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Low-Cost
Controllable
Hypoxia Chamber
for Exploring Stem
Cell Behavior

Objective & Motivation

Design and develop a low-cost hypoxia chamber for stem cell research.

- Stem cells naturally grow in a low-oxygen environment
- Simulating this environment during experiments allows:
 - Efficient cultivation of stem cells
 - Research regarding the effect of low-oxygen environments on the cells' development



Product Requirements

Functionality

Maintain oxygen levels between 1% and 21%
Maintain CO₂ levels at 5%

Durability

Maintain airtight hypoxic environment for 21 days
Work for multiple experiments

Working Environment

Function in temperature and humidity conditions in incubators

Logistics & Construction

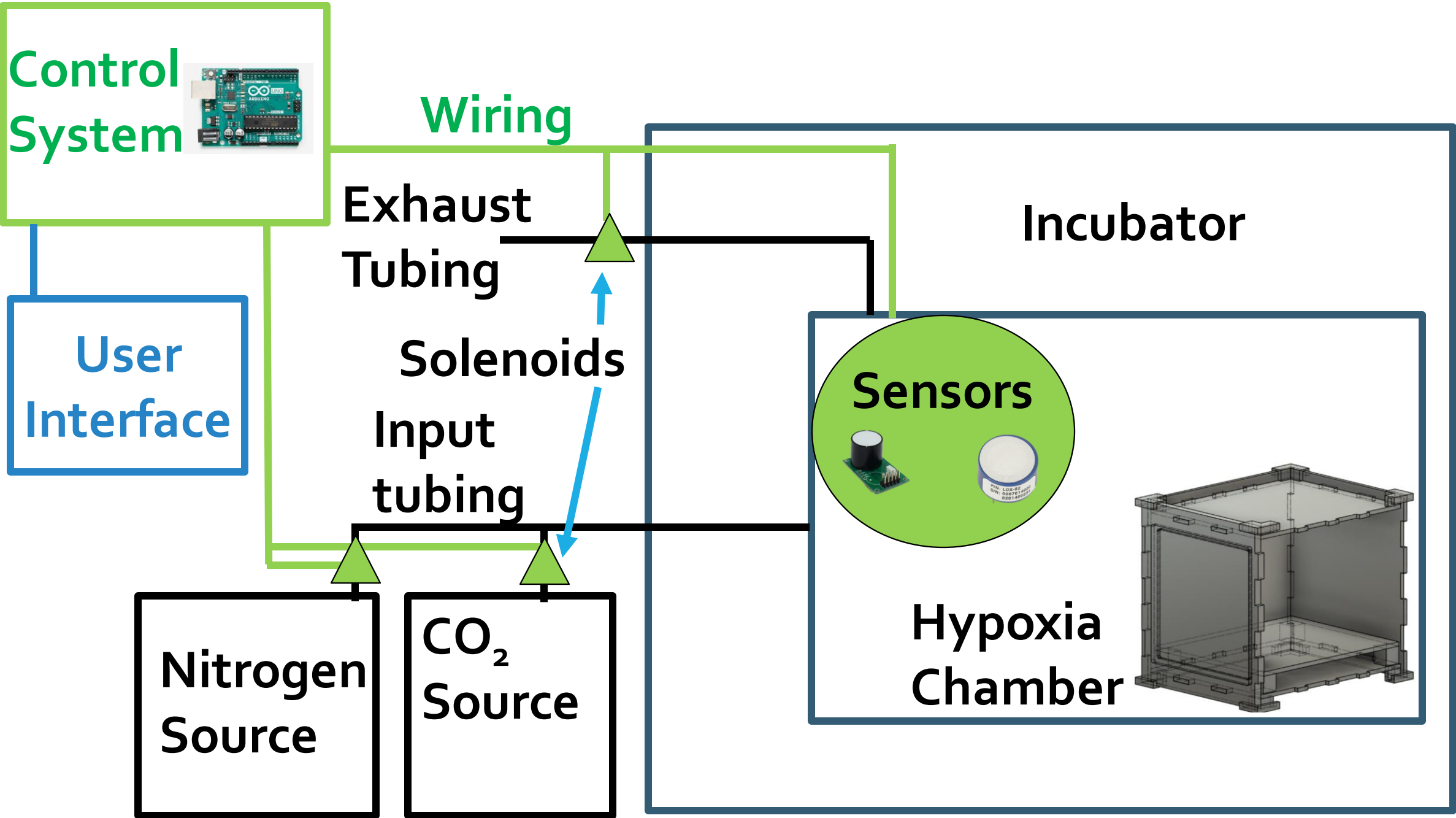
Have a simple user interface
Simple and reproducible construction process
Low-cost

