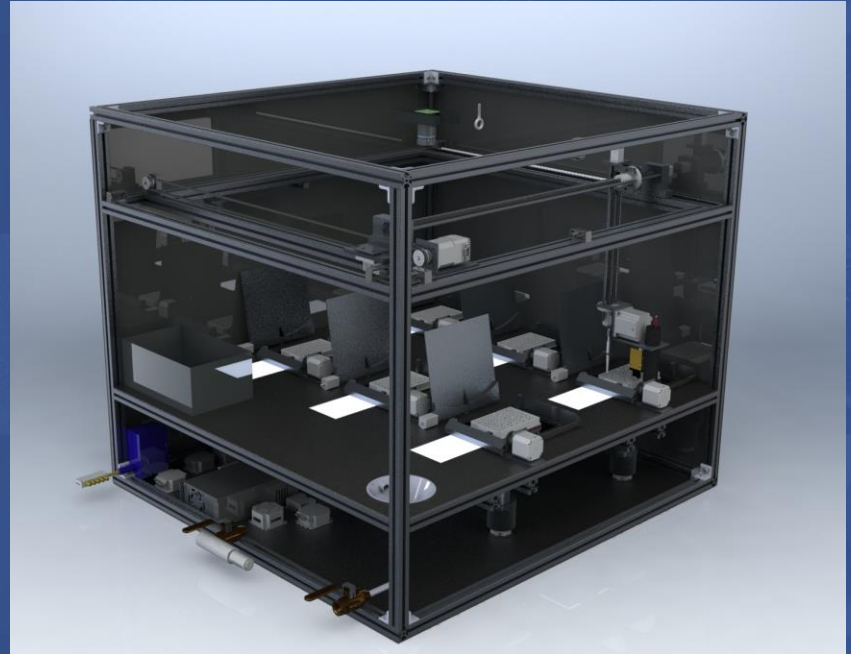




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M.A.T.E.



EML4501 Fall 2020 Group 14 - Samuel Bunner, John Cappeller, Narottama Esser, Kyle Jagielski, Kristian Michael, Matthew Mitchell, Josiah Pool

Presentation Outline

- Hedgehog Concept
- Product Overview
- Subsystem Analyses
- Cost Analysis
- Summary

Hedgehog Concept

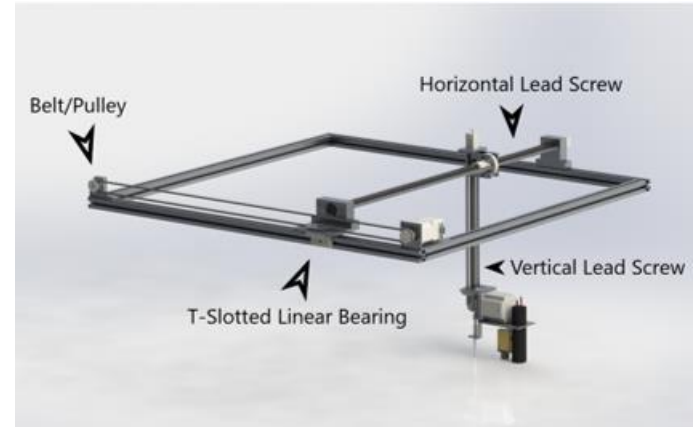
The M.A.T.E. device harnesses our desire to process the largest volume of cells in the quickest fashion possible by offering seamless transfer of liquid between compartments in addition to adjacent culture monitoring platforms.

Product Overview

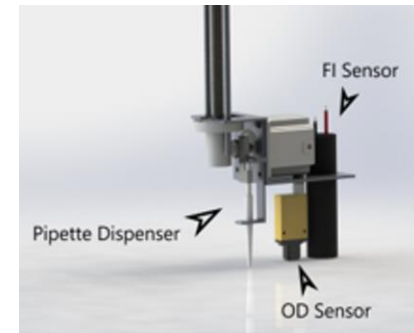
- Liquid handling 3D motion provides versatility in extraction from reservoir and precise OD and FI monitoring placement
- Stepper motor controlled pipette offers accurate liquid flow rate
- Integrated plate shaking and temperature control coupled with automated gas manifold for simplified incubation
- 80/20 frame and access hinges for easy assembly and user interaction
- The device occupies 32" height x 42" length x 36" width

