

Presentation Agenda

- Hedgehog Concept
- Key Product Specifications
- Subassembly Highlights & Features
- Engineering Analysis
- Product Testing
- Cost Summary

Hedgehog Concept

We aimed to improve our final product by utilizing our members' specializations in CAD, coding, and circuitry.



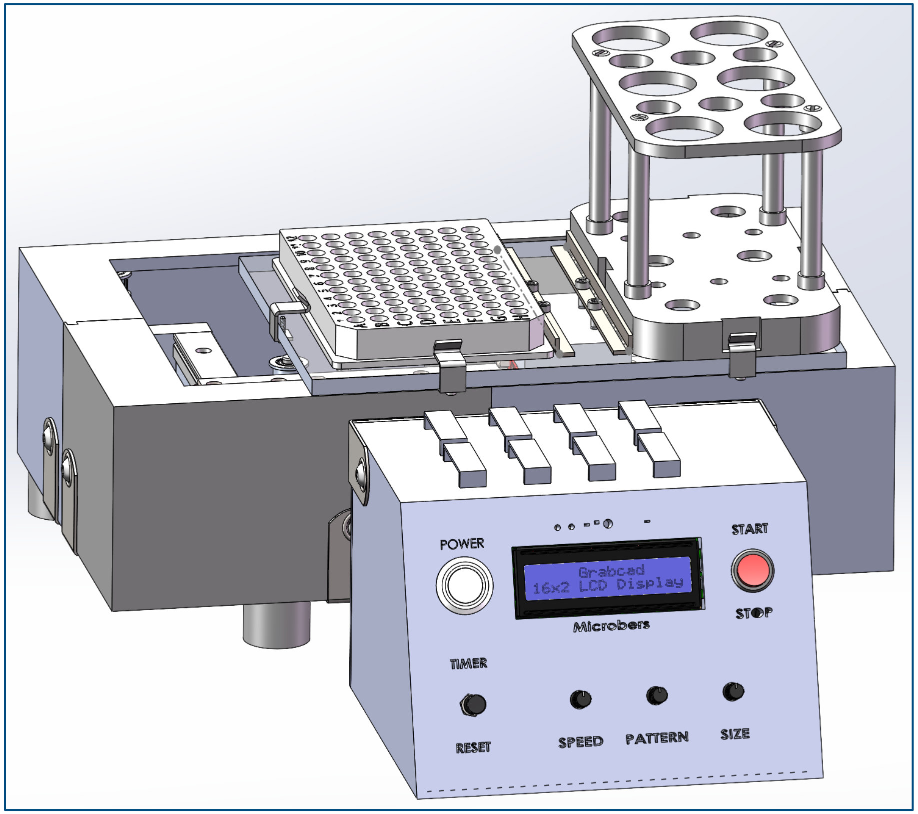
Key Product Specifications

- Core XY Movement
- Usable Size:
  - 11.90" x 7.60" x 7.50"
- Lightweight Design:
  - 11.75 pounds
- Max Orbital Diameter:
  - 53.7 mm
- Accurate OD/FI Sensors:
  - Within 3% of calibration
- Heat Rated Parts:
  - Aluminum and PETG

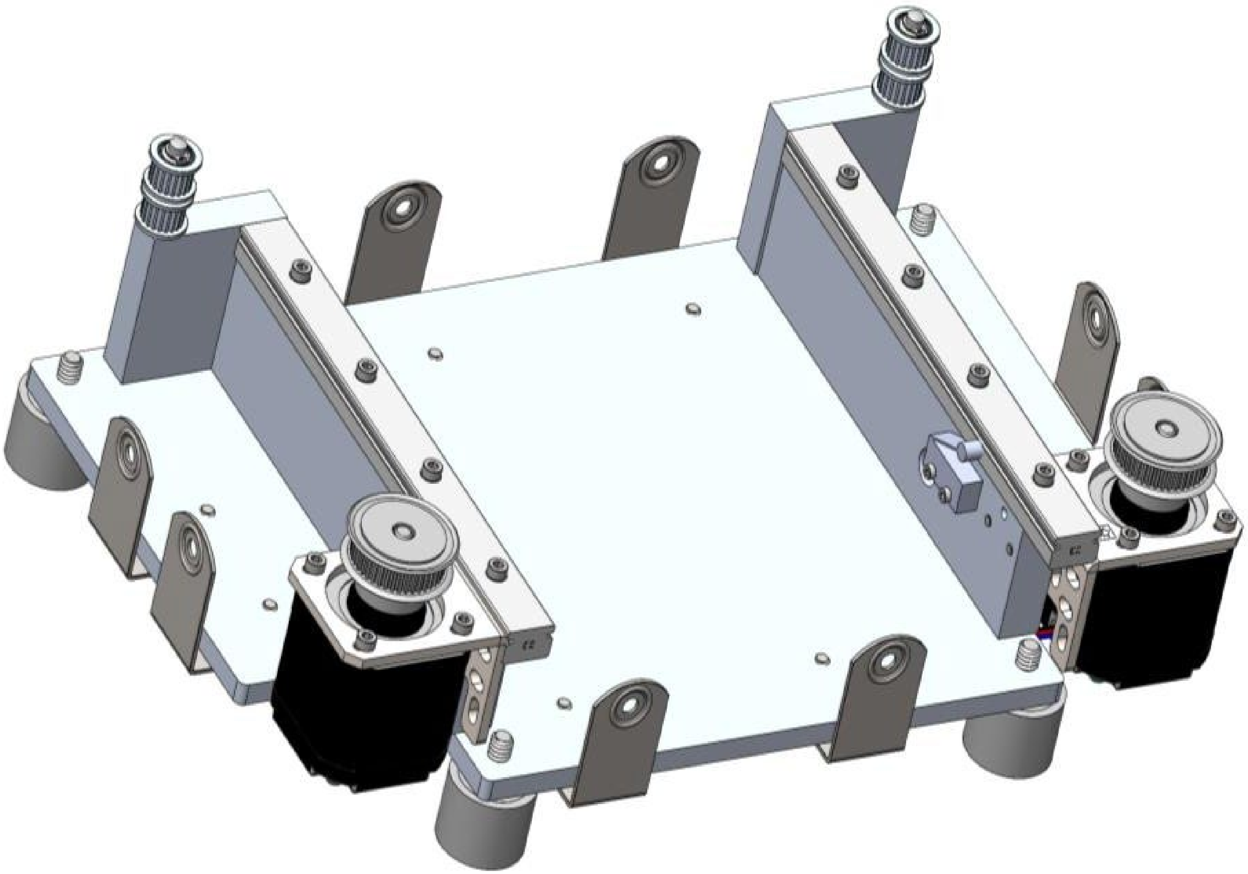
Customer Need	Metric	Microbe Mixer's Implementation
1	Dimensions: 14" (356 mm) x 9.75" (248 mm) x 7.5" (191 mm)	11.90" x 7.60" x 7.50"
7	Assembled weight and packaging < 49 pounds	11.75 pounds
23	IP rating > IP-X5	IP – X5 Silicon Coating
25/26/27	Adjustable and variably linear, orbital and double orbital patterns at 25 mm diameter and 1200 rpm speed	Max Diameter: 53.7 mm Nema-17 Stepper Motors Used
28	Number of conical 15 mL tubes held ≥ 6 Number of conical 50 mL tubes held ≥ 6	# of 15 mL Clear Tubes = 6 # of 50 mL Clear Tubes = 6
33	Number of shut-off buttons ≥ 1	# of shut off buttons = 1
34	Number of pause buttons ≥1	# of pause buttons = 1
36	Max rated speed for 2 weeks at 70 C	Aluminum and PETG Parts
38	355nm wavelength light source Light source ≥ 6V	365nm UV LEDs
48	OD sensor reading is within 15% of fluid range calibration	Sensor Reading ≤ 3%

Full System Design

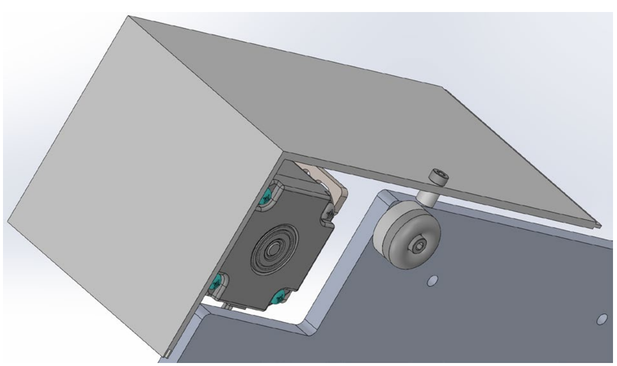
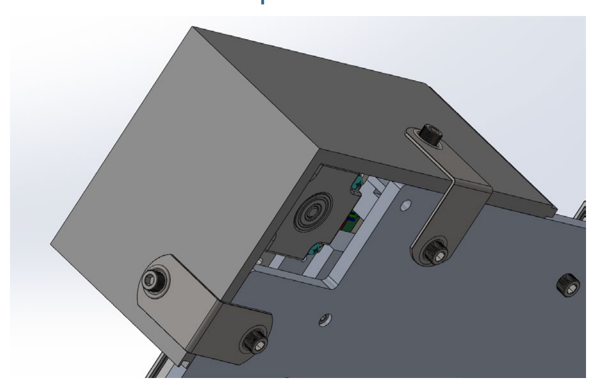
- Core XY movement
- Base Plate Subassembly
- Shaker Plate Subassembly
- UI Subassembly



