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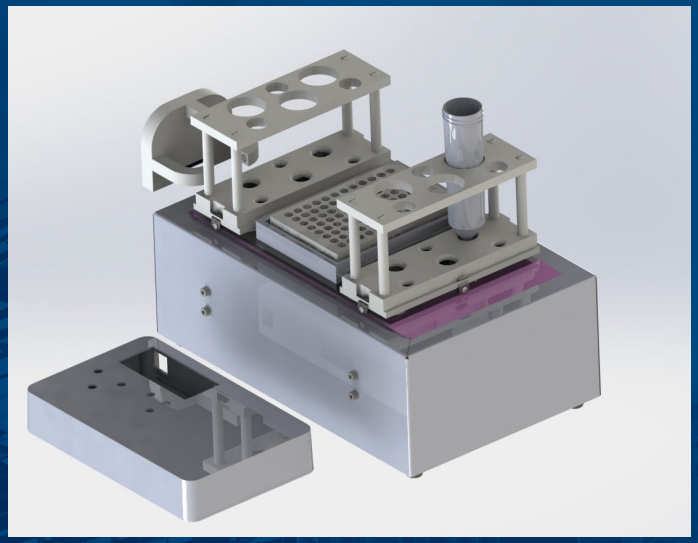
Mechanical and Aerospace Engineering



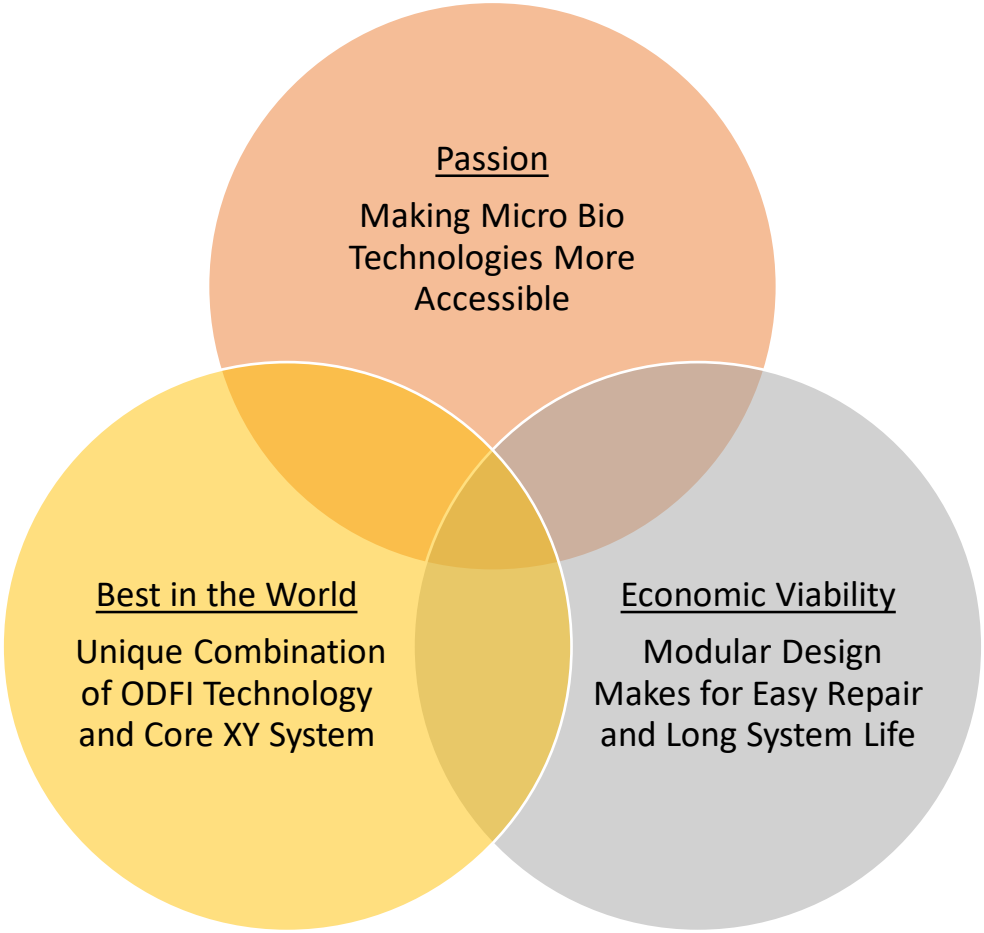
COUNTER CULTURE BIO

EML4502 Mechanical Engineering Design III Spring 2023

Group 261F – James Bond, Israel Chinn, John Faiella, Luke Nevins, Ryan Ringrose, Brianna Szymanski, Adam Wolcott

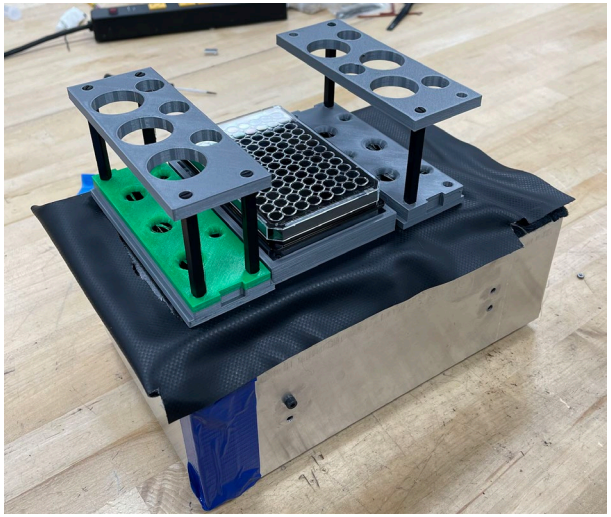
Hedgehog Concept

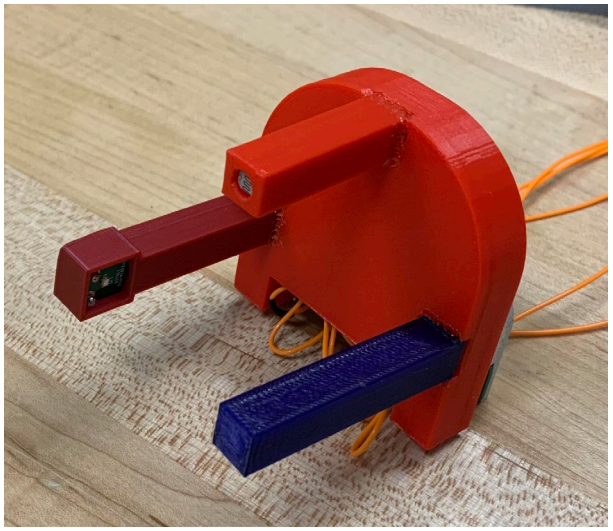
Our design philosophy is to create an efficient Core XY system that incorporates OD/FI technologies, is easily operable, and can integrate into Micro Bio labs effortlessly.