Physical Properties

Large enough to fit at least 4 well plates
Transparent
Fit inside incubator

Risk Management

- Pressure buildup
- Contamination
- Gas leaks
- Construction risks
- Response time
- Sensor accuracy





Chamber Design Solutions

First Prototype



The Prototype Next to a 6 Inch Ruler



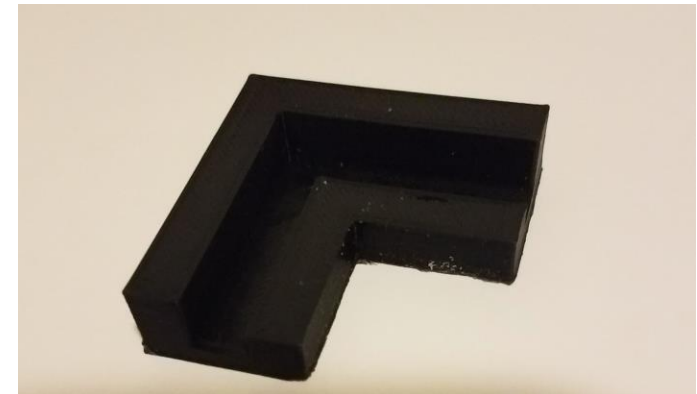
Right Side View



Left Side View

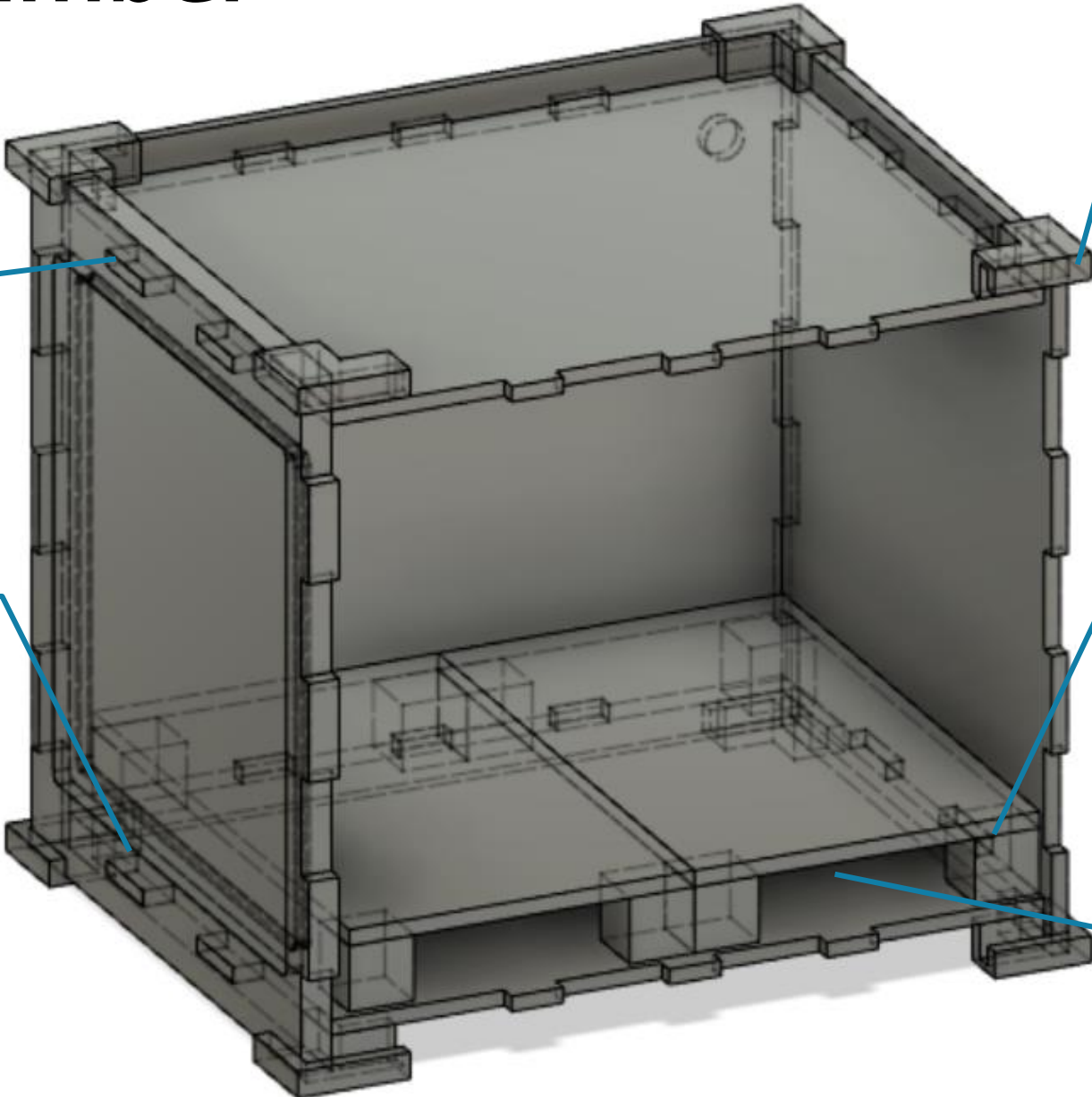


Front View, with 3 plates inside



Corner Piece

Custom Chamber



Jigsaw design for durability