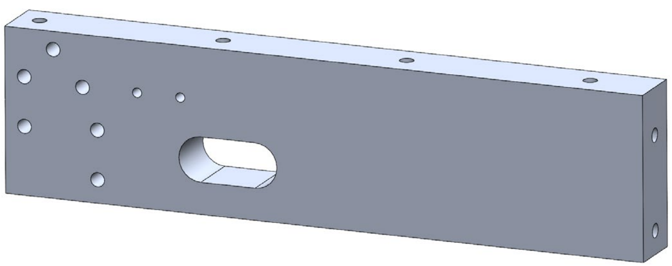
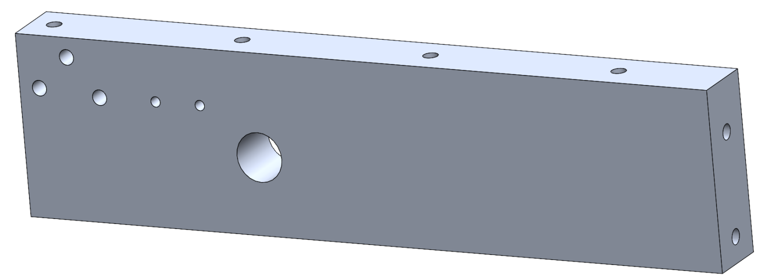
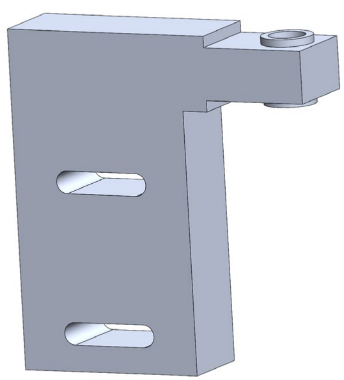
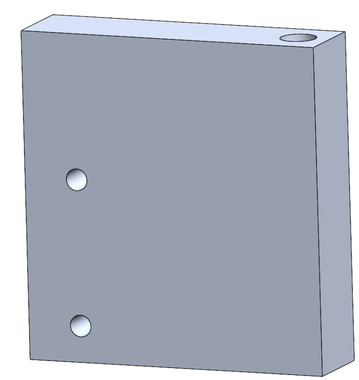
Base Plate Subassembly



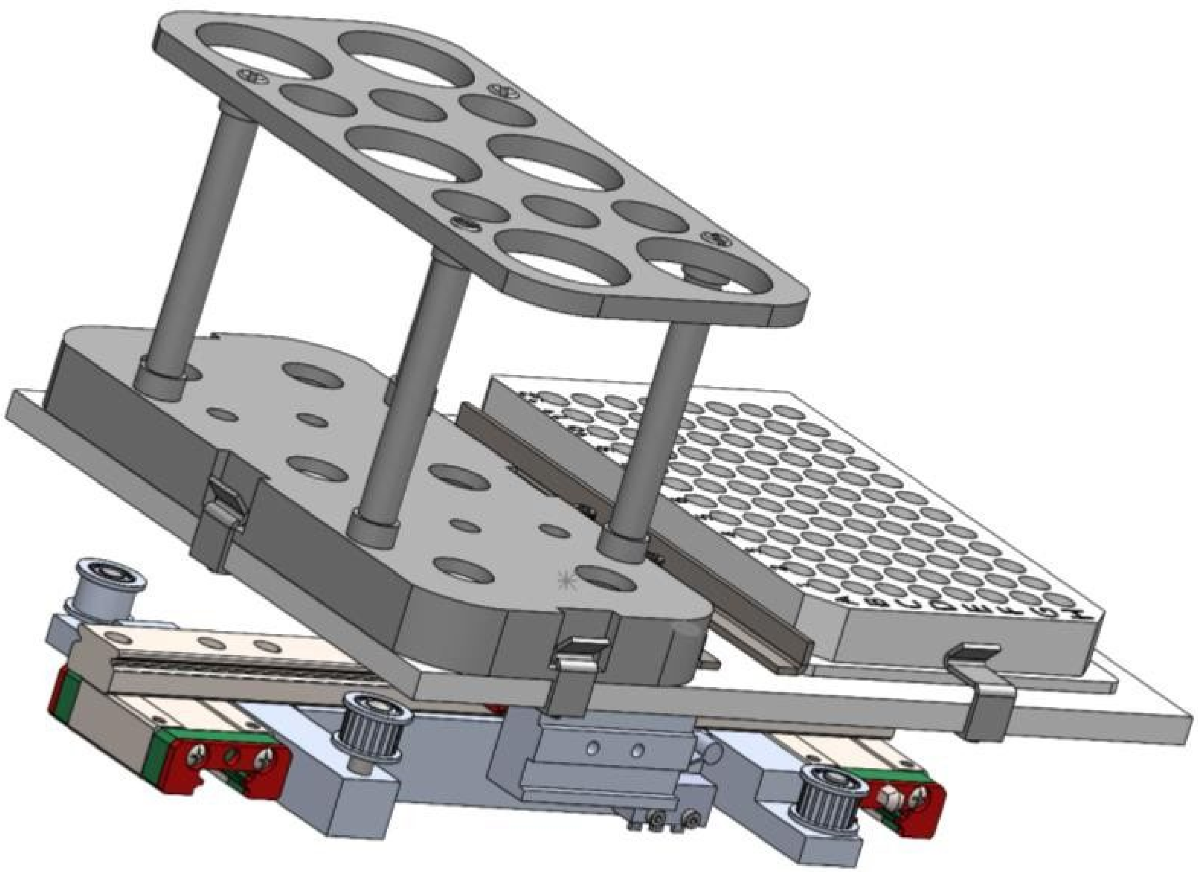
Base Plate: Design Highlights

	Old Design	New Design
Rubber Feet	▪ Unthreaded bumper made out of SPR Rubber 	▪ High-Temperature Load-Rated Threaded Bumper 
Wall Mounting	▪ Wall enclosures fastened into thin base plate 	▪ L-Brackets added and fasteners now located in manufacturable places 

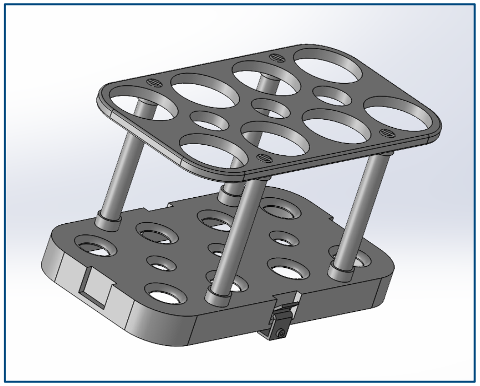
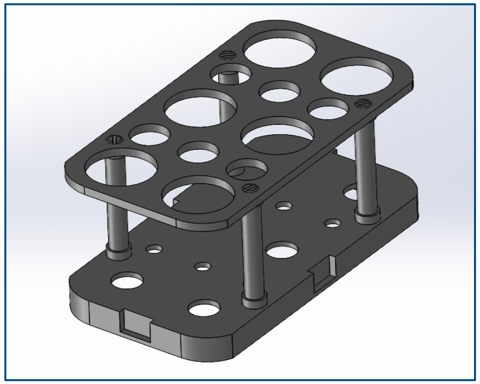
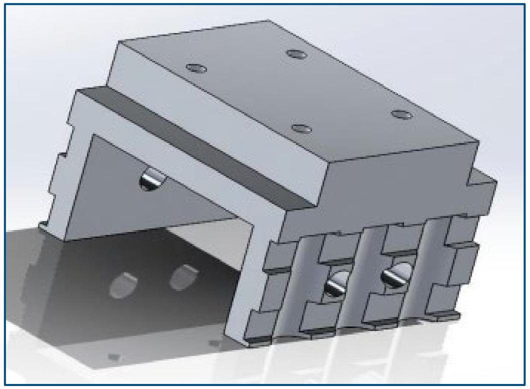
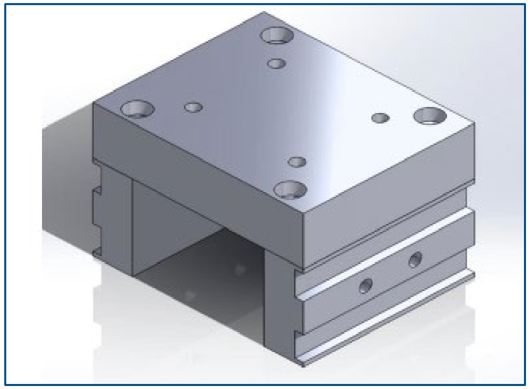
Base Plate: Design Highlights

