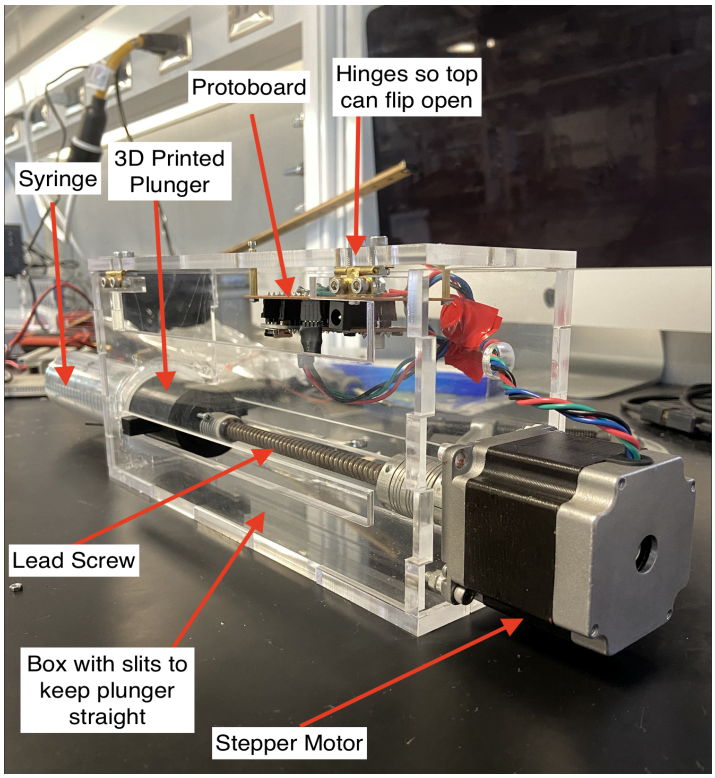
Volumetric Control System Documentation
VCS Background: URC: VCS Presentation



Volumetric Control System for Fludic Soft Robot

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Jacob's School of Engineering, University of California San Diego

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1. Bill of Materials (for 1 VCS)

It is best to order more than the required number of parts to ensure you have a backup in case a part breaks. Keep in mind that shipping times can be long so order in advance!

Green = Main Mechanical Components
Orange = Main Electrical Components
Yellow = Miscellaneous

Part	Quantity	Cost	Notes
Lead screw & Ball Nut (200 mm)	1 of each	$8.99	- 200mm - Make sure its the screw AND nut
Flexible Coupling (6 to 8 mm)	1 pc	$8.99 for 5 pcs	- 6mm to 8 mm - Only need one from the pack
200 ml syringe	1 pc	$13.90 for 2 pcs	- 200 ml - Only need one syringe body and the rubber tip (other parts not needed from the set)
0.25 Inch Acrylic Sheet	2 sheets		Two sheets should leave enough space in case there needs to be a recut.
Stepper Motor	1 pc	$33.50	
PCB from the manufacturer	1 pc	~$50 for 3 pcs	- Ordered from OSHPARK - Could also use a protoboard and solder connections