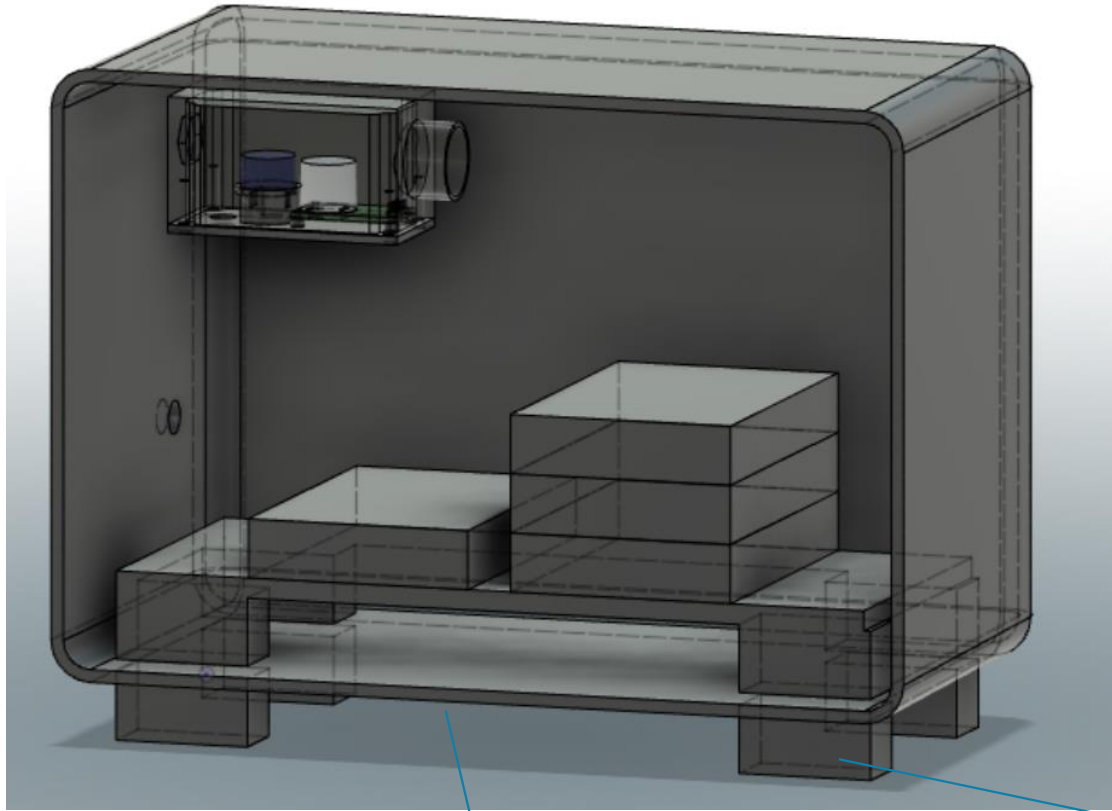
Airtight O-ring seal on door

3D printed corner pieces

Humidity control shelf

Transparent acrylic sheets

Pre-Built Chamber



Handle and door seal



3D printed Stilts

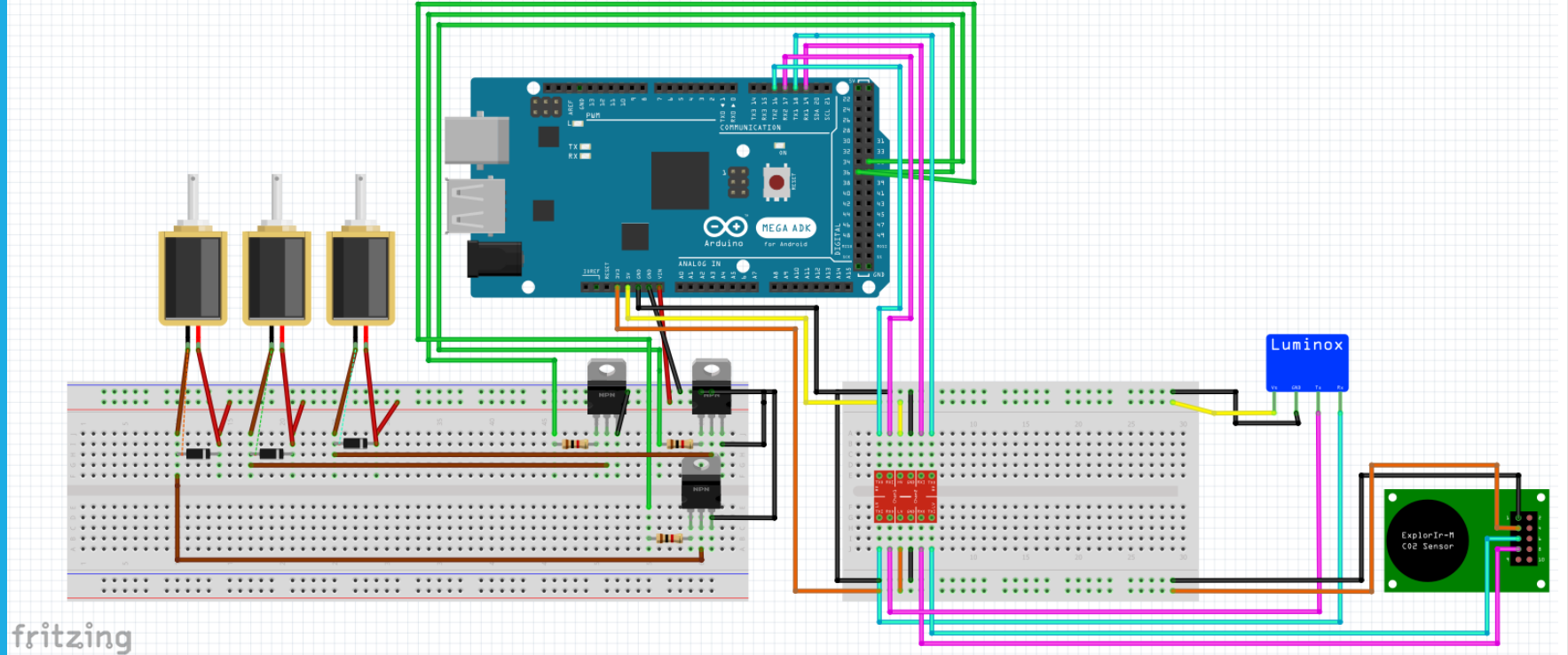
Guaranteed airtight