	Old Design	New Design
Side Rail Support	▪ Holes designed for rail, limit switch, motor and idler mounting, with added holes for tensioning methods and a wire passage 	▪ Oval-like cut replaced with a circle and holes for tensioning removed for ease of manufacturing 
Idler Mounts	▪ Two slits for tensioning and a cantilevered structure with complex geometry 	▪ Redundant tensioning method eliminated and simplified machining implemented 

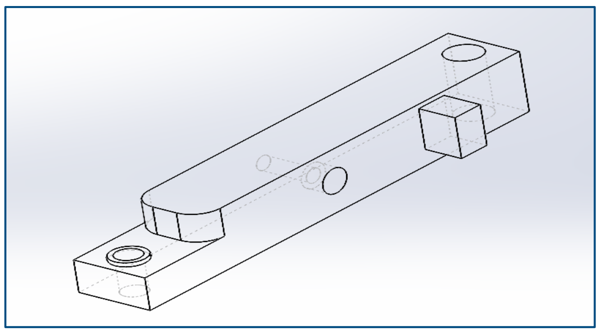
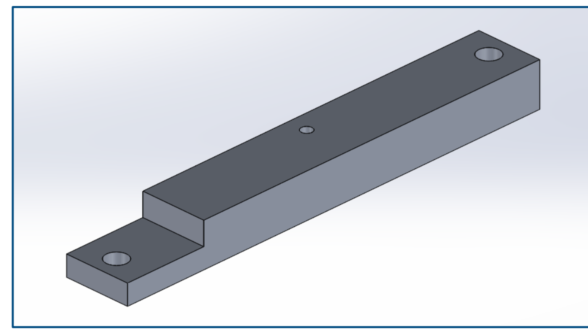
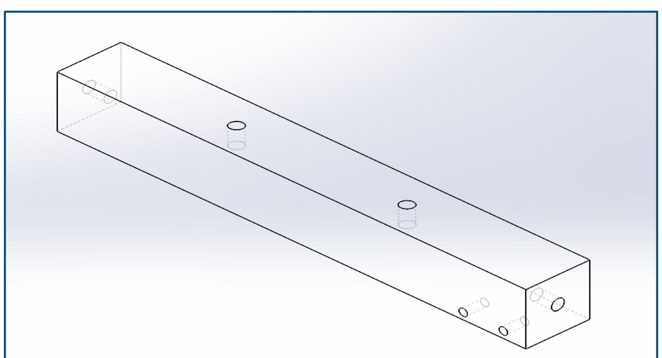
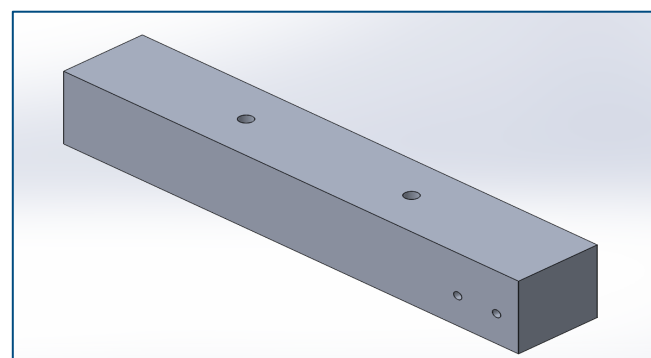
Shaker Plate Subassembly



Shaker Plate: Design Highlights

	Old Design	New Design
Test Tubes	▪ The designed holes allow for eight 50 mL tubes and three 15mL tubes 	▪ The designed holes allow for six 50 mL tubes and six 15mL tubes 
Belt Tie Down	▪ A one-piece design with curves along the sides. A manufacturers nightmare! 	▪ Separated into three pieces, which added four holes. Curves replaced with straight edges. 

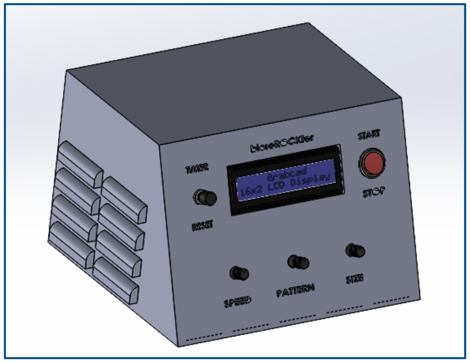
Shaker Plate: Design Highlights

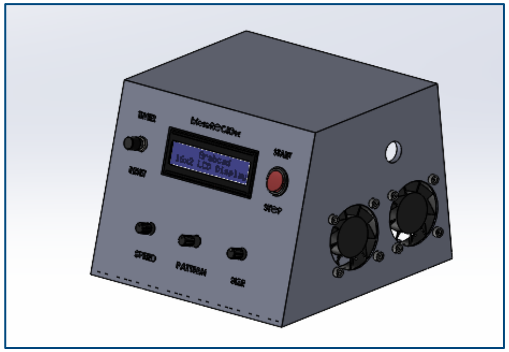
	Old Design	New Design
Lower Idler Mount	▪ A chamfer was applied to the cutout located at the top. The fastening location and a protrusion are located on the side of the piece. 	▪ The chamfer and protrusion were eliminated to make a simpler design. The fastening location was moved to the top for ease of assemblance. 
Lower Idler Positioner	▪ Holes were designed for top rail, lower idler and limit switch mounting 	▪ Lower idler mount fastening hole was eliminated, while limit switch holes were raised for touching 

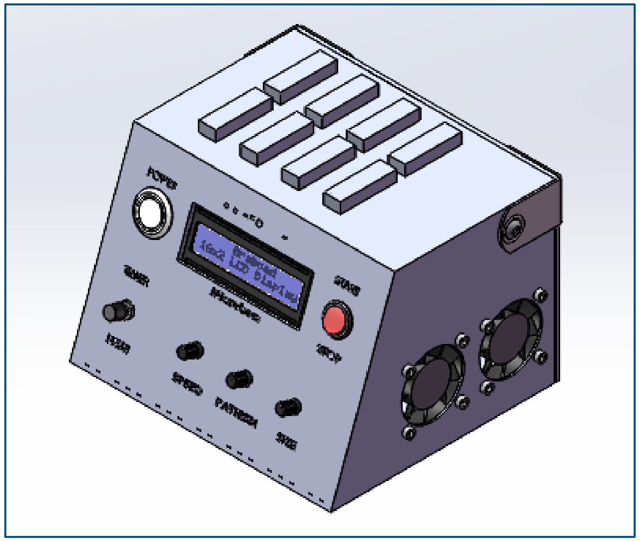
User Interface Subassembly

User Interface: Design Highlights

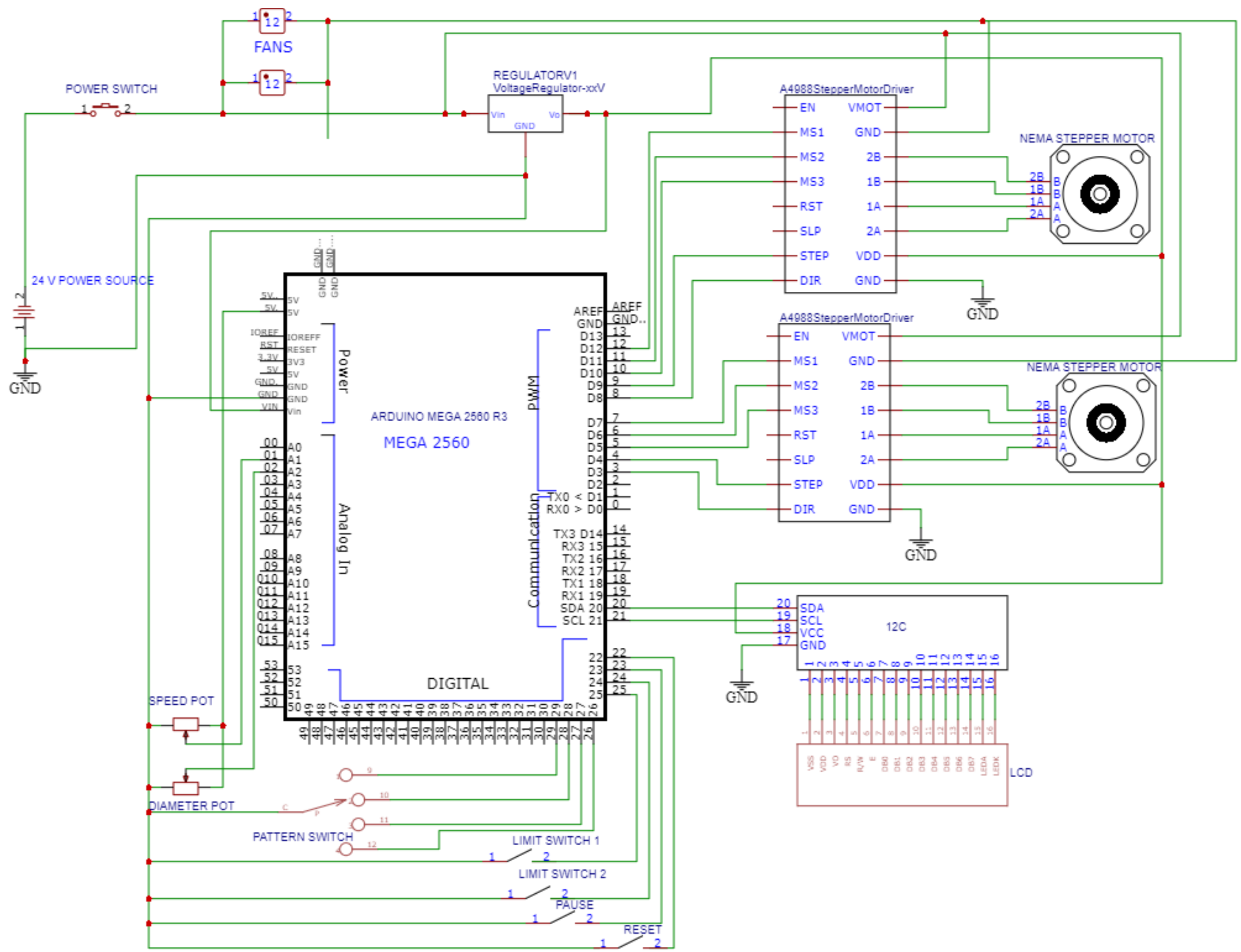
- Redesigned for user safety
- Potentiometers tune the speed and path diameter
- Air vents relocated to the top
- Back panel designed to keep the electronics better protected
- LCD display shows easy to follow instructions and updates