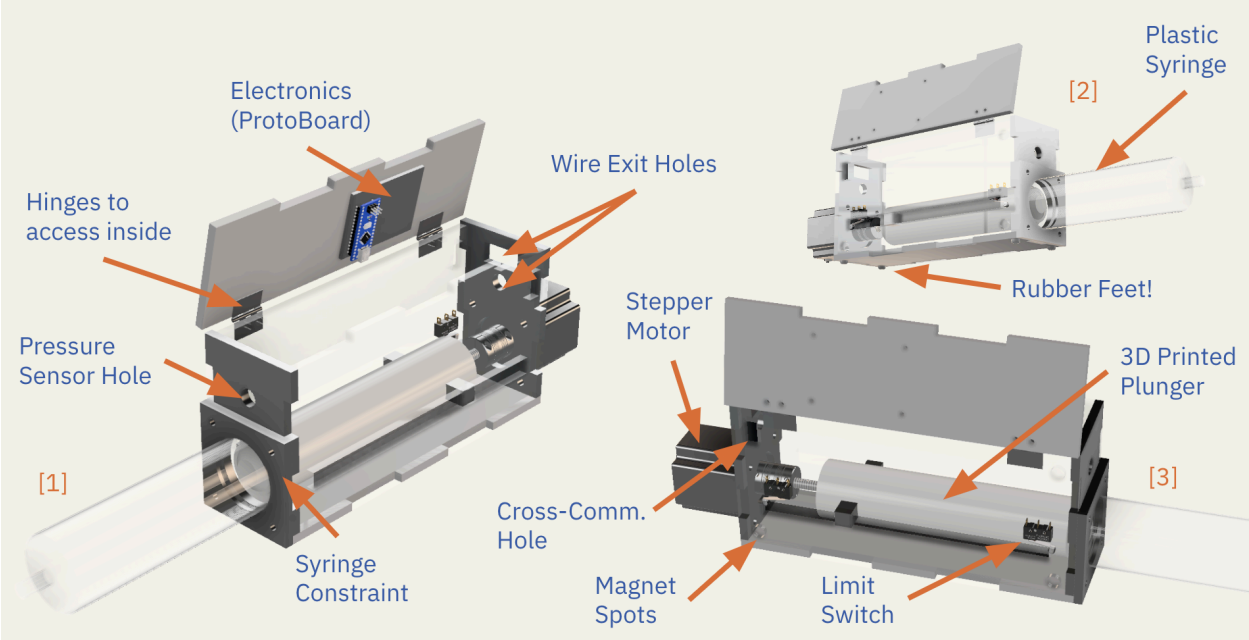
Motor Driver	1 pc	$21.50	
Arduino Nano Board & USB mini A-wire	1 pc	$24.90	
12V Power Adapter	1 pc		
Barrel Jack	1		
LED (5mm) & 130 Ω Resistor	1 of each		- LED Connection Resource
3 Pin Magnetic Connector	2 pcs	$11.90 for 2	Type 3 and 4 CAD models on grabcad
Mini Magnets (12x3mm)	Pack	$6.99 for a pack	
Hinges	2 pcs	McMaster	
Hinge Screws and Nuts	4 Each	Size: –	
Motor Screws and Nuts (M4)	4 Each	Size: M4	
PCB Screws & Stand-offs (M2)	4 Each	Size: M2 Standoff w/ CAD	
Male and Female Header pins			
Various wires and housings			

Tools & Glue for the acrylic			

Extra Parts:

Part	**Quantity**	**Link**	**Notes**
Pressure Sensors/transducer & push to connect	1 of each	- DigiKey Packaged Pressure Sensor - Brass NPT Push-to-Connect - FF Adapter	
Silicone Feet	Pack		
Limit Switches	At least 2		
Digital screen w/ buttons to manually control	1 pc		

2. Mechanical



2.1 Mechanical Material List

Part	Quantity	Cost	Notes
Lead screw & Ball Nut (200 mm)	1 of each	$8.99	- 200mm - Make sure its the screw AND nut
Flexible Coupling (6 to 8 mm)	1 pc	$8.99 for 5 pcs	- 6mm to 8 mm - Only need one from the pack
200 ml syringe	1 pc	$13.90 for 2 pcs	- 200 ml - Only need one syringe body (other parts not needed from the set)
0.25 Inch Acrylic Sheet	2 sheets		Two sheets should leave enough space in case there needs to be a recut.

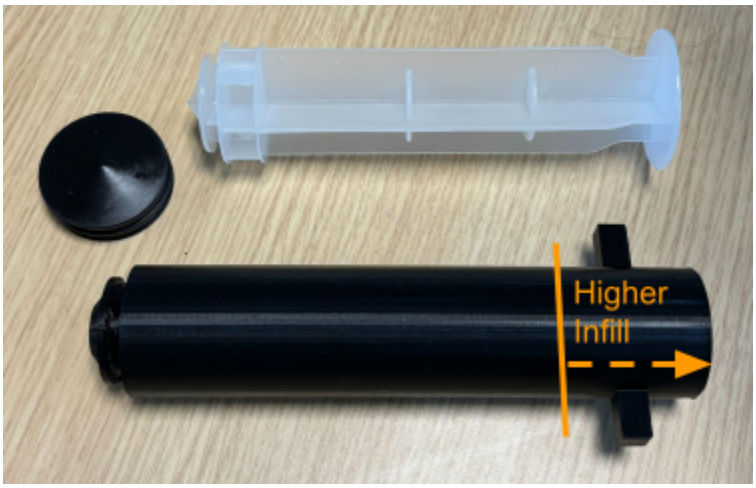
Stepper Motor	1 pc	$33.50	

2.2 CAD Files

a. 3D printing (4 pieces total)