Ample space for several well plates, humidity control system, and sensors



Control System

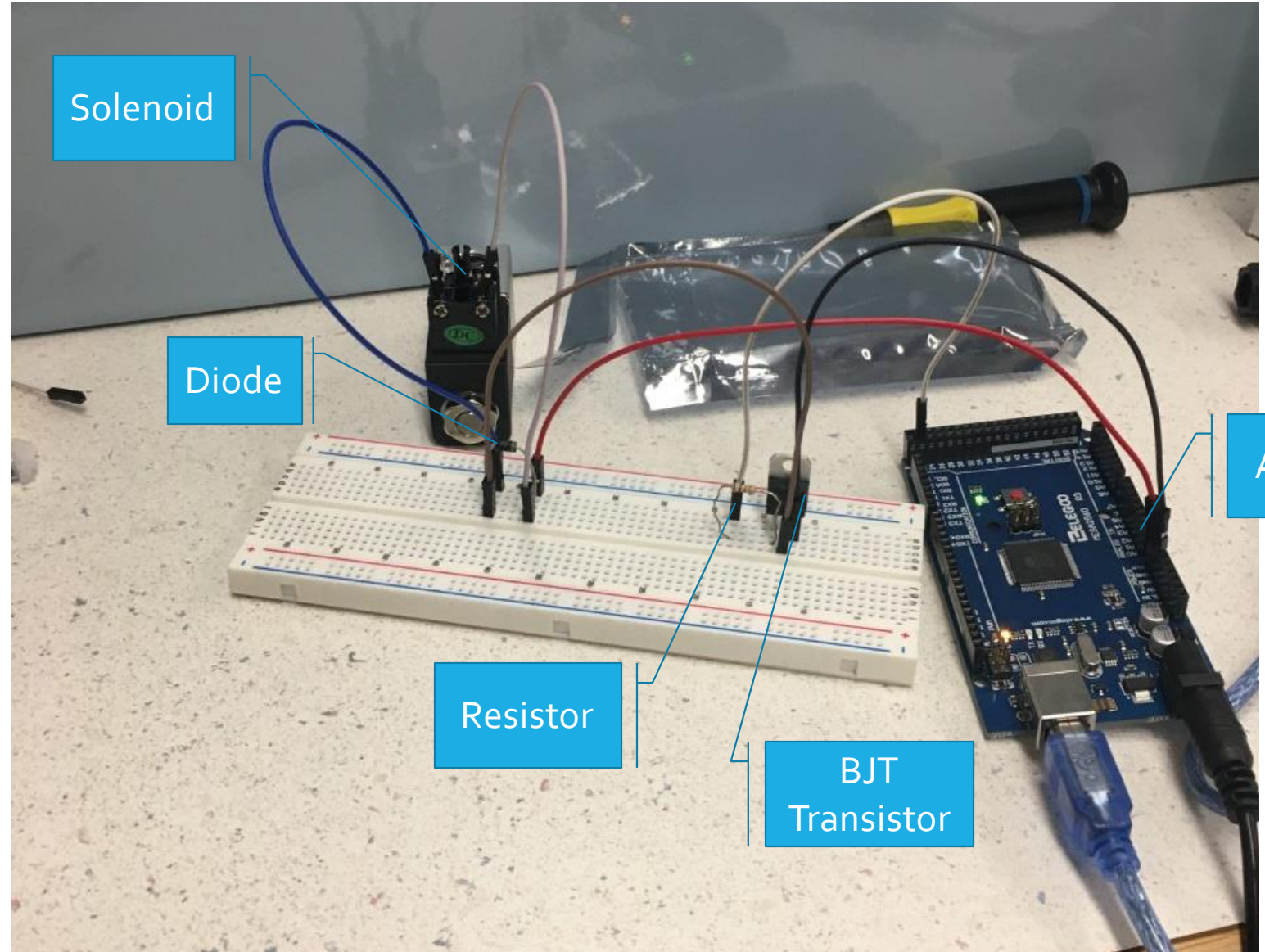
Control System



fritzing

- Solenoids being controlled by Arduino using diodes, BJT transistors, and resistors.
- O₂ and CO₂ sensors being controlled by Arduino