Key Product Specifications

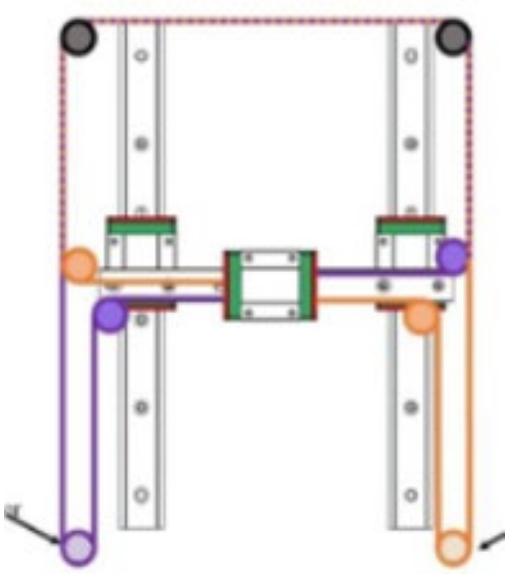
- Product dimensions:
  - 11.93” x 7.34” x 8.03”
- OD/FI
  - Claw: 3 pronged arms: 2 sensors and 1 LED
  - Holds 3 big and 3 small test tubes
  - 96 well plate
- Enclosure:
  - Aluminum sheet metal
  - Boot material: black vinyl polyester fabric
- Reaches maximum speed of 350 RPM
- Reaches maximum radius of 25 mm
- Incorporates PCB

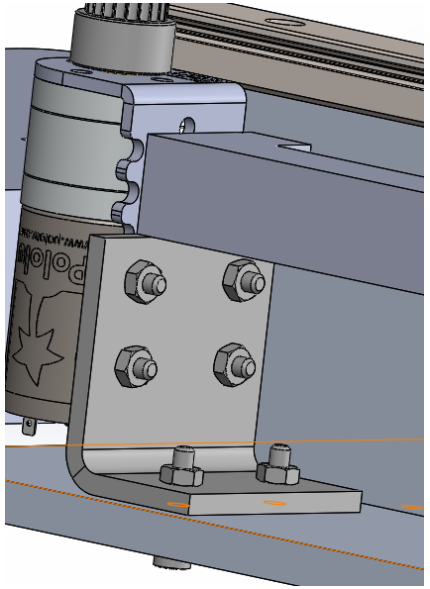




Drive Subsystem

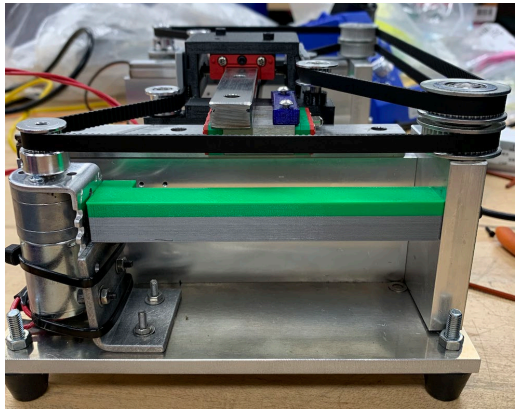
- Includes 3 OTS rails and 3 OTS rail blocks
- Belts in CoreXY path
- Parts manufactured out of aluminum or PETG 3D printed plastic depending on strength needs and geometry
- Motor mounts are OTS brackets with modified through holes

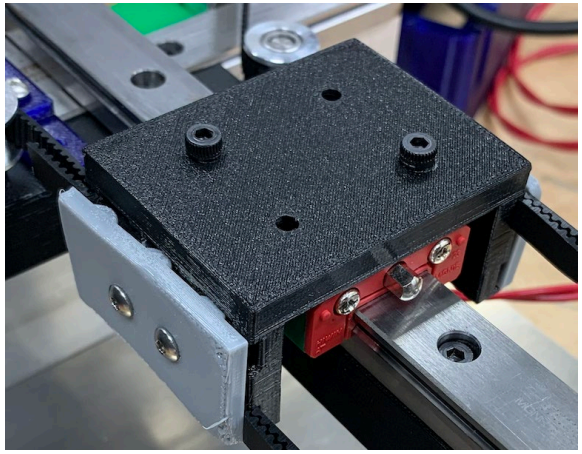


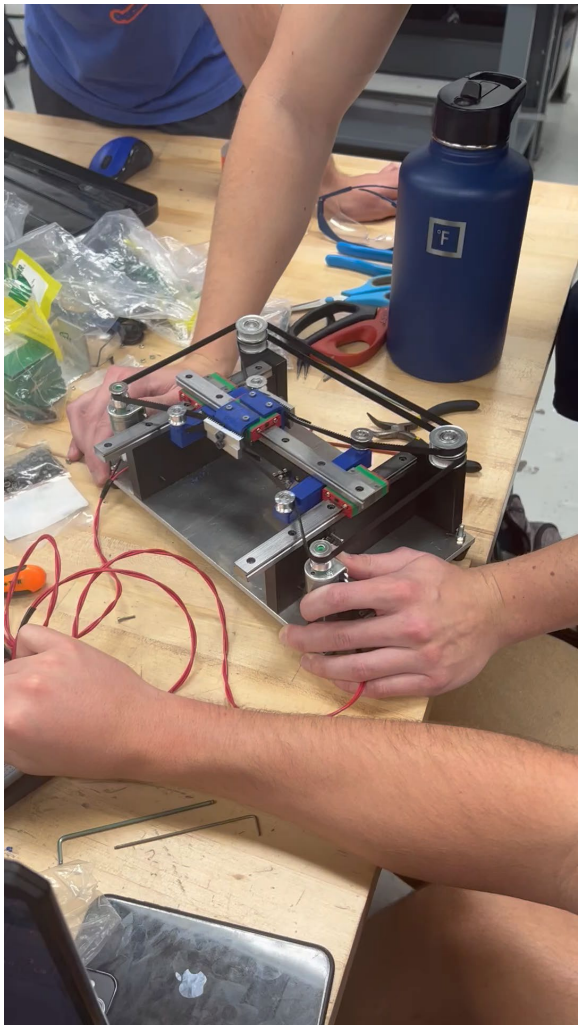


Evolution of Design – Drive System

- Many of the parts were originally 3D printed out of PETG and had threaded inserts
- The belt clamp was improved from the original design
- The middle idler mount was consolidated into one part and made thinner
- A spacer was added to structurally support the motor mount