i. 3D print the plunger, syringe holder plate/constraint, and 2 magnetic connector housings (files found in the GitHub)

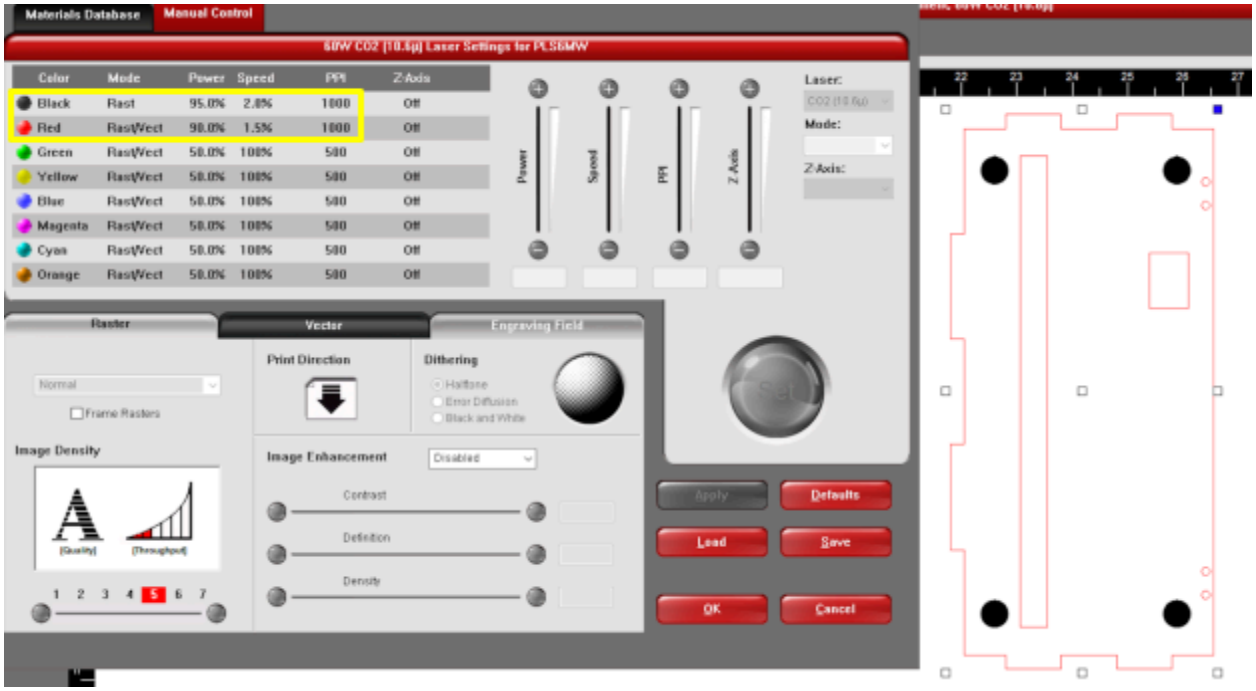
1. The plunger infill can be around 25%, maybe even less (the other 2 parts can be about 15%). However, the part that holds the arms should have a larger infill (~80%) to prevent breakage.
2. The rubber tip (black) from the commercial syringe plunger should be attached to the 3D-printed one so our plunger can push out fluid from the syringe.



b. Laser Cutting (Body of the VCS)

i. There are 6 faces that need to be laser cut from 0.25-inch acrylic. All of the CAD files can be found on our GitHub.