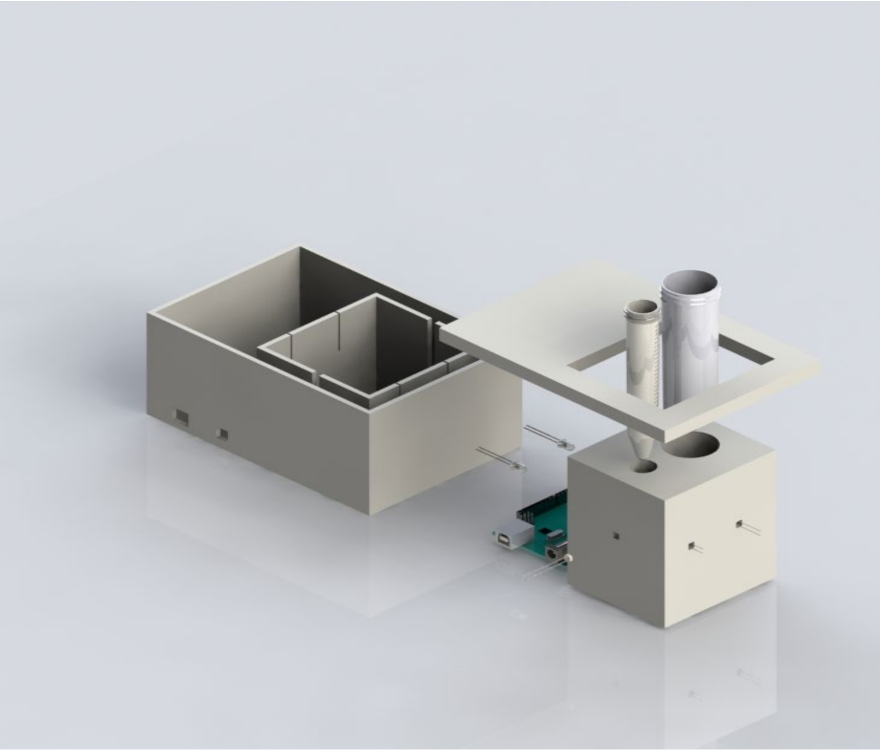


User Interface: Electronics

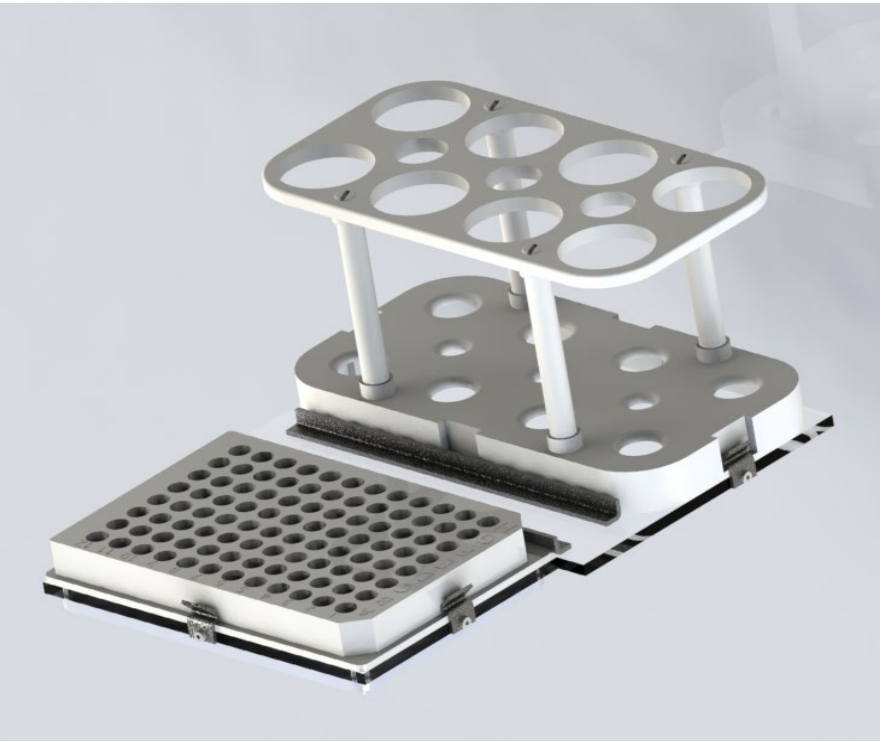
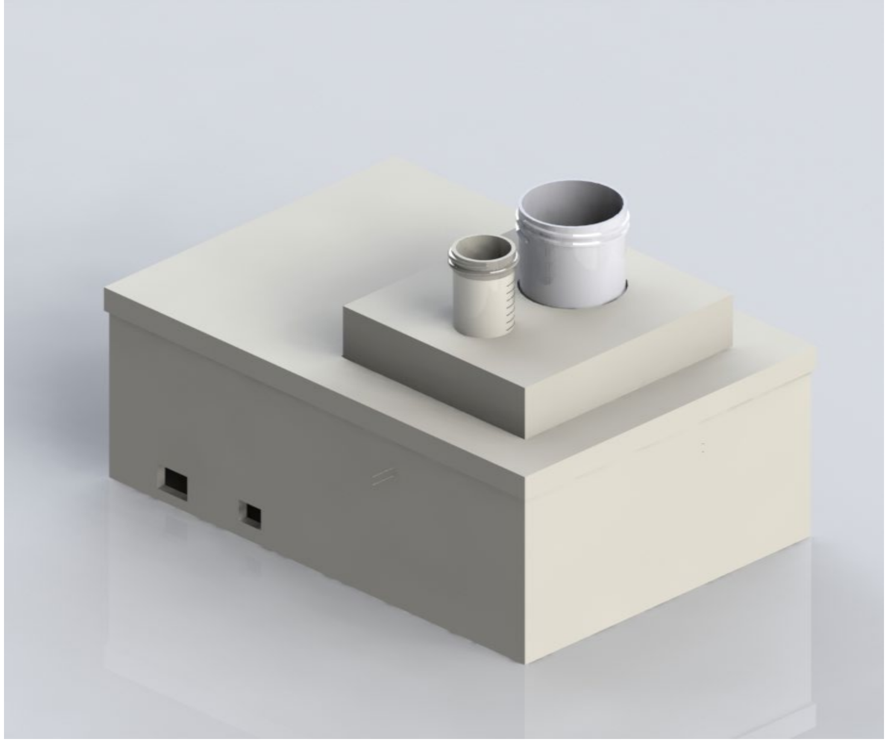