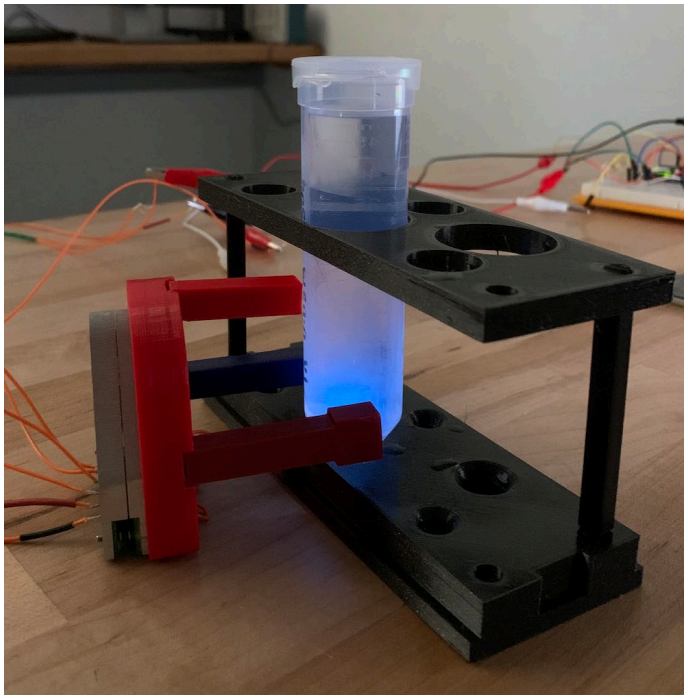


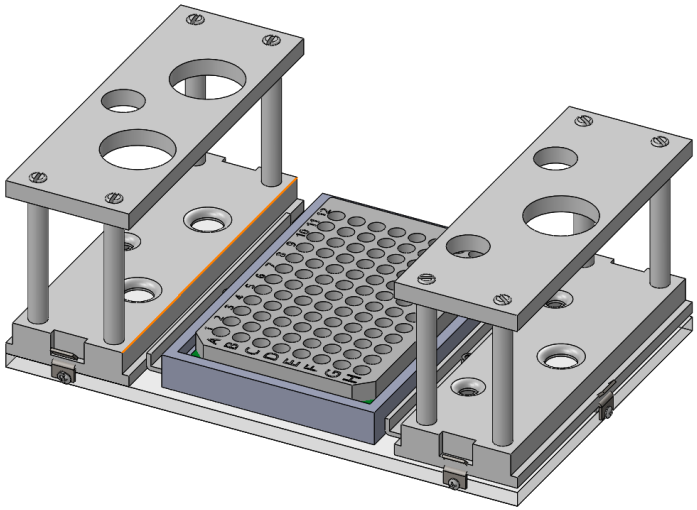


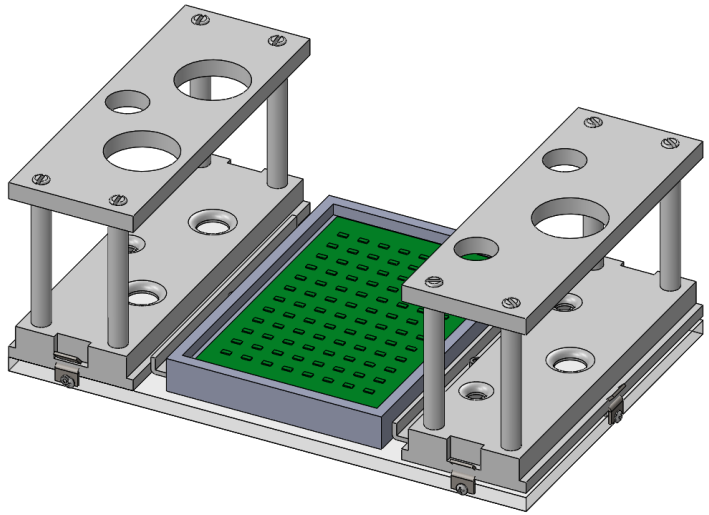


OD/FI Subsystem

- The Claw uses a LED to illuminate the test tubes a sensor on the opposite side reads the OD and the Sensor above reads the FI
- LEDs below the well plate illuminate each well of a 96 well plate individually and the top sensor reads both the OD and FI measurement