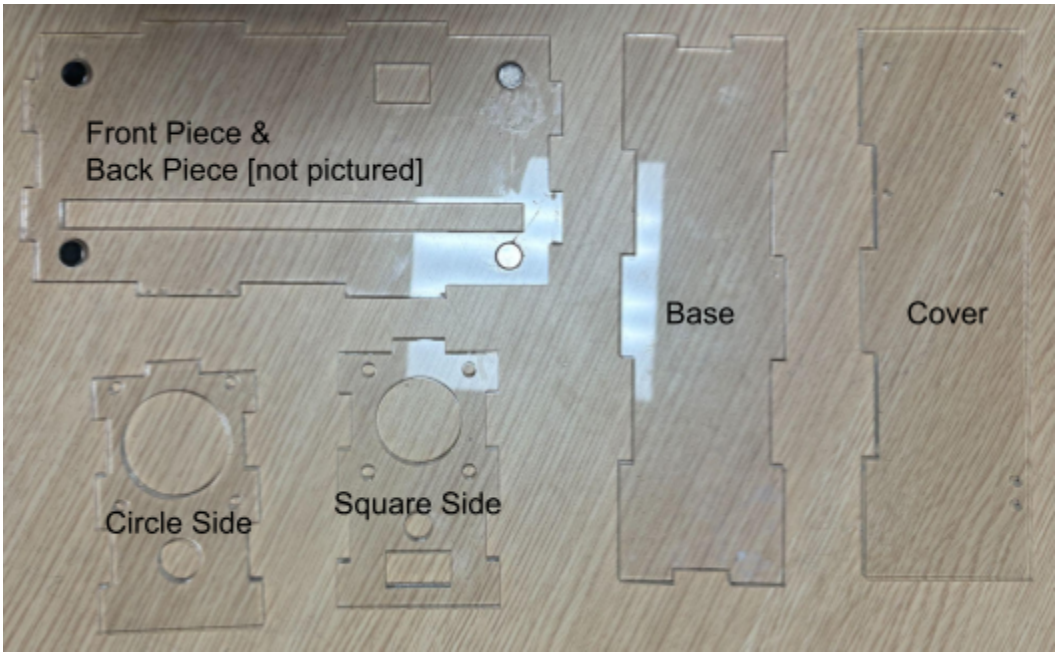
1. Important Note: the magnet holes on the two faces of the acrylic are not vector cuts they are rasta cuts at about 4mm deep into the acrylic (depending on how strong your magnets are you can cut deeper)
2. Please refer to the internal lab website for the settings for the laser cutter to cut out these parts.
3. Below are the settings we used highlighted in yellow (red = vector cut, black = rasta):



4. Simply upload the files, set up the appropriate settings, and cut!

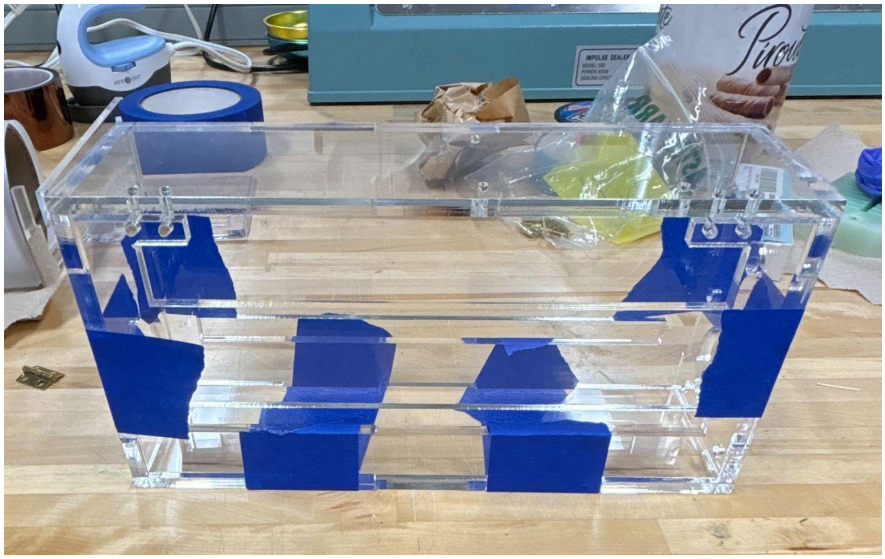
ii. Glue the magnets into the holes on the inner side of the acrylic (8 total)