Liquid Handling

- Customer needs addressed: 10, 15, 25, 33, 34, 35
 - All components within subsystem meet 10-year lifetime requirement. (10)
 - Polyethylene has compatibility rating of A for majority of chemicals. (15)
 - Fluid addition and subtraction with motorized pipette (25)
 - Dispense rate between 225 and 300 $\mu\text{L/s}$ achieved with NEMA 23 position-control DC stepper motor (33)
 - Dispensing accuracy of $\pm 0.3\%$ (34)
 - Pythagorean cup waste disposal and irrigation system (35)



3D motion control of pipette and light sensors



Liquid Handling

- Design highlights
 - Pythagorean cup waste disposal
 - Waste neutralization and liquid handling incorporated into singular pipette system
 - Versatile movement system to accommodate well plates and tubes
- TRL's
 - Highest level: Lead screws and pulley system **TRL 9**
 - Lowest level: Pipette rack and pinion system **TRL 3**



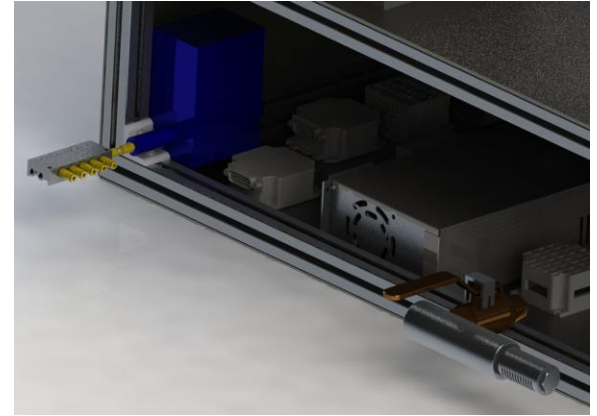
Passive waste disposal tubing network



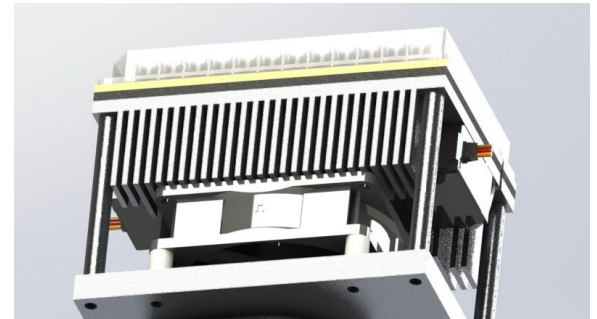
Pythagorean cup valveless catchment

Culture Condition Control

- Customer needs addressed: 18, 19, 20, 24, 26, 27, 28, 29, 30
 - Hibernation Time (18)
 - Closed-loop Control (19)
 - Culture Temperature Range (20)
 - Uniform Heating (24)
 - Effluent Gas Capture (26)
 - Gas Control (27)
 - OD and FI Measurement (28)
 - Monochromator vs Filter (29)
 - Light Intensity and Wavelength (30)



Gas evacuation and addition systems



Peltier thermoelectric cooler with heat sink

Culture Condition Control

■ Key Features:

- An optical camera within the system paired with red light illumination, allowing for visual monitoring of the process without interfering with the culturing of cells.
- 6 well plates being cultured in the same time frame
- A gas manifold with a short connection to the system, minimizing residual gases and any negative effects they could present within the manifold.

■ TRLs:

- Highest Level: Volumetric Flow Meter **TRL 9**
- Lowest Level: Sterilization Channels **TRL 3**

Frame

- Customer needs addressed: 1, 2, 3, 4, 5, 7, 8, 12
 - Fit inside facility (1)
 - Standard wall outlet (2)
 - Easily accessible (3)
 - Ease of assembly (4)
 - 1.15 FOS (5)
 - Manual emergency shut off (7)
 - Automatic shut off (8)
 - No external fixtures (12)