OD/FI Subassembly

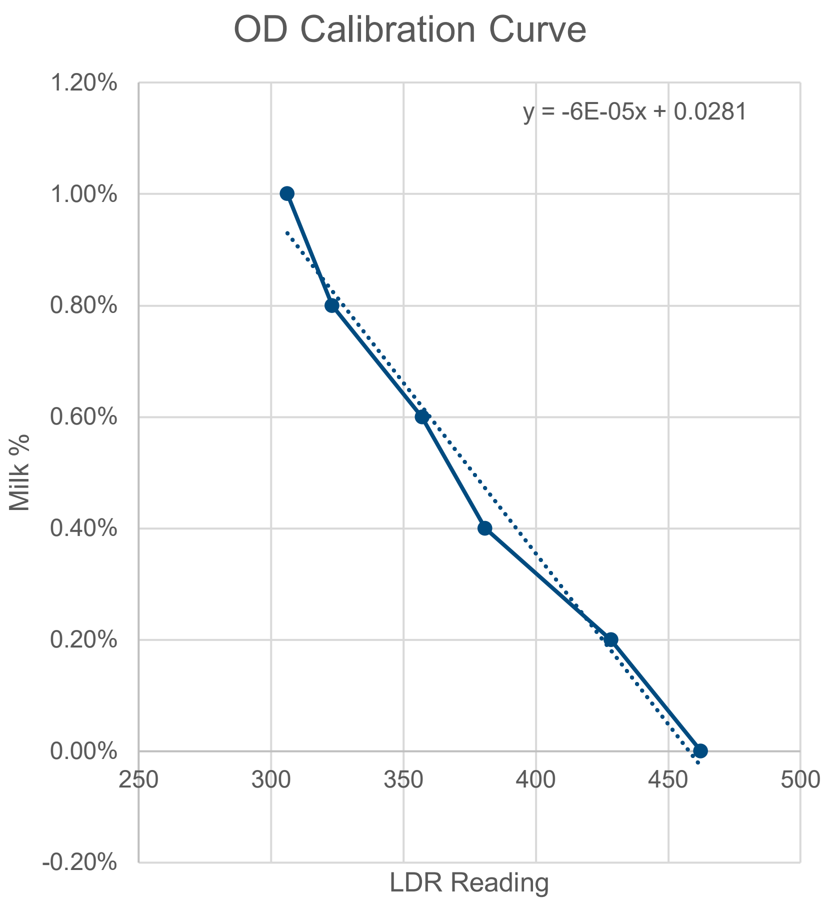
- Featured here is:
  - 15ml test tube
  - 30 ml test tube
  - Arduino Uno
  - 4 LDRs
  - 2 365nm UV diodes
- All housed within a 3D printed unit that will use a USB cord to connect this unit to the main UI
- Housing features a cover to protect electronics from any spillage, as well as keeps all components in one neat package.

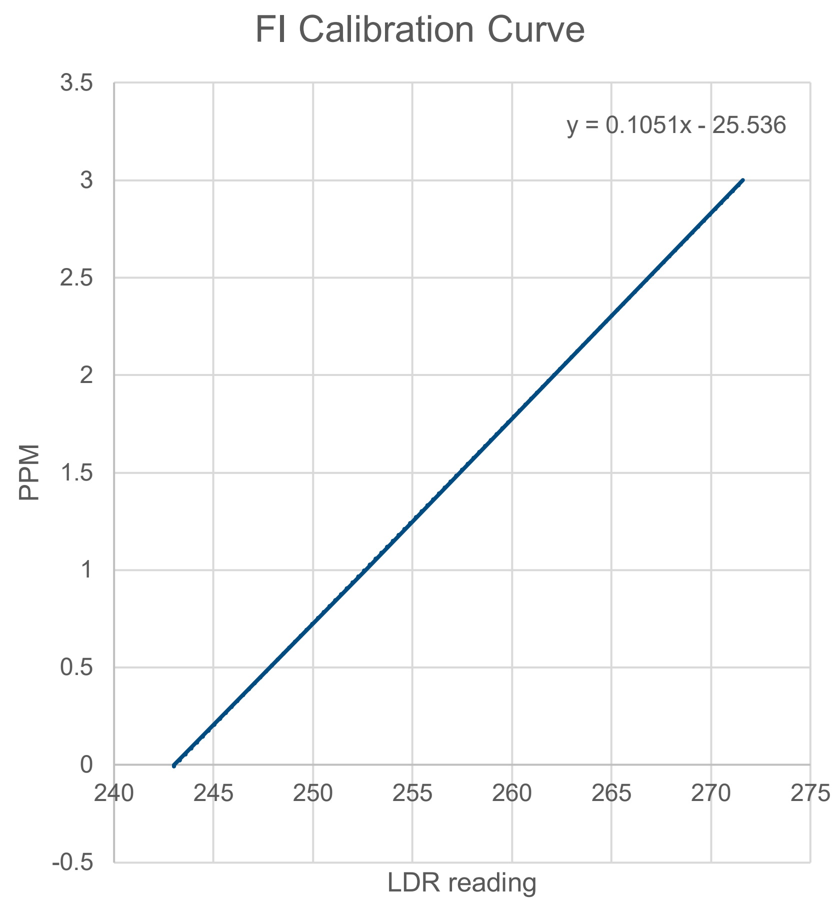


Evolution of Design: OD/FI

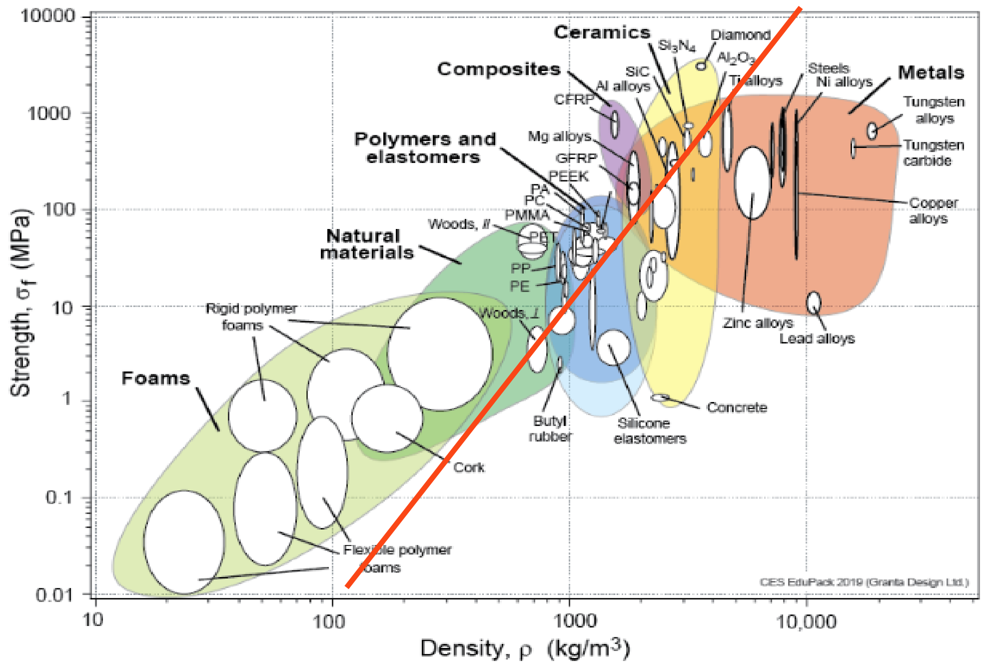
Old Design	New Design
	

OD/FI Analysis





Material Ashby Plot Analysis



$$C_{butyl\ rubber} = \frac{\sqrt{\sigma_f}}{\rho} = \frac{\sqrt{2\ MPa}}{900\ \frac{kg}{m^3}} = 1.57\ x\ 10^{-3}\ \frac{m^3\sqrt{MPa}}{kg}$$

$$C_{aluminum} = \frac{\sqrt{\sigma_f}}{\rho} = \frac{\sqrt{100\ MPa}}{275\ \frac{kg}{m^3}} = \boxed{36.3\ x\ 10^{-3}\ \frac{m^3\sqrt{MPa}}{kg}}$$

Shaker Top Plate Bending Analysis

$$\frac{1}{12}bh^3 = \frac{1}{12}(149.2\ mm)(6.35\ mm)^3 = 3.184\ x\ 10^3\ mm^4$$

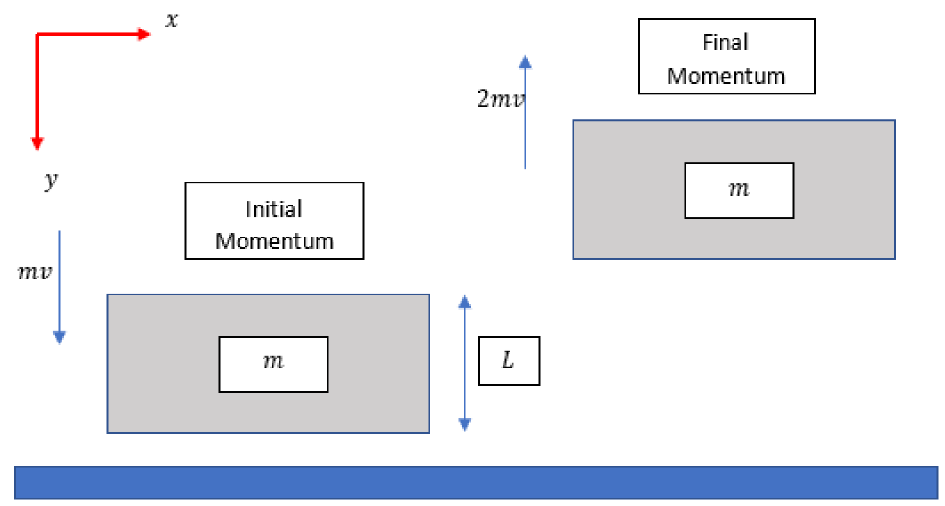
$$\delta = -\frac{PL^3}{3EI} = -\frac{(11.1\ N)(103.25\ mm)^3}{3(68.9\ x\ 10^3\ MPa)(3.184\ x\ 10^3\ mm^4)} = 0.01856\ mm$$