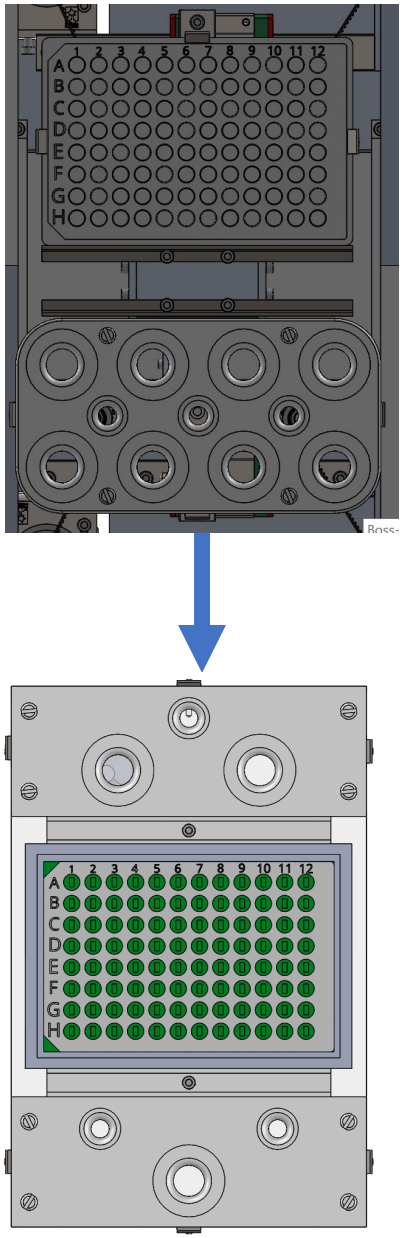






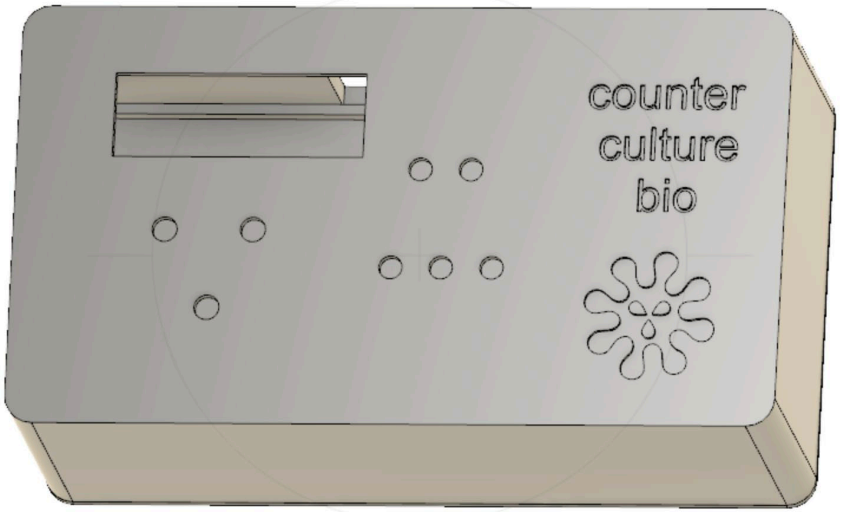
Evolution of OD/FI

- The 96 LED PCB went from below the top plate to directly below the well plate
- The Claw went through several iterations making it smaller and to improve the fit between test tubes
- The mounting of the well plate from being held on with edge clips to a custom 3D printed part



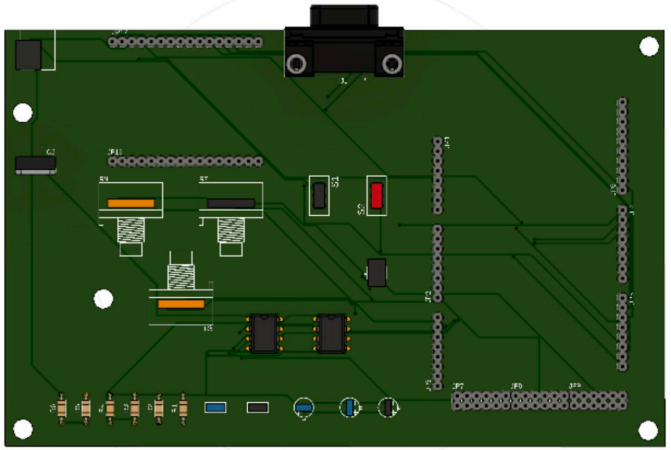
Electrical Subsystem

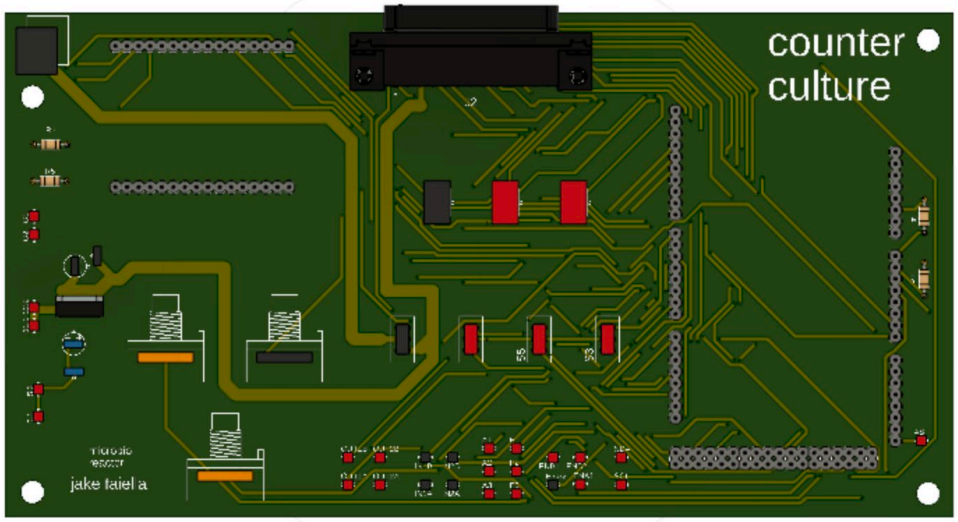
- 2 parts – the controller unit and shaker table unit
- Shaker table unit is responsible for joining the motors, limit switched and ODFI light board into one spot
- Controller Unit provides the operator with various controls: power, rpm, radius, pause, etc.
- Controller and shaker table are connected via a serial cable
  - The controller requires 12V power

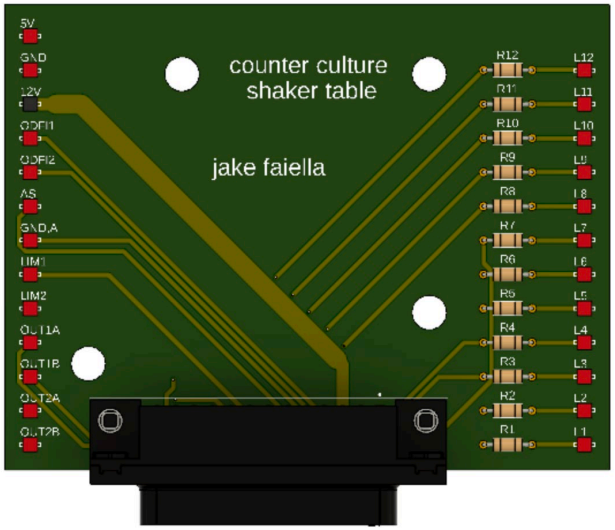


Evolution of Design – Electrical

- A PCB was designed for the table and for the controller unit
- Controller went through 2 iterations
  - Larger serial connector
  - More switches and buttons
  - Breakout pads in case things went wrong