Frame

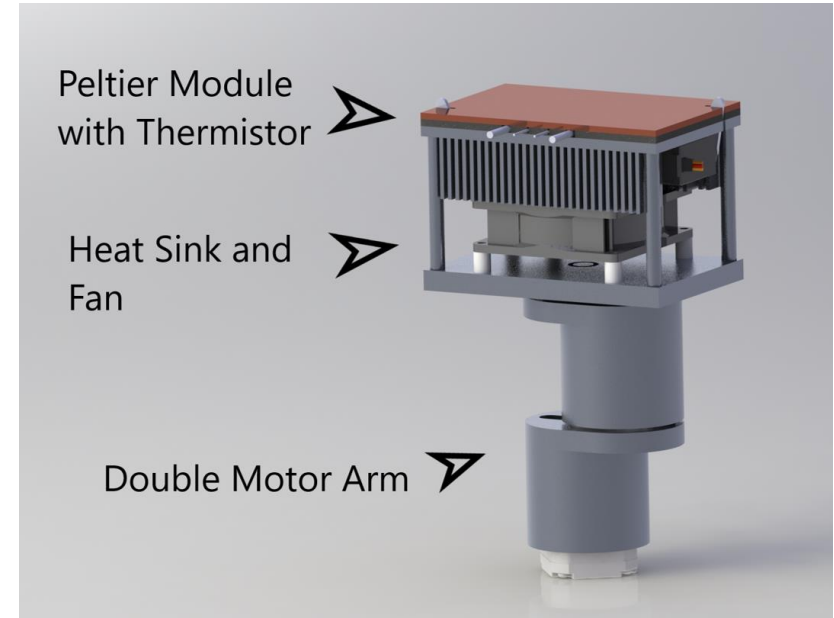
- Design Features:
 - 14-gauge sheet metal side panels with hinges for easy user access
 - A size footprint of 32" height, 42" length, and 36" width to fit on standard laboratory benchtops and through laboratory doors
 - 80/20 frame for modularity and ease of assembly
 - Integrated push button mechanical safety shutoff
 - Rubber contact seals to prevent gas leakage and maintain internal gas composition
- TRLs:
 - Highest Level: 80/20 Extrusions **TRL 9**
 - Lowest Level: Contact seals **TRL 3**

Plate Movement

- Customer needs addressed: 21, 22, 23, 31, 32
 - Capsules must be fully enclosed (21)
 - Must accommodate standard well plate sizes (22)
 - Must accommodate standard conical tube sizes (23)
 - Can perform linear, orbital, and double orbital shaking patterns (31)
 - Plates can move independently from each other (32)

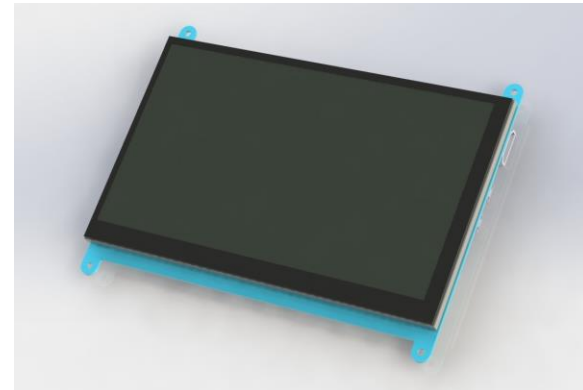
Plate Movement

- Motion-based features
 - Six independent motion platforms
 - Two stepper motors per platform
 - Aluminum cross-contamination prevention cover
- Temperature-based features
 - Thermistor
 - Heat sink with fan and Peltier module
- TRL's
 - Highest Level: thermistor **TRL 9**
 - Lowest Level: double orbital motors **TRL 3**



User Interface

- Customer needs addressed: 6, 9, 11, 13, 14, 16, 17
 - Includes fail-safe system, and a software alert for condition failure (6)
 - Has a visual indicator for: (9)
 - a. System on/off
 - b. Mode and time duration
 - c. If an error is present
 - Total cost cannot exceed \$10,000 (11)
 - Control parameters can be changed via programming (13)
 - Must be an intuitive interface (14)
 - Must meet BSL-2 lab space requirements (16)
 - Exterior surface temperature may not exceed 55° C (17)



User Interface

- Design Features:
 - Externally attached to side panel with direct wire connections
 - Completely programmable for making operation intuitive through binary decisions
 - Digital 7 in. HD display provides clear and programmable visual indicators
 - Does not unfavorably affect machine's external temperature
 - Affordable and allows total cost to be within budget

- TRLs:
 - Highest Level: Human touch recognition **TRL 9**
 - Lowest Level: Control systems **TRL 2**

Simplified Cost Overview

- OTS parts include motors, thermoelectric coolers, gas controllers and optical monitoring devices
- Most raw materials went towards aluminum motor mounts and sheet metal walls
- Assembly was rated at \$16.21/hr based on U.S. labor statistics

Autonomous Microbioreactor Cost

OTS	\$ 6861.11
Raw Materials	\$ 812.70
Manufacturing	\$ 1113.53
Assembly	\$ 15.38
Total	\$ 8802.72

Why M.A.T.E.?

- Precise culture control
 - Electrochemical sensors
 - Mass-flow controller and Venturi vacuum
- Quick experimentation
 - Seamless liquid transfer
 - Condensed layout
- Economic
 - Simple, yet effective design
 - Within budget

Thank you!

The image features a blue background with a grid of faint, semi-transparent photos of students and faculty. On the left, there is a vertical orange bar. The text is centered in the middle of the page.

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