Drop Test Analysis

$$v_f = \sqrt{2gh} = 3.836\,\frac{m}{s}$$

$$m = \rho_{PETG} V_{enclosure} = 0.698\ kg$$

$$c = \sqrt{\frac{E}{\rho}} = 1283.744\,\frac{m}{s}$$



$$F = \frac{\Delta p}{\Delta t} = \frac{mv_f - mv_i}{\Delta t} = \frac{\cancel{2}mv}{\cancel{2}\frac{L}{c}} = mv\frac{c}{L} = m\frac{c}{L}\sqrt{2gh} = 17805.88\ N$$

$$\sigma = \frac{F}{A} = 712\ kPa$$

$$n_{FOS} = \frac{\sigma_t}{\sigma} = \frac{45.8\ MPa}{0.712\ MPa} = 63.62$$

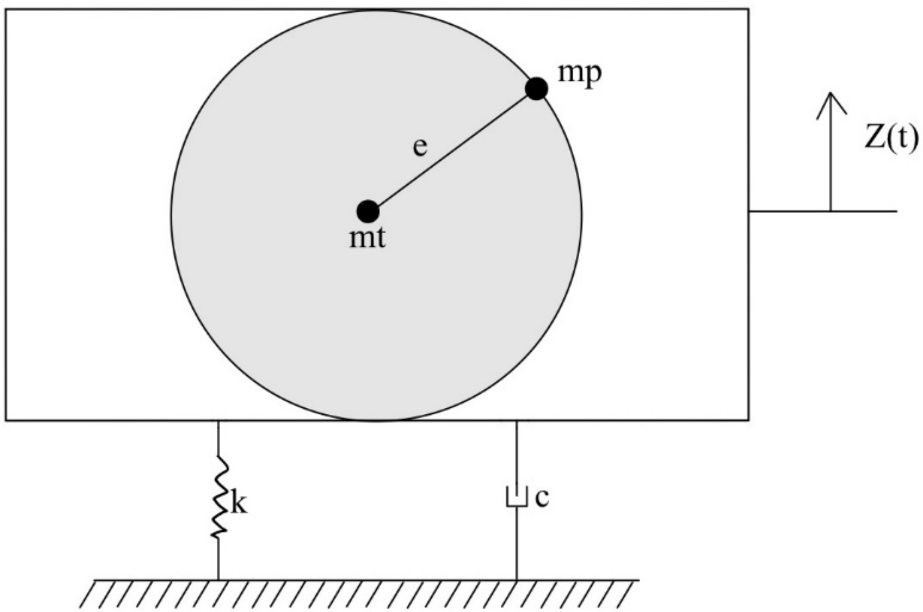
Vibration Analysis

$$z_r(t) = esin(\omega t)$$

$$\ddot{z}_r(t) = -\omega^2 esin(\omega t)$$

$$m\ddot{z} + c\dot{z} + kz = m_p e\omega^2 \sin(\omega t)$$

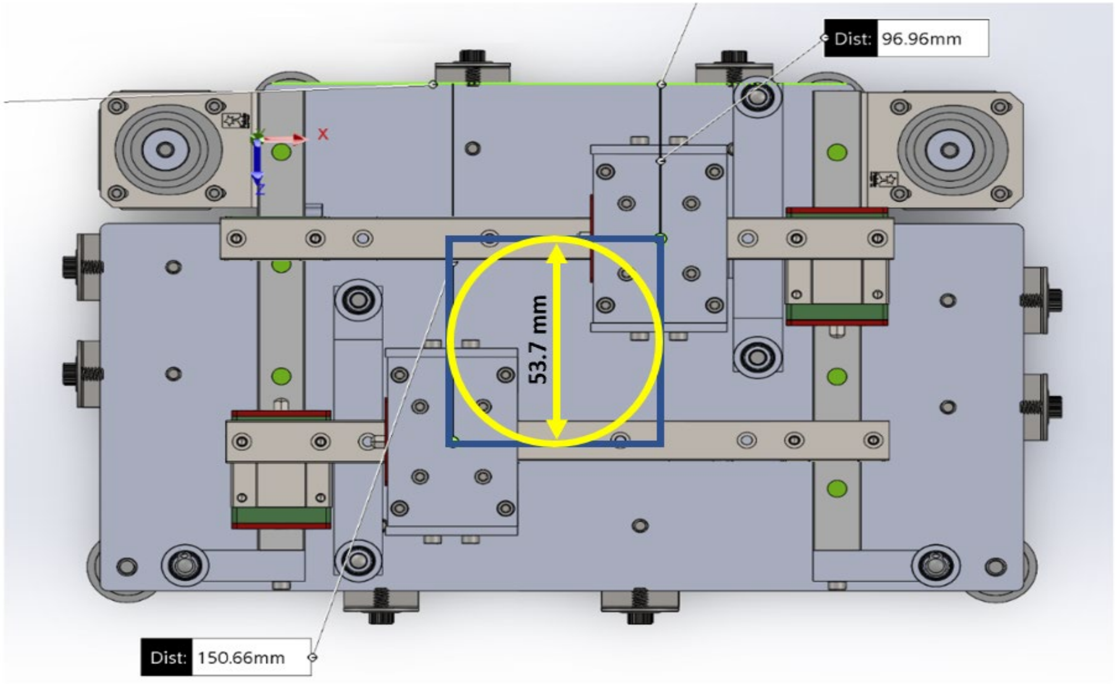
$$r = \frac{\omega}{\omega_n} = 0.5$$



$$Z = \frac{m_p e}{m} * \frac{r^2}{\sqrt{(1-r^2)^2 + (2\zeta r)^2}} = 1.55 \qquad \theta = \tan^{-1}\left(\frac{2\zeta r}{1-r^2}\right) = 1.8$$

$$z(t) = Zsin(\omega t - \theta) = 1.392\, mm$$

Orbital Diameter Calculation



Center of Rail Block in Relation to Top Edge of Base Plate

$$L_{max} = 150.66\ mm$$

$$L_{min} = 96.96\ mm$$

$$d_{max} = L_{max} - L_{min} = 53.7\ mm$$

Speed Calculation

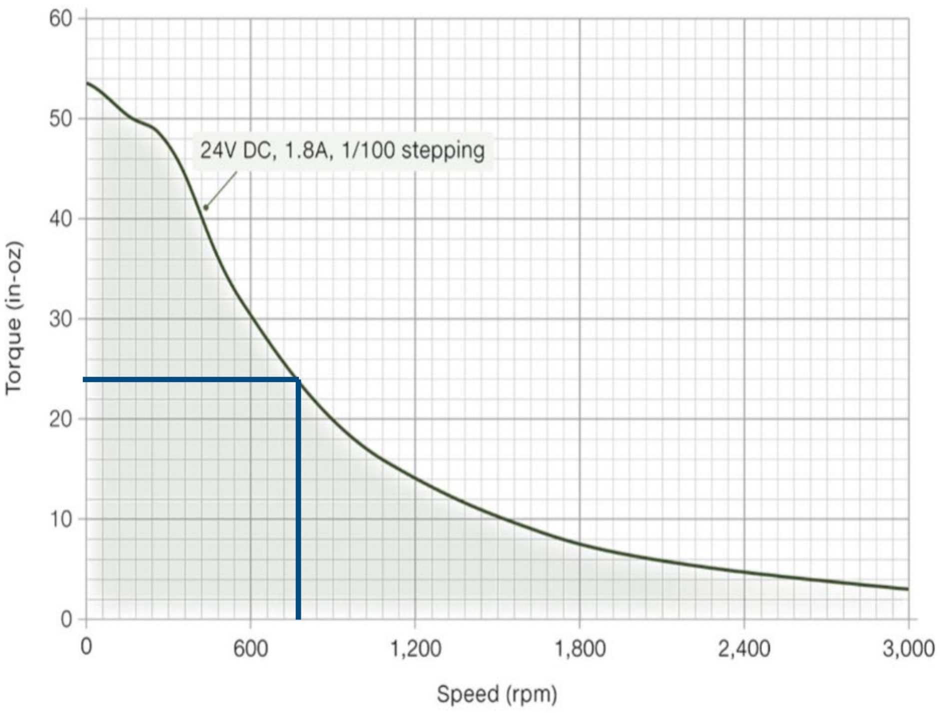
$$F_f = W_{sys} * \mu = 150.7\ oz * (0.3) = 45.21\ oz$$