1. Note: Make sure you glue the magnets on the right side (all north or all south poles) to ensure that when the two VCS connect it doesn't repel

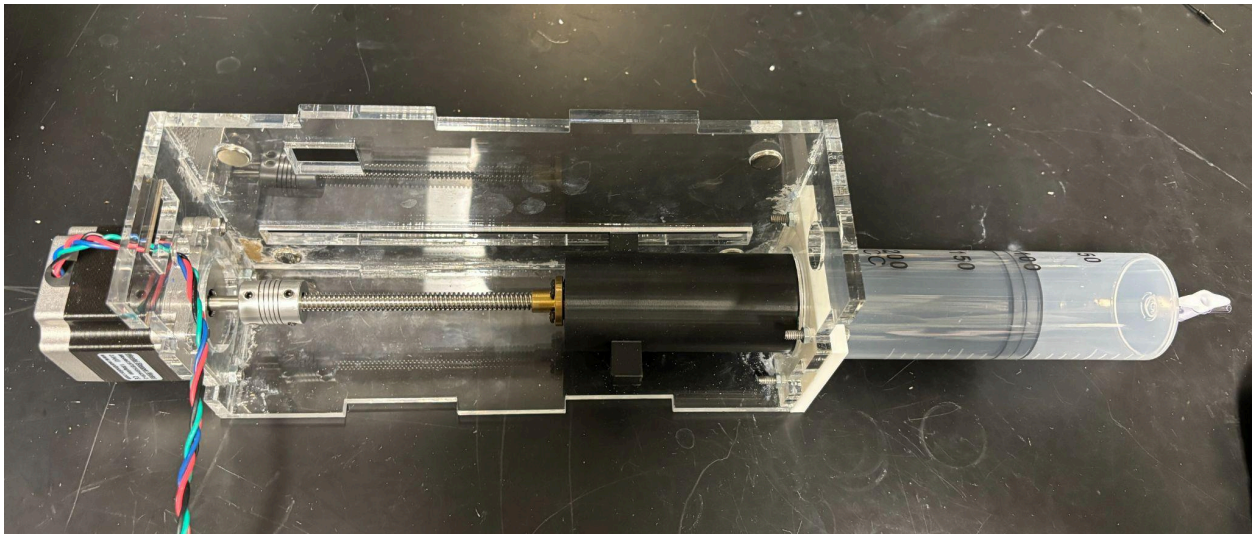


2.3 Mechanical Assembly

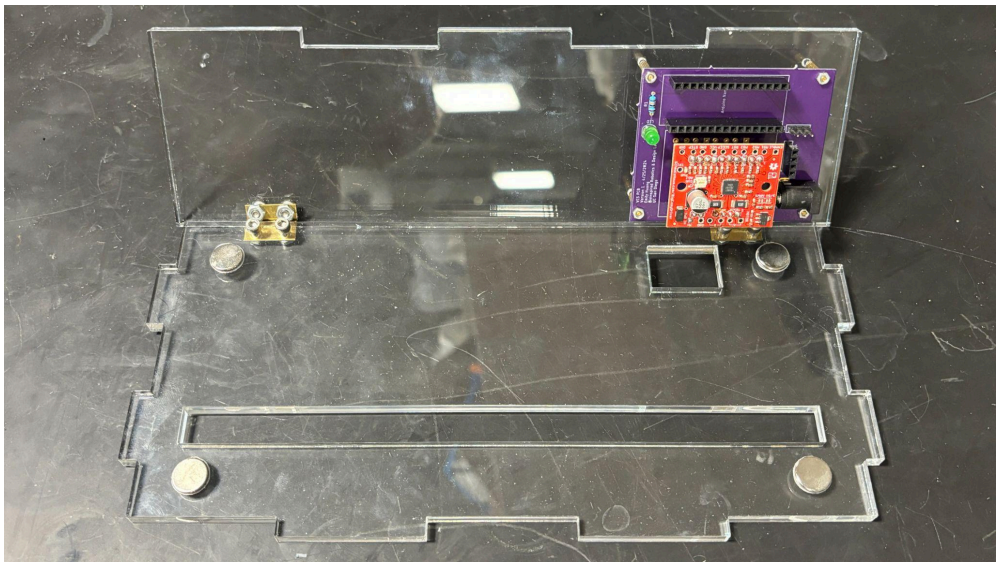
Note: Before gluing all the parts together, it is recommended that you try fitting all the pieces together first to ensure the right orientation of each piece (you can use painter's tape to hold each piece together).