- Adapter board helps with level shifting

Solenoid Setup



Sensors



O₂ Sensor

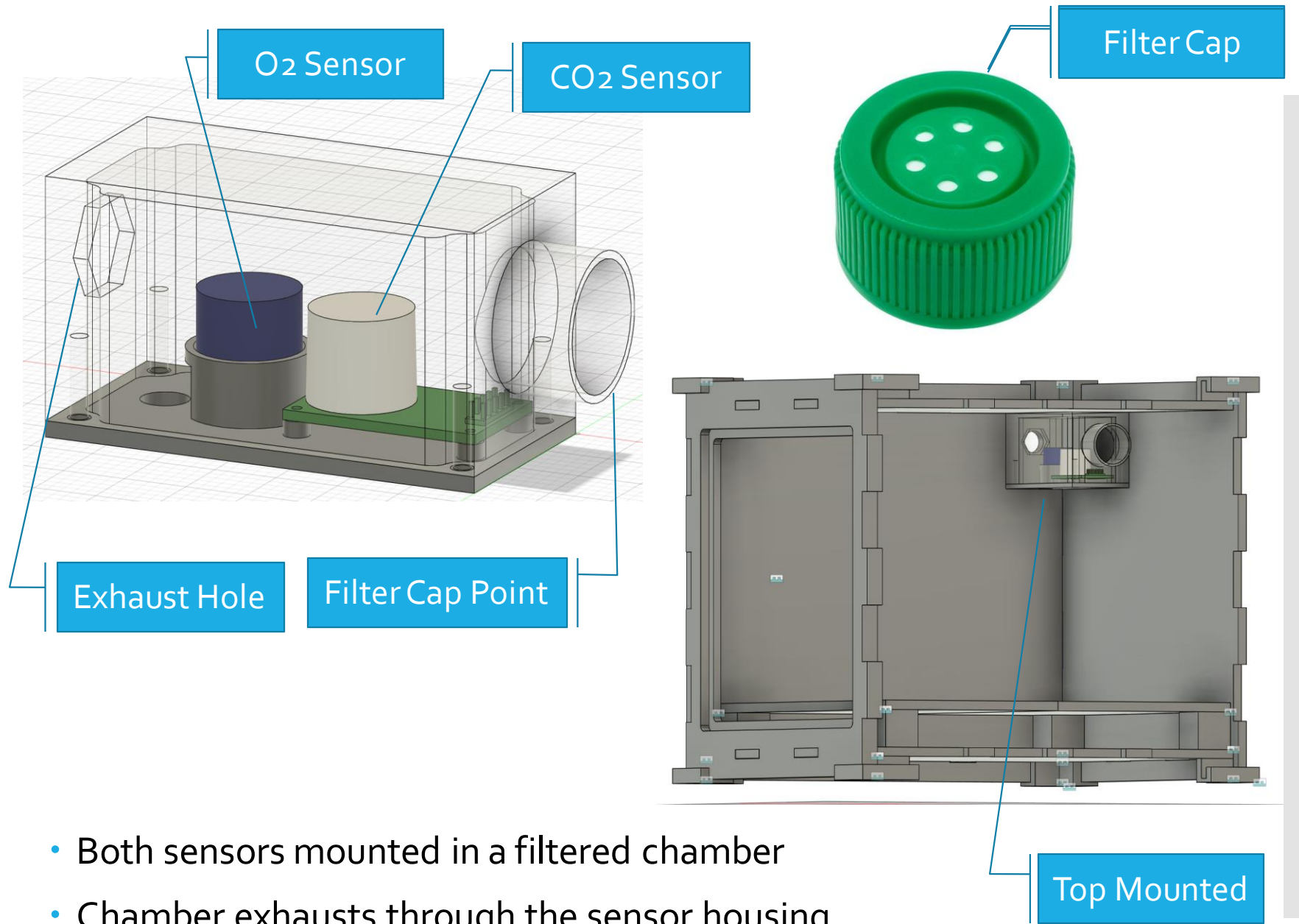
- Measurement Range: 0 to 25% O₂
- Response Time: <60s
- Resolution: 0.01%
- Lifetime: >5 years
- Voltage: 4.5-5.5VDC
- Interface: UART