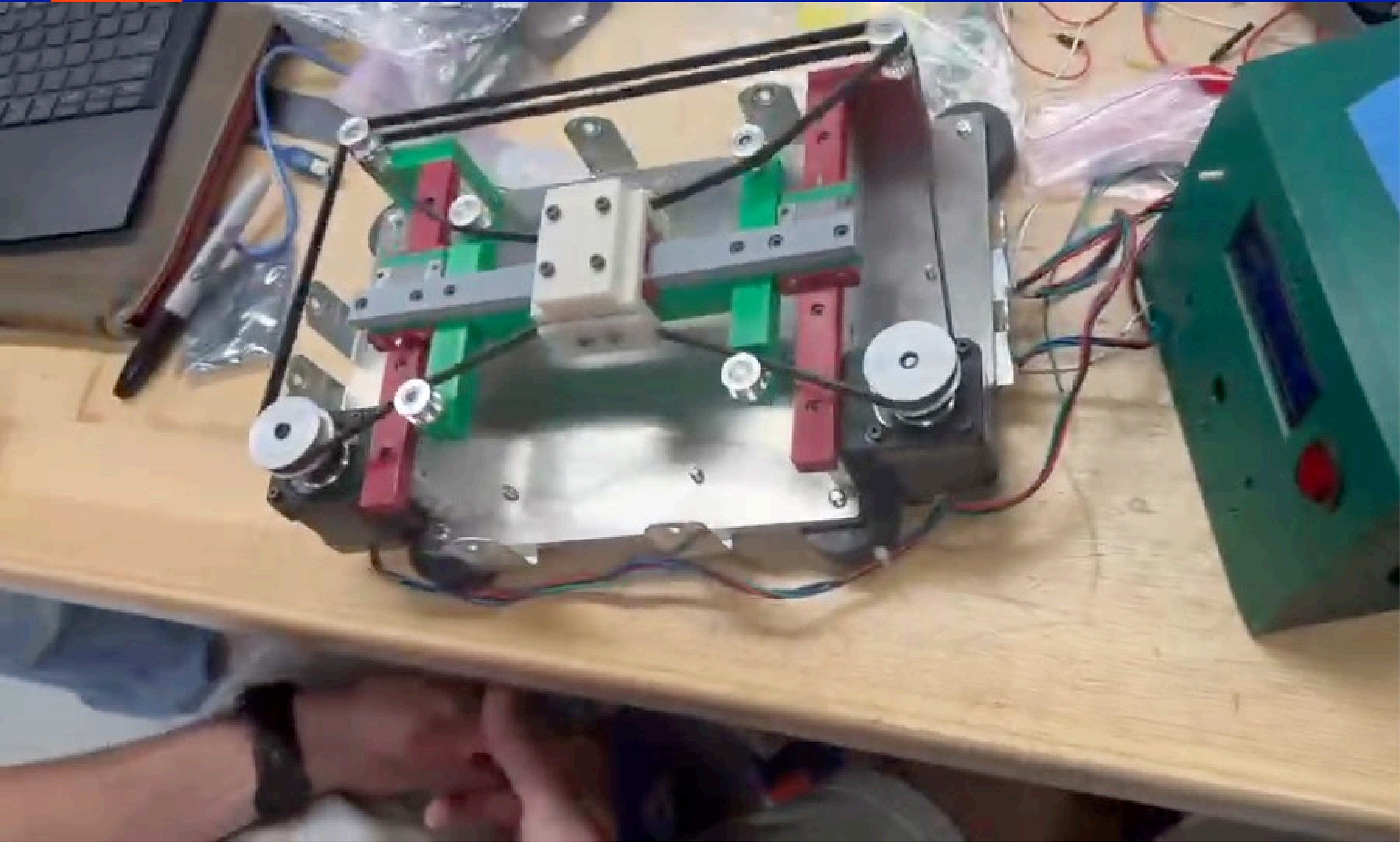
$$T = F_f * r_p = (45.21\ oz)(0.54\ in) = 24.20\ in - oz$$

$$780 \frac{rev}{min} * \frac{2\pi}{1\ rev} * \frac{1\ min}{60\ s} = 81.68 \frac{rad}{s}$$

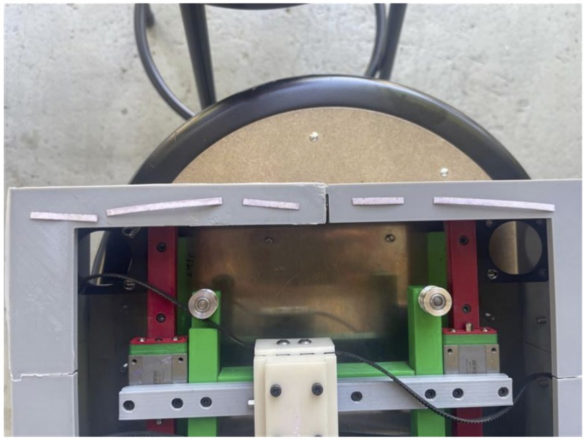
$$V_{belt} = C_p * \omega_{motor} = \left(81.68 \frac{rad}{s}\right) * (0.085\ m) = 6.98\ m/s$$

$$\omega_{orbit} = \frac{V_{belt}}{C_{orbit}} = \frac{6.98 \frac{m}{s}}{0.0785\ m} * \frac{1\ rev}{2\pi\ rad} * \frac{60\ s}{1\ min} = 849.09\ rpm$$

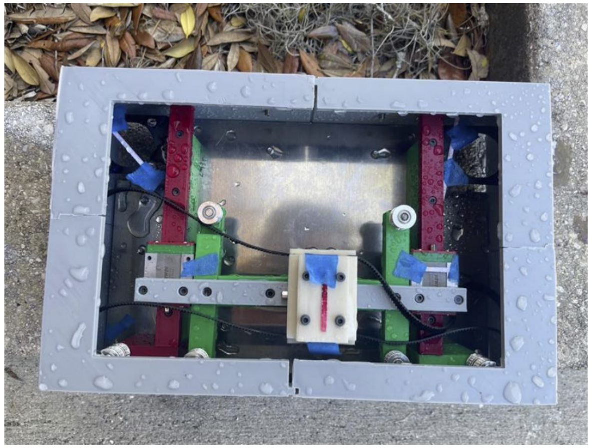




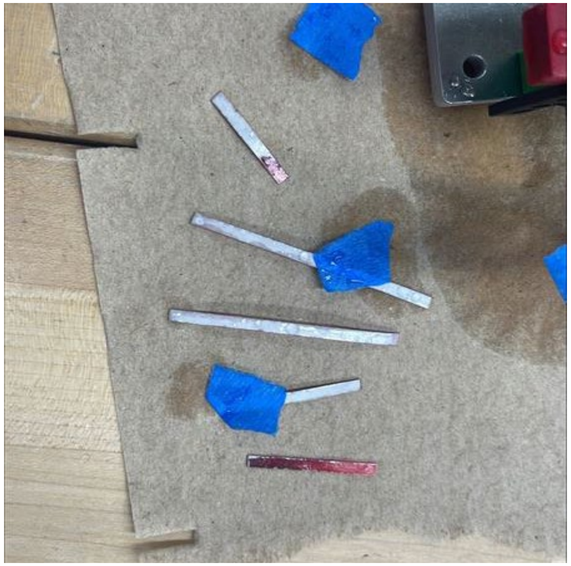
Product Testing: IP-X5



As a preliminary test, the utilized IP-X5 Silicon spray was applied to the moisture indicators.



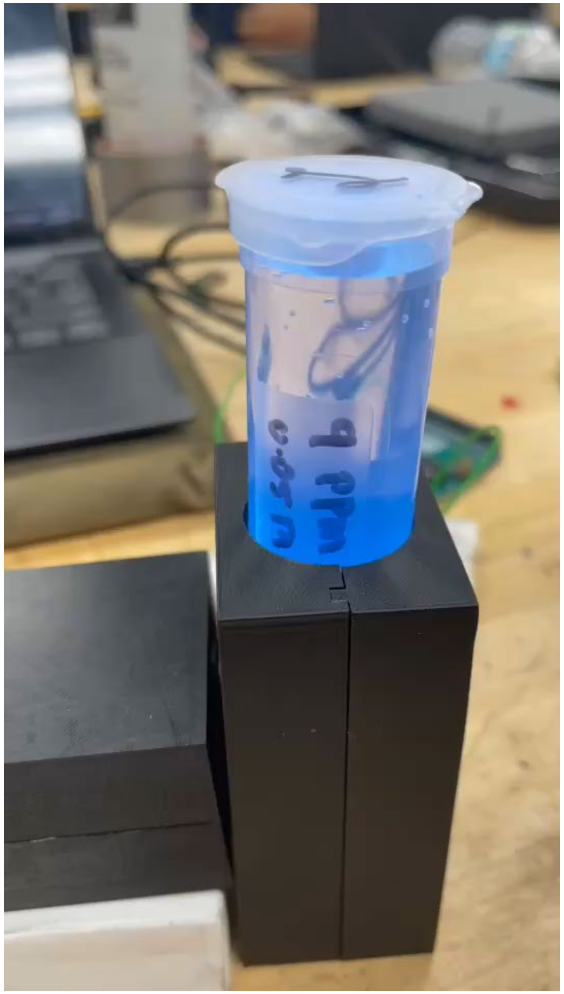
The strips were stored inside the table's housing and a constant water stream for the IP-X5 test was placed upon the design.