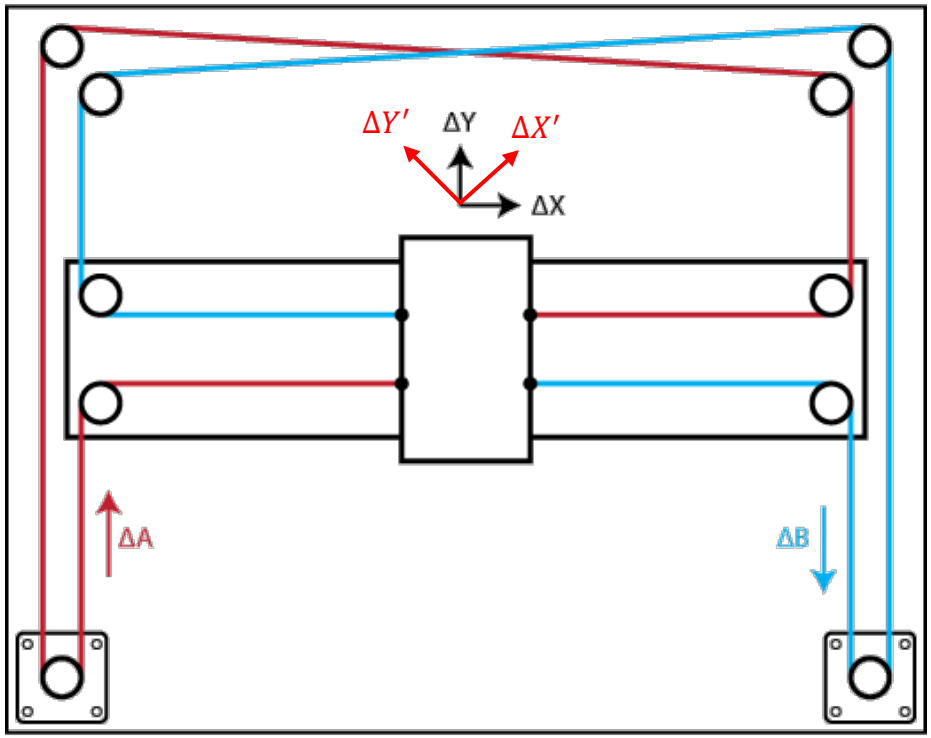
Software Subsystem

- Rotate the coordinate plane by 45° for orbital and double orbital motion.
- Parametrize as a function of rotation angle.

- Double Orbital
- $X' = \frac{r_{orbit}}{2} cos\theta$
- $\dot{X}' = -\frac{r_{orbit}}{2}\frac{d\theta}{dt}\sin(\theta) = r_{pulley}\omega_A$

- $Y' = \frac{r_{orbit}}{2}\cos(\theta)\sin(\theta)$
- $\dot{Y}' = \frac{r_{orbit}}{2}\frac{d\theta}{dt}\cos(2\theta) = r_{pulley}\omega_B$

- Arduino takes PWM signals as the input:
- $PWM_A = -\frac{r_{orbit}}{r_{pulley}}\frac{d\theta}{dt}\sin(\theta)\frac{60s}{1\,min}\frac{1rev}{2\pi}\frac{1}{K_V}\frac{255}{6}$
- Where K_V is the motor constant in rpm/V.



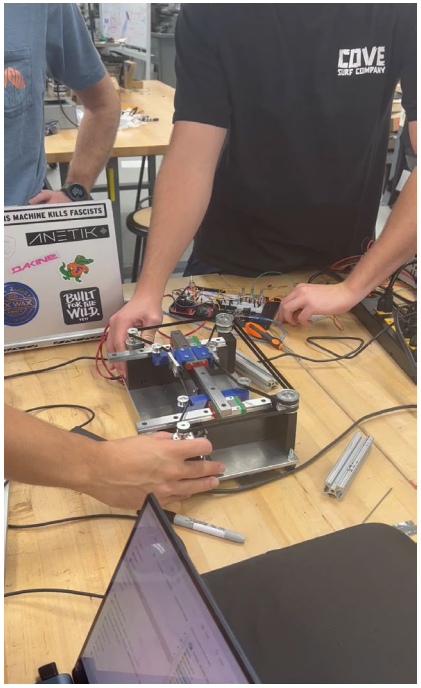
Equations of Motion:

$\Delta X = {}^1\!/_2(\Delta A + \Delta B)$, $\Delta Y = {}^1\!/_2(\Delta A - \Delta B)$

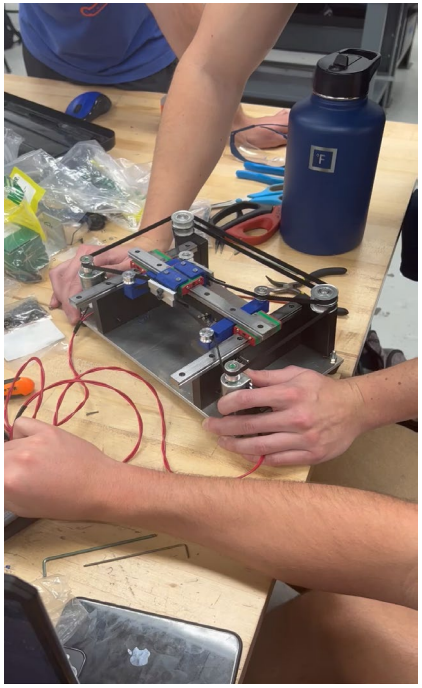
$\Delta A = \Delta X + \Delta Y$, $\Delta B = \Delta X - \Delta Y$

Evolution of Design – Software

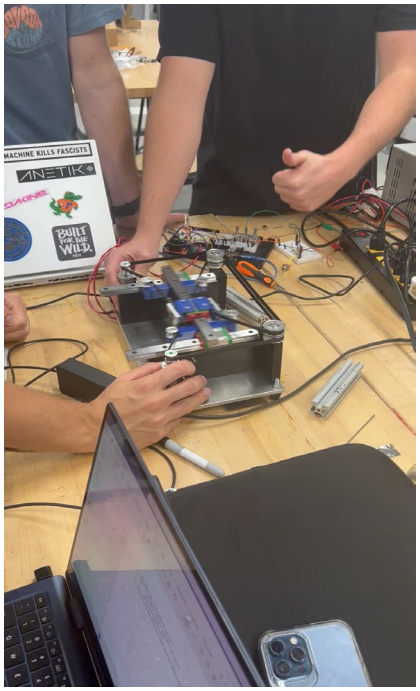
- Press button to rotate between the 3 different drive patterns
- Pause button added
- Rotate knobs to apply different velocity/radius values
- Initial testing drive patterns shown below:



Linear



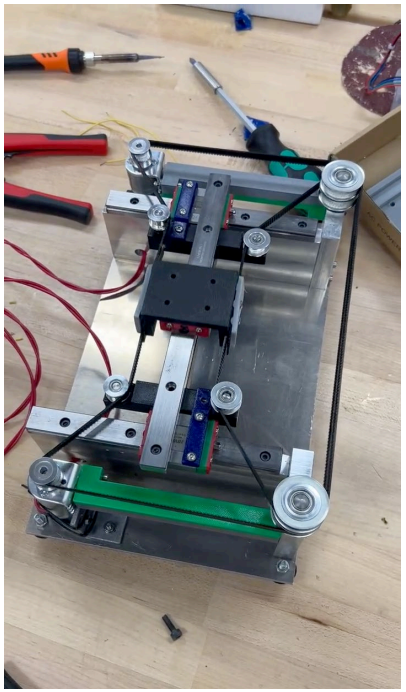
Orbital

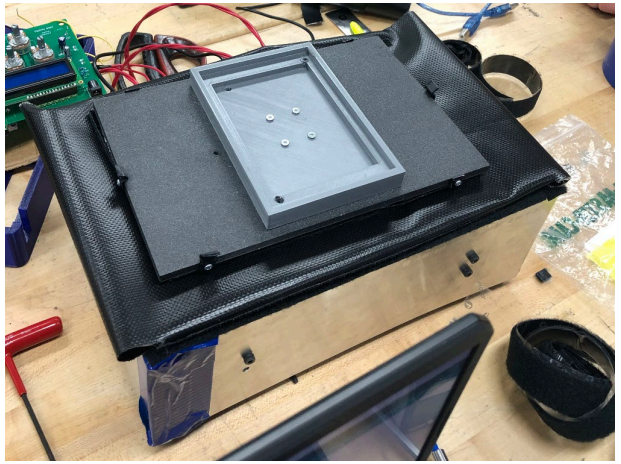


Double Orbital

Performance Eval 1: IP - X5 Infiltration test

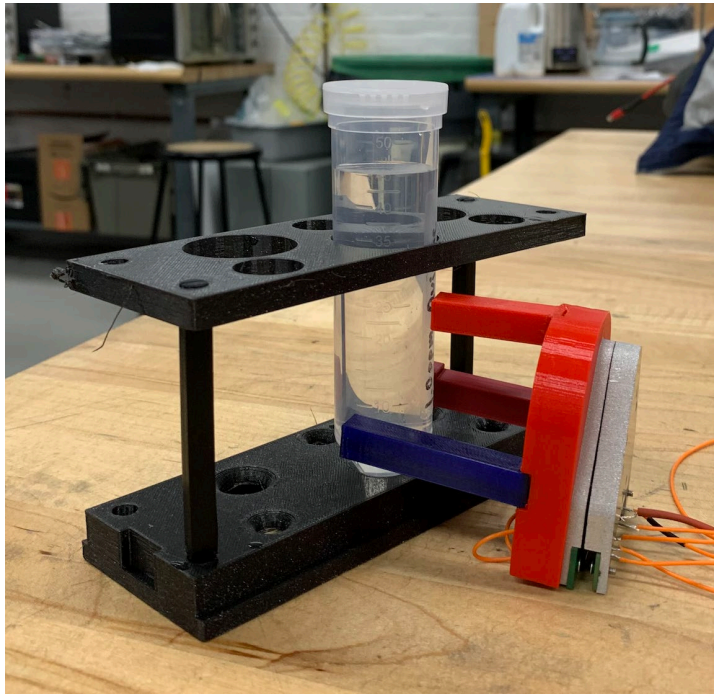
- Water sprayed from hose 3 meters away and aimed at table
- Allotted time: 4 minutes
- Leave to soak for 20 mins
- Run successfully

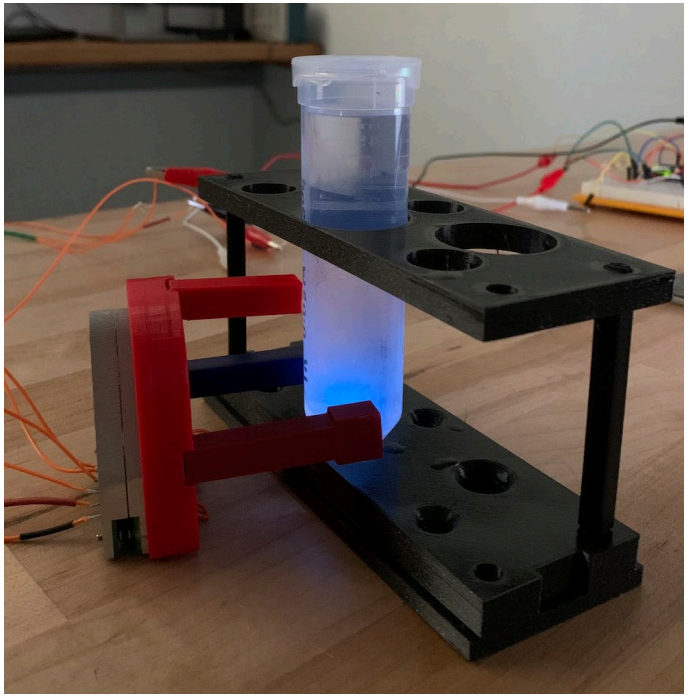




Performance Eval 2: OD/FI Integration

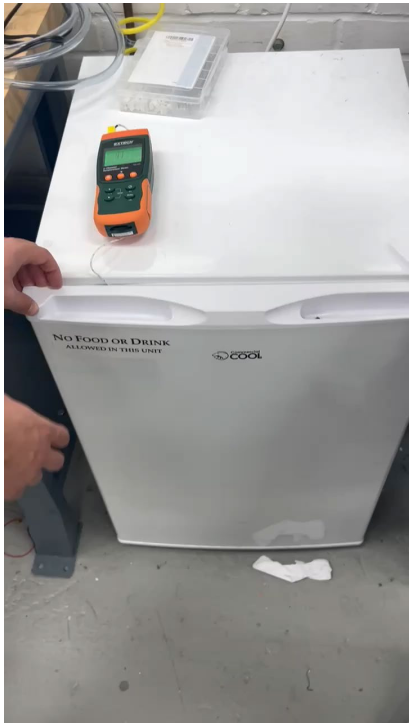
- Optical density test measured turbidity of milk/water mixture
- Fluorescent intensity test measured concentration of any quinine solution in a 0.05 M H2SO4 background
- Test identified 6 mystery concentrations for each test
- Performed successfully





