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### Abstract

Our design will provide a unique, all in one functionality that will set it apart from any microbioreactors currently on the market. The environment the cultures are exposed to can be changed quickly and easily using a user interface with touch screen and voice control capabilities. Unlike most shakers on the market, our device uses a combination of motors and custom designed parts to allow for shaking in the usual linear and orbital patterns as well as the unique double orbital pattern. Our design utilizes a unique arrangement of mirrors and a rail system to allow OD measurements to be obtained for the culture in any tube or well plate with the use of only one laser. In terms of safety, the device will automatically shut off in the case of dangerous forces or pressures. Additionally, our design has the built-in functionality of a BSL2 safety cabinet.

### System Overview

**Liquid Handling** manipulates desired fresh and waste media.

**Measurement** uses a filter cube, mirrors, and a laser to report changes in quantity of the culture

**Environmental Control** regulates temperature, agitation, and lighting.

Safety & UI includes touch screen and mechanical input and force-based safety limit shutoff for all systems.

**Gas Handling** controls atmosphere composition inside the vessel.

**Experimental vessel** ensures controlled environment and regulates air circulation

**Frame & Mounting** contains all components and prevents the user from contacting harmful surfaces



### **Full System**



# **Exploded Views**





The shaker system (left) utilizes a linear actuator and rotary motor to achieve transfer orbital double orbital and linear motion during experimentation.

The rail system (below) provides x and y axis motion to move the head which supplies liquid and directs the to the laser specified wells/test tubes.

### **Design Specifications**

The CultiGator is designed to fit on a standard lab bench work top area. Total weight: 21.6 lbs (9.8 Kg) **Overall Dimensions:** 60 in x 24 in x 38.5 in



### Measurement System



The measurement system features a series of mounted mirrors capable of redirecting a laser into any well on the system. The light is sent through a filter cube and output is read by a photomultiplier tube.

Process

OTS

Modified OTS

**Raw Materials** 

Manufacturing

**Energy Consum** 

Assembly Labor

**Total Cost** 

### Laser Geometry

### **Cost Estimate**

	Cost (\$)	
	\$13,382	
	\$467	
	\$1,414	
Labor	\$3,296	
nption	\$1,170	
r	\$2,382	
	\$22,111	

C1: Fits in research facility and on benchtop

C2: Runs from 120V AC from standard wall outlet with 15-amp breaker

C3: Accessible to average height and build user

C4: Easily assembled/disassembled

C5: 1.15 factor of safety

C6: Fail-safe system and culture condition failure alert

C7: Emergency shutoff

C8: Force-based safety limit shutoff

C9: Visual indicator

C10: 10-year operational lifetime

C11: under \$10,000 production

C12: No external fixtures or support

C13: Programmable control parameters

C14: Intuitive user interface

C15: Nonporous and nonreactive materials in contact with cell culture

C16: Meet BSL2 lab space requirements

C17: Exterior surface not exceeding 55 C

C18: Incubation period from 1 hour to 2 weeks

C19: Culture condition closed loop control

C20: Can culture in temperature range 4-70 C

C21: Can culture in fully enclosed, interchangeable compartments allowing for media exchange

C22: Accommodate various well plate sizes

C23: Accommodate various conical tube sizes

C24: Prevent condensation of wells and tubes

C25: Automated liquid handling with fluid addition and subtraction from each well/tube C26: Must capture effluent gases

C27: Can inject and regulate required gases C28: OD and FI measurements for individual wells/tubes C29: Designed with respect to filter cube vs monochromator tradeoff

C30: Light intensity of 1 kW/cm^2 at 640 nm C31: Linear, Orbital, and Double Orbital shaking patterns