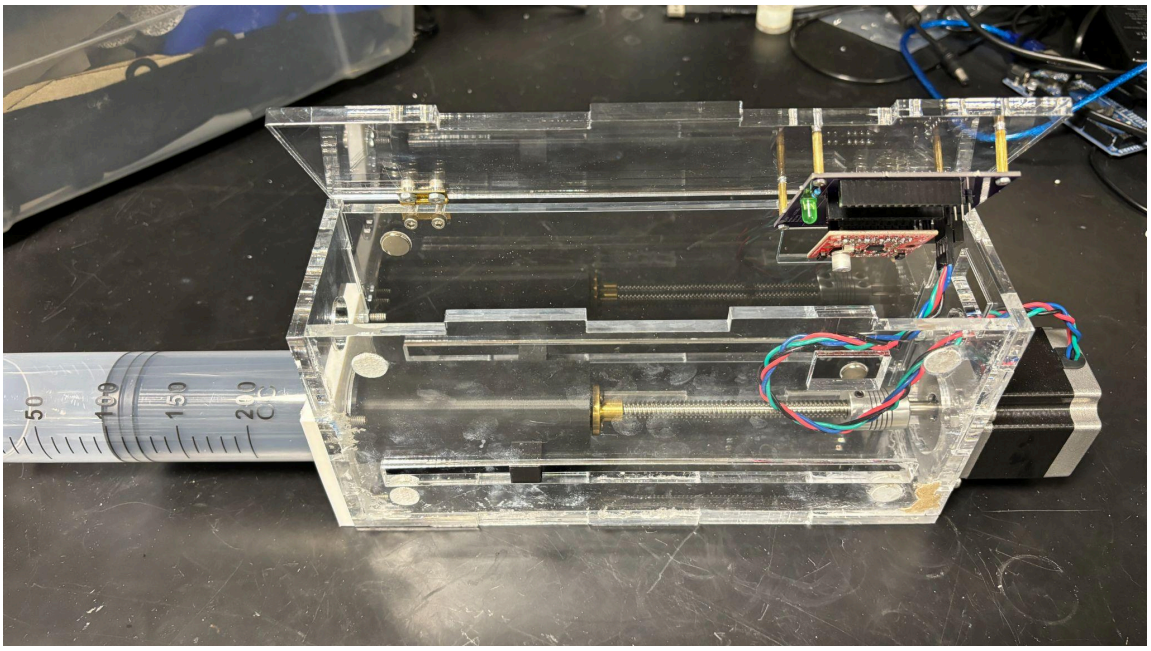
a. Using acrylic glue (or instant adhesive/professional grade super glue pictured in materials list) glue 4 acrylic faces together first (base, front, & sides). Hold off on the other faces, this gives us room to add the mechanical parts inside.
    i. Double-check that all plates are in the proper orientation (ex. All square cut-outs should be on the same side of the VCS where the electronics board is also at)
b. Before you complete the following step, make sure the motor wire has the appropriate housing to connect to your electronics board (4-pin header). Screw your stepper motor against the acrylic on the motor side (should have shorter screw holes).
c. Place your plastic syringe against the acrylic side on the other side (make sure it's on the syringe side, there should be taller screw holes on this side). Now add your 3D-printed syringe holder plate, that should align with the arms of the plastic syringe. Screw everything into place with the pre-cut holes in the acrylic.
d. Screw the ball nut onto the arm side of the 3D-printed plunger, and screw the plunger onto the ball screw.
e. Attach a flexible coupling onto the other side of the lead screw.
f. Put the 3D-printed plunger through the side piece with the big hole, through to the other side where the plastic syringe is.
g. Attach the other side of the coupling to the motor arm.
h. Now the internal mechanical system should be set! It should look like the image below.



i. Now you can assemble the cover with the leftover acrylic faces:
    i. Add the hinges, electronic board legs, and soon electronics board (assembly in the next section).
    ii. Once you are done with this step, you can glue the last face to the overall body. Don't accidentally glue the cover shut!