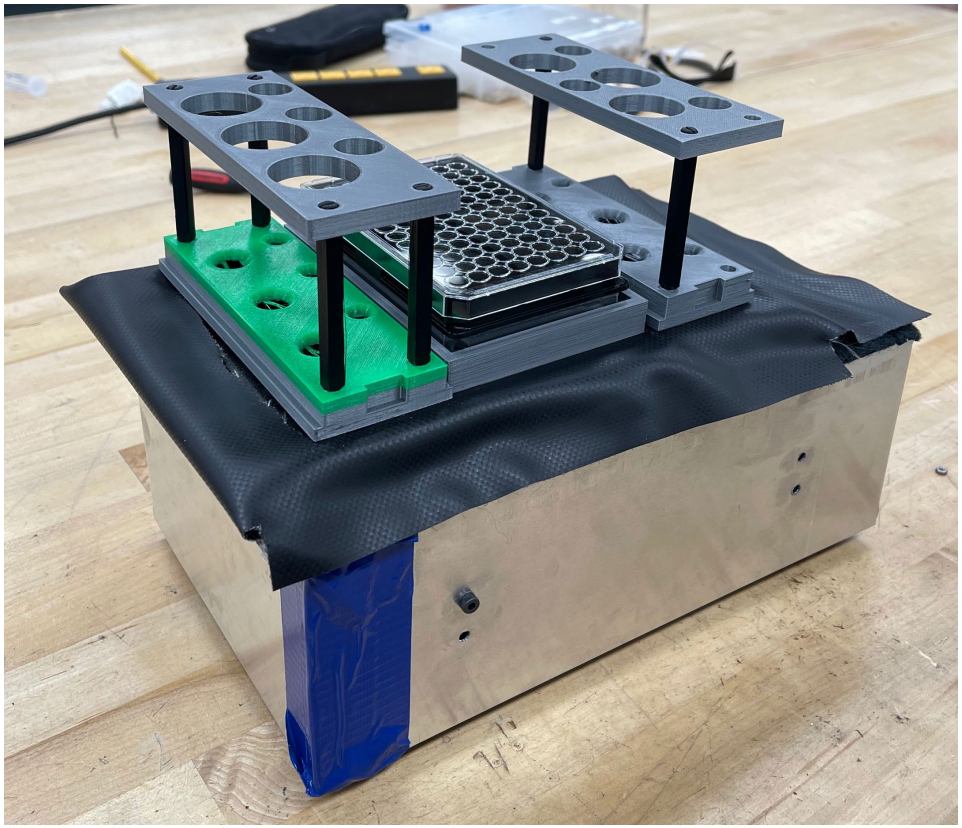
Performance Eval 3a & 3b: Low & High Temp Test

- Shaker table was placed in 4°C refrigerator for 90 minutes then operated at 0.1 Hz for linear and double orbital patterns
- Test was successful
- Shaker table was placed in 70°C oven after preheating and operated at 350 RPM for orbital pattern
- Test is pending



Eval 4a – Drop Test

- Aluminum sheet metal was selected as its ductility allows for the enclosure to deform upon impact.
- The enclosure protrudes past the base plate to provide a crumple zone.
- The placement of critical components within the reactor was carefully considered to ensure they are not directly exposed to impacts.



Cost to Build Prototype

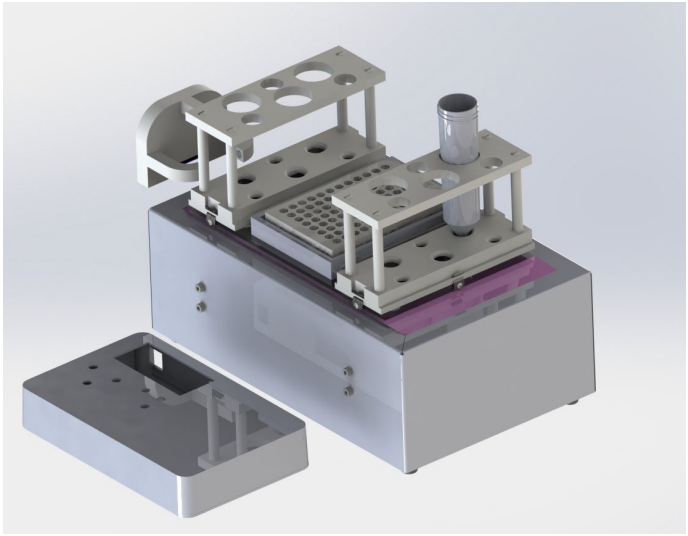
Item	Cost
Raw Materials	$790
Drive Subsystem	$471
Housing Subsystem	$57
Electrical Subsystem	$120
OD/FI Subsystem	$143
Labor (Manufacturing, Assembly)	$520
Total	**$1,310**

Cost Production Scale - Run

Item	Cost
Fabricated Parts (Manufacturing included)	$150,000
OTS Parts	$451,000
Assembly Costs - Determined through Ruth Dewhurst Chart	$70,000
Total	**$671,000 Total** **$671 Per Unit**

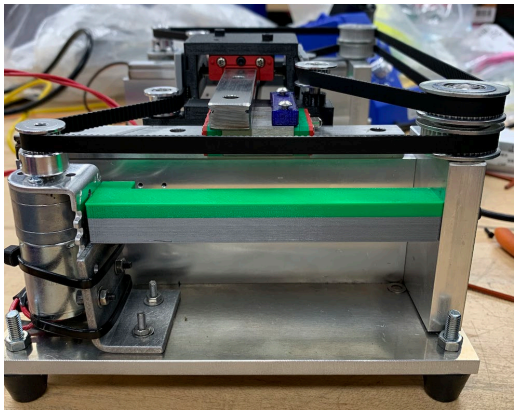
Why Choose Counter Culture Bio?

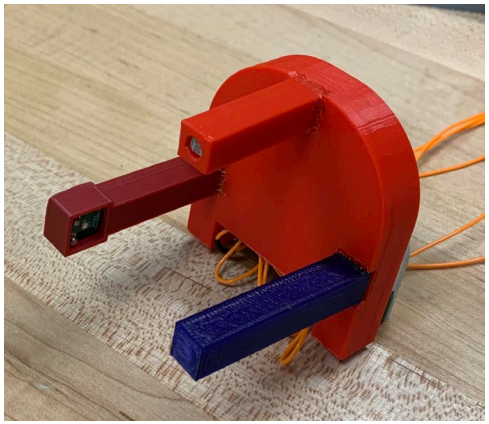
- To summarize:
  - Core XY Drive System provides fluid and efficient movement of system
  - Electrical PCB integration
  - Water resistant design
  - OD/FI system accurately record measurements
  - Heat resistant to temperatures up to 70 degrees Celsius
  - Can survive cold temperatures down to 4 degrees Celsius
  - User friendly operating system