Only one indicator experienced failure and it was due to improper fastening. The tape holding the strip peeled the adhesive and altered the performance.

Product Testing: OD/FI

- 5 vials of florescent quinine were prepared and tested. Obtaining the concentration of quinine in the solution within a 15% range for all five was considered passing. (Florescent Intensity)
- 5 vials of a milk solution were prepared and tested. Obtaining the concentration of milk in the solution within a 15% range for all five was considered passing. (Optical Density)
- Successfully identified both milk concentrations and quinine concentrations within a range of 0 to 9% offset.



Future Testing

- For acoustic testing, the table must run at the full 350 rpm for 5 minutes while not exceeding a 50dBA sound level. Both linear and orbital patterns will be tested.
- For temperature testing, the table will be heated to a temperature of 70°C and must run at 350 rpm for 4 minutes. The same conditions must be met at a temperature of 4°C.
- The table must be fully functional after being dropped from a height of 75 cm onto concrete.

Cost of Materials

PROTOTYPE

Part Type	Cost
OTS	$ 843.45
Raw Material	$ 84.48
Custom	$ 20.99
Total:	**$ 948.92**

MASS PRODUCTION

Part Type	Cost
OTS Parts	$ 676.01
Raw Material	$ 82.73
Custom	$ 15.33
Total:	**$ 775.81**

- OTS Parts
  - Fasteners, pulleys, rails, electronics
  - McMaster-Carr, Amazon, Digi-Key
- Raw Material
  - 6061-Aluminum
  - Base Plate, Shaker Plate
- Custom Parts
  - 3D-Prints (PETG)
  - Wall Enclosures, Tube Rack

Cost of Assembly

Subassembly	Assembly Time (sec)
Base	615
Shaker Plate	490
User Interface	768
Total:	**1873 sec = 0.52 hours**

The average salary for an assembler in Florida: $16.27/hour

Total Assembly Cost: $8.46

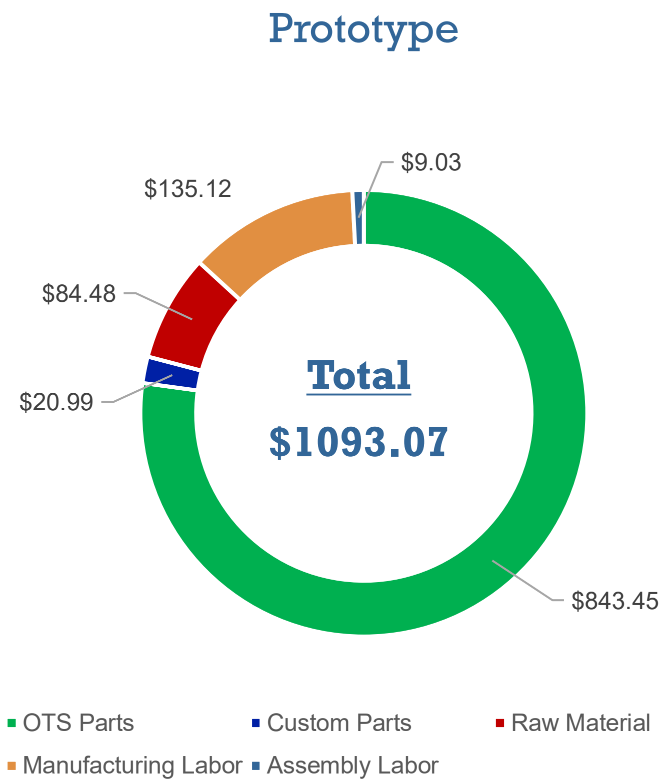
Cost of Manufacturing

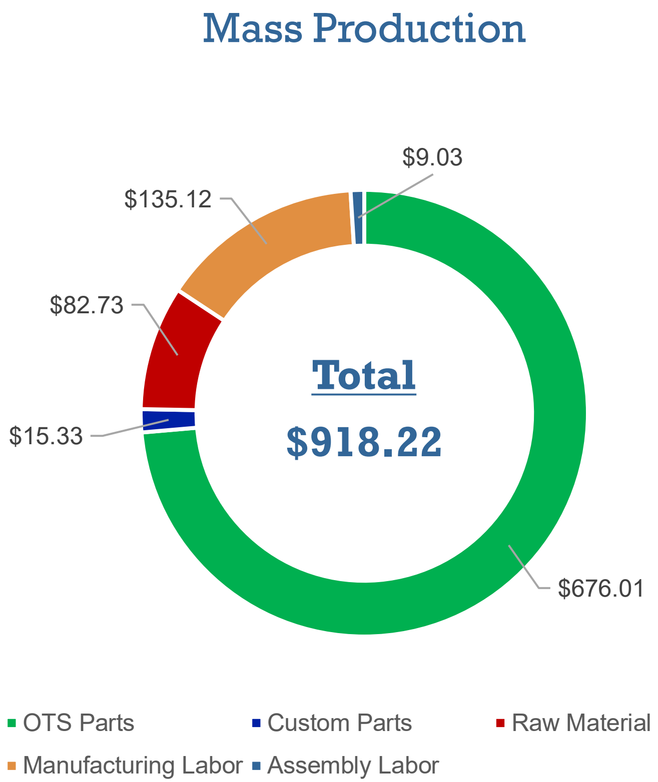
Subassembly	Assembly Time (Hrs.)
Base	3.5
Shaker Plate	2.5
User Interface	0
Total:	**6 hours**

The average salary for a machinist in Florida: $22.52/hour

Total Assembly Cost: $135.12

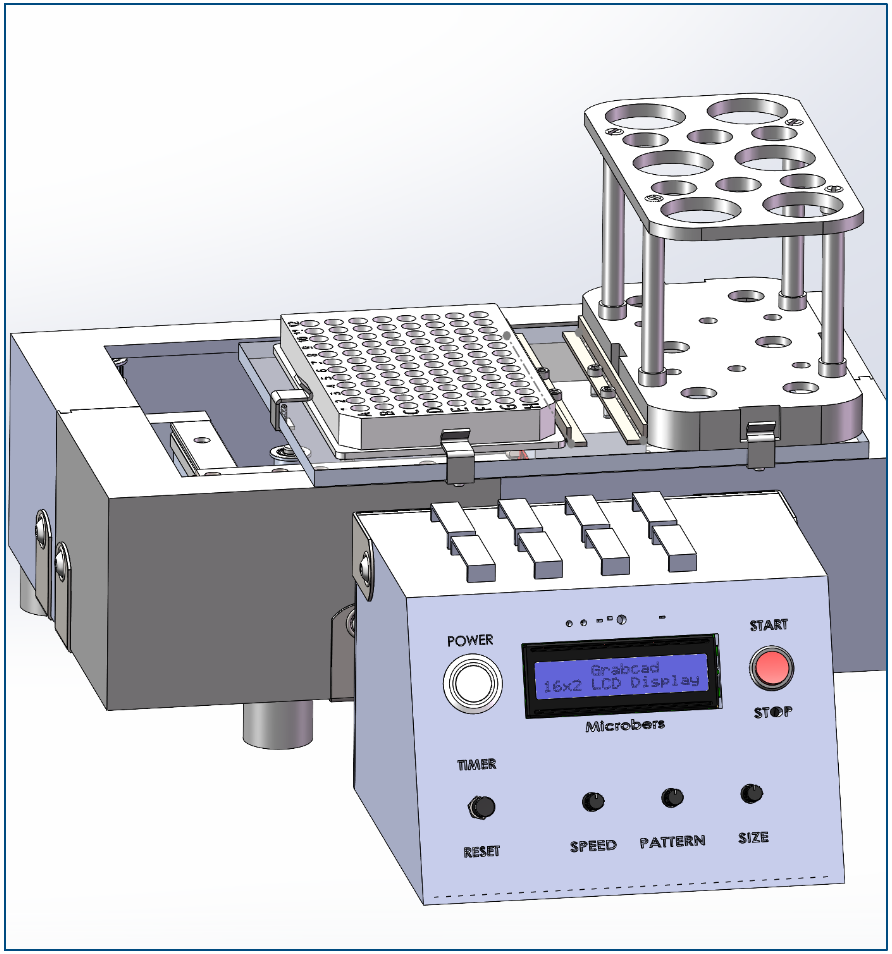
Total Cost


Prototype
$9.03
$135.12
$84.48
$20.99
Total
$1093.07
$843.45
OTS Parts
Custom Parts
Raw Material
Manufacturing Labor
Assembly Labor


Mass Production
$9.03
$135.12
$82.73
$15.33
Total
$918.22
$676.01
OTS Parts
Custom Parts
Raw Material
Manufacturing Labor
Assembly Labor

Design Summary

- Expansions in the design make for a multifaceted project.
- Room for improvement in most aspects of the project.
- Low cost and high versatility show enough promise that the concept should be completed.



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Thank You.

Questions?

POWERING THE NEW ENGINEER TO TRANSFORM THE FUTURE