COMPLETED MECHANICAL ASSEMBLY



3. Electrical

3.1 Electrical Material List

Part	Quantity	Cost	Notes
PCB from the manufacturer	1 pc	~$50 for 3 pcs	- Ordered from OSHPARK - Could also use a protoboard and solder connections
Motor Driver	1 pc	$21.50	
Arduino Nano Board & USB mini	1 pc	$24.90	

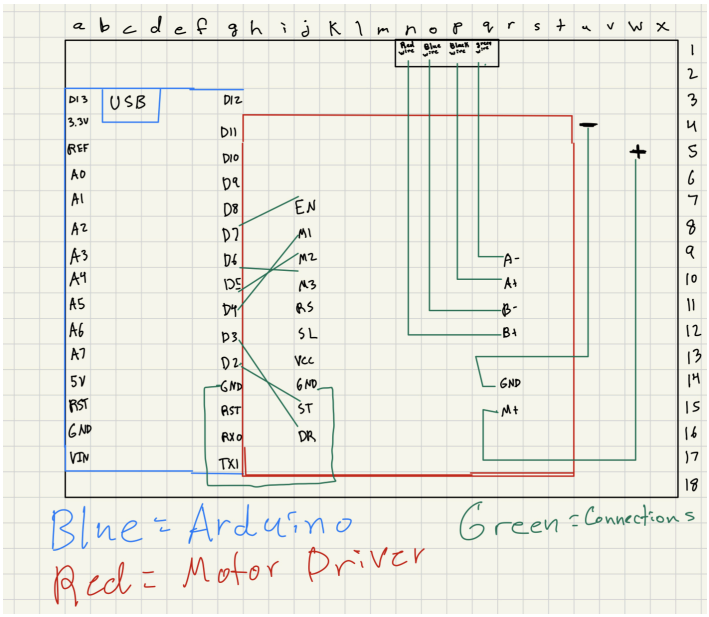
A-wire			
12V Power Adapter	1 pc		
Barrel Jack	1		
LED (5mm) & 130 Ω Resistor	1 of each		- LED Connection Resource

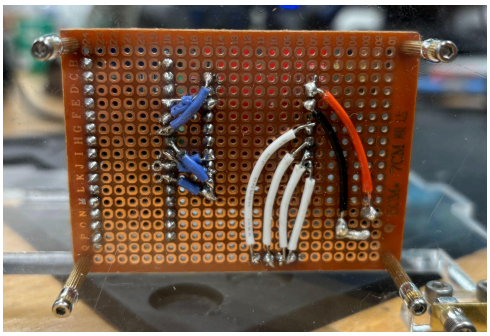
3.2 Circuit Board

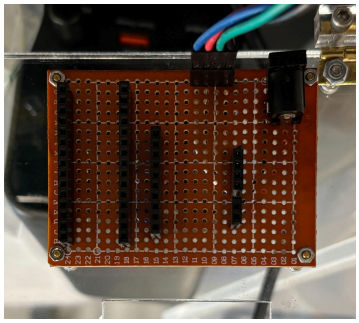
a. ProtoBoard or Printed Circuit Board (PCB)

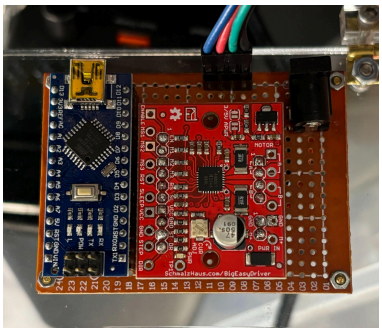
i. Protoboard

1. You would need to solder connections on the back in this form
2. Additionally, you will need to solder the female headers and barrel jack onto the board.









ii. Printed Circuit Board (PCB)