CO₂, Temp, Pressure, Humidity Sensor

- Measurement Range: 0 to 20% CO₂
- Response Time: 10s to 3min (Configurable)
- Resolution: 10ppm
- Lifetime: >15 years
- Voltage: 3.3v
- Interface: UART

Sensor Housing



- Both sensors mounted in a filtered chamber
- Chamber exhausts through the sensor housing



Sensor and Solenoid Demo

Budget

- Budget - \$1000

Purchased Items:

Chamber:	
Through-Wall Tubing Connector x2 - 1201N92	\$16.00
Tubing - 25ft Black	\$10.00
Acrylic from MG&A (12"X12"X1/4")	\$12.00
Acrylic from MG&A (12"X24"X1/4") x2	\$40.00
Acrylic from Amazon (12"X12"X1/2") x2	\$36.00
Epoxy (pack of 2)	\$12.00
3 ft of 1/8" round O-Ring Cord Stock	\$7.29
3D Filament	\$25.00
Premade Chamber	\$23.49
Chamber Total:	\$181.78

Electronics:	
Arduino Mega	\$16.00
O2 Sensor	\$100.00
CO2 sensor and MX board	\$180.00
Adapter board-UART-for sensors	\$7.30
Solenoids X3	\$39.00
Solenoid Control Transistors	\$10.00
12V 3 A Powersupply	\$13.00
Bread Board	\$9.00
Electronics Total:	\$374.30

Full Total:	\$556.08
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Design Validation

Requirement	Testing
Maintain a hypoxic environment (1% O₂ and 5% CO₂) for at least 21 days	<ul style="list-style-type: none">• Run control system to pump the correct % of gas in to create hypoxic environment• Use sensors for daily measurements for 5 days• Run 21-day test to confirm durability
Airtight	<ul style="list-style-type: none">• Slightly pressurize chamber and use soapy water to check for bubbles on all edges
Reach hypoxic conditions within 15 minutes	<ul style="list-style-type: none">• Create a setpoint on the GUI and check if it reaches that level within 15 minutes.
Product must be durable to sterilization procedures	<ul style="list-style-type: none">• Review the properties of the components used
Sensors read accurate data to the Arduino	<ul style="list-style-type: none">• Connect the O₂ and CO₂ sensors to the Arduino and try and get sensors values
Disable functionality when door is opened	<ul style="list-style-type: none">• Create a switch on the gui to alert when the door is open and disable input of gas
Achieve 95% humidity within the chamber	<ul style="list-style-type: none">• Place a well of water or saturated sponge in the chamber and measure humidity over a day period

Looking Forward

	Sept	Oct	Nov	Dec	Jan	Feb	March	April
Concept design & Brainstorming	Yellow							
Modeling, Design, & Prototype Development		Yellow						
Prototype Development and Modifications			Yellow	Green				
Product Testing & Modifications				Green	Green	Green		
Final Product Preparation							Green	Green

Immediate Tasks:

- Continue construction and modifications to custom chamber prototype
- Continue testing parts as we get them
- Finalize design of premade chamber