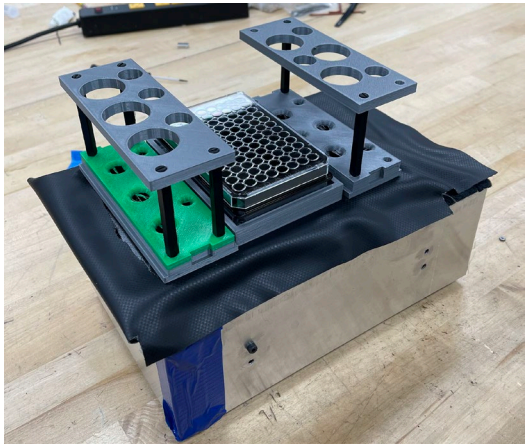


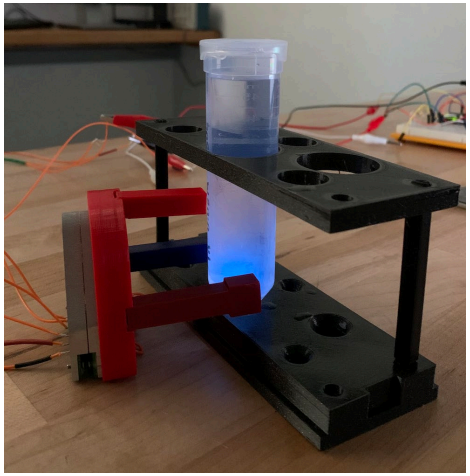
Thank you for joining us!

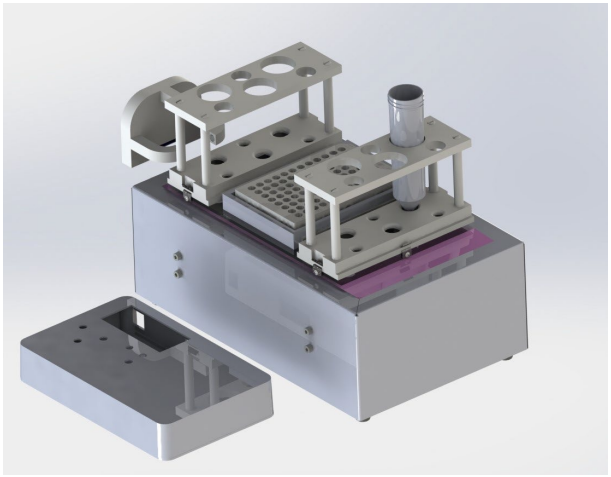
- Questions?

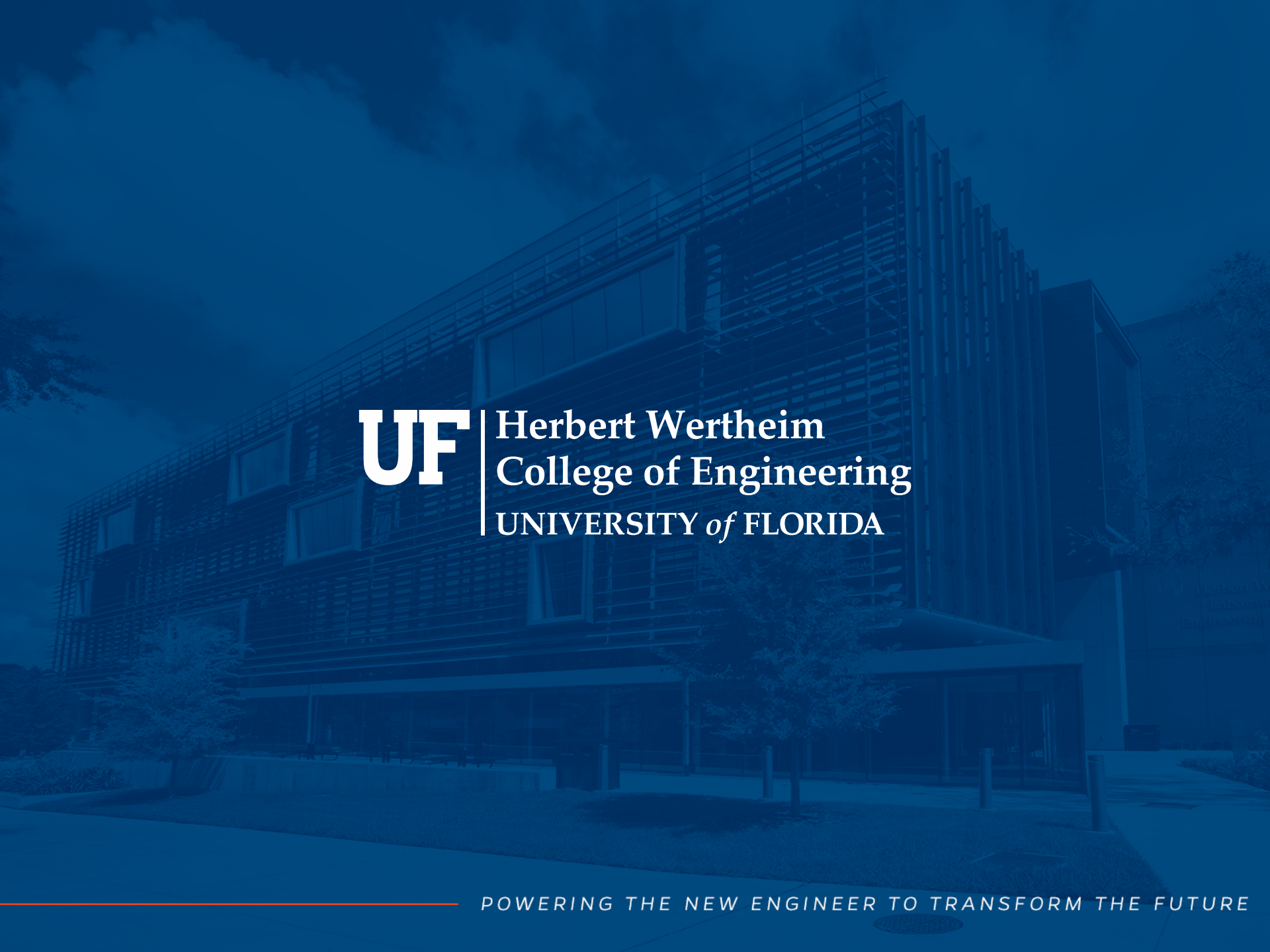








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