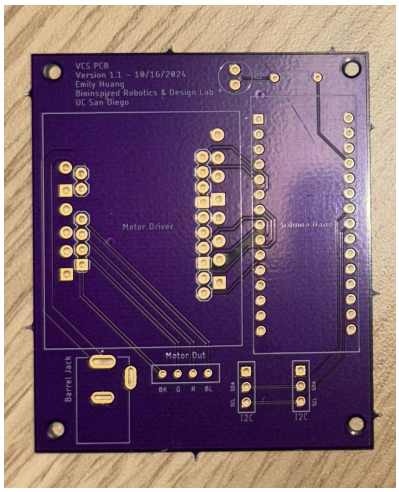
1. PCB file can be found in the Github, which you can send in to get manufactured by OSHPARK or any other manufacturers
2. Additionally, you will need to solder the female/male headers, barrel jack, LED, and resistor onto the board
3. The board should be labeled with each component, below are some extra notes:
    a. Arduino Nano:
        i. The plug should face the same side as the barrel jack
    b. Motor Out Header:

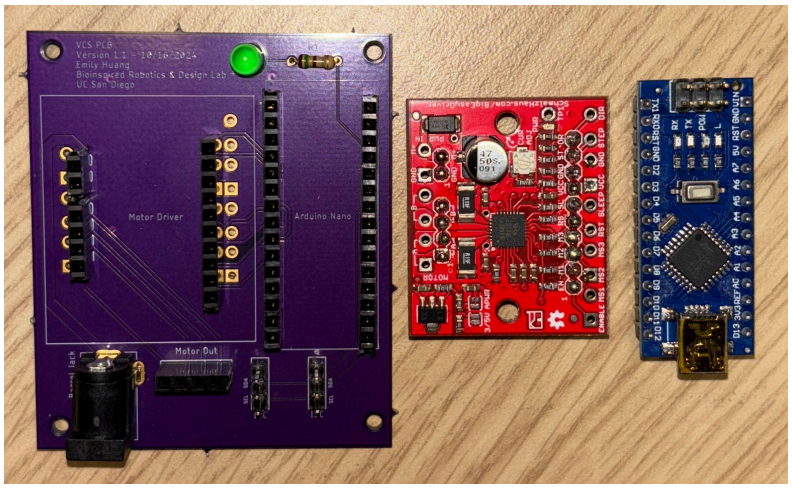
i. Bk = Black

ii. G = Green

iii. R = Red

iv. Bl = Blue





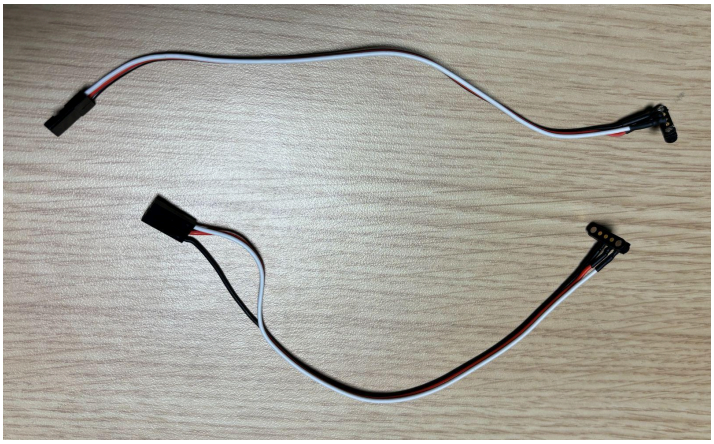
iii. Now you may screw the electronics board onto the legs on the cover of the body.

b. Cross Communication Assembly

i. You will need to make the I2C cable with 3 wires for SCL, SDA, and ground (ensure they are ordered the same way indicated on the PCB)

ii. One side should be soldered onto the magnetic connector (use heat shrink to prevent wires from touching). The other should be crimped and put into a 3-pin housing.

iii. Make a second wire as there will be two sides of connections for the VCS (bottom right is an image of how it will magnetically connect)



4. Arduino

4.1 Code

Note: The Arduino code can also be found on GitHub. This code should work for any iteration of this project. It simply measures the steps the motor takes and keeps track of the location so the motor doesn't conduct any movements it shouldn't. Comments in the code explain how it works.

a. Using one VCS

b. Using multiple VCS