C32: Shaking patterns independent for each plate/tube C33: Dispensing rate between 225 and 300 ul per

second

C35: Dispose and neutralize waste

C34: Dispensing accuracy and precision

# **Customer Needs Map**

M1: No bigger than 28"x72"x30"	All powered components combined do not
M2: Max operating power 1800 W	User interface is located and sized for acceptable accessibility
benchtop	Touch screen and voice-controlled interface
M4: Operable parts require < 5lbf	No more than 5 lbf required to
M5: < 5lbf for assembly/disassembly	assemble/disassemble device
M6: 1.15 factor of safety	Factor of safety factored into all other metrics
M7: At least 69 W hr backup battery	User interface device has built in backup battery
M8: < 5lbf for emergency shutoff button M9: emergency shutoff requires no more	OTS emergency shutoff button required under 5 Ibf to activate
than one hand	Emergency shutoff button can be operated with one hand
M10: 15 lbf force based shutoff	Current based shutoffs on motors calculated to
M11: Visible from at least 10 ft	41 nt font is used for LIL visible from 16 ft
M12: 10 year operational lifetime	All parts designed or chosen have at least a 10-
M13: Under \$10,000 production cost	vear operational lifespan
M14: Require 0 external fixtures	No external fixtures are required
MI15: At least 2 GB memory	Programmable UI device has 2 GB of memory
M16: At least 64 GB storage M17: At most 1 correctable error from average	Programmable UI device has 64 GB of storage
user interface task M18: Materials in contact with culture at most	Touch screen and voice-controlled options make UI intuitive and error free
0.1 micrometer porosity M19: Air flow consistent with BSL2 standards	Low porosity materials selected for liquid
M20: Max external temperature 55 C	System of ducts and filters ensures air flow
M21: Can operate for 16 days	within device meets BSL2 lab space standards Device's external casing ensures cooling using
M22: Evaluation rate between 1-10 Hz	surrounding air Device can continuously operate for up to 16
M23: Temperature can be 4-70 C	days
M24: No gaps greater than 0.3 micrometers in experimental vessel	between 1 and 10 Hz
M25: Can accommodate plates between 50x50x50 mm and 200x200x150 mm	Liquid heat exchanger used for cooling and electric heating element
M26: Can accommodate tubes between 50x50x50 mm and 200x200x150 mm	Air-tight experimental vessel uses rubber seal to allow no escaped gas or microbes
M27: Must be able to heat tubes/plates at least 1 C above dew point	Shaker can accommodate all required well plate
M28: 1.44 L liquid reservoir	Sizes Shaker can accommodate all required conical
M29: Must be a fully enclosed waste gas reservoir	tube sizes Sufficient reservoir size and 3 axis nozzle allows
M30: Must be able to regulate gas with 1% accuracy	for fluid addition and removal
M31: Must measure both OD and FI	can be manually emptied
M32: Must use either monochromator or filter cube	Diaphragm pump, regulators, and sensors allow for acceptable gas concentration control
M33: 1 kw/cm^2 640 nm light source	System of mirrors directs light to sample and
M34: Must be able to achieve all 3 patterns	Device includes a filter cube
M35: Shaking must be independent for each plate/tube based on number in design	
M26, dispensing rate must meet need	OIS laser with acceptable intensity is incorporate
wise: dispensing rate must meet need	in the device Combination of OTS motors and custom parts
M37: At least 2% accuracy	Combination of OTS motors and custom parts allows for all 3 shaking patterns
M37: At least 2% accuracy M38: At least 2% precision	Constraint acceptable intensity is incorporate in the device Combination of OTS motors and custom parts allows for all 3 shaking patterns Only 1 well plate or rack of tubes is accommodated by this device
M37: At least 2% accuracy M38: At least 2% precision M39: 1.65 L Waste Reservoir	OTS laser with acceptable intensity is incorporate in the device Combination of OTS motors and custom parts allows for all 3 shaking patterns Only 1 well plate or rack of tubes is accommodated by this device Piezoelectric pump allows for excellent fluid dispensing control
M37: At least 2% accuracy M38: At least 2% precision M39: 1.65 L Waste Reservoir	Constrained with acceptable intensity is incorporate in the device Combination of OTS motors and custom parts allows for all 3 shaking patterns Only 1 well plate or rack of tubes is accommodated by this device Piezoelectric pump allows for excellent fluid dispensing control Sufficiently large, manually emptiable liquid

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