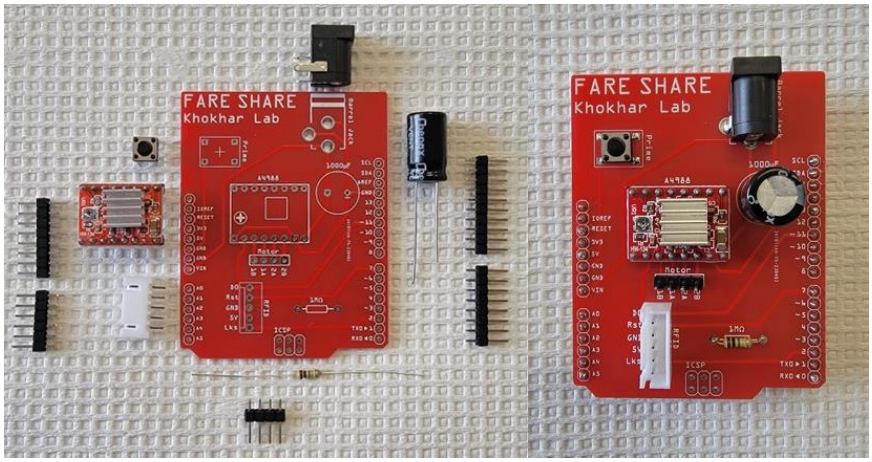
Build Instructions

Table 1: Bill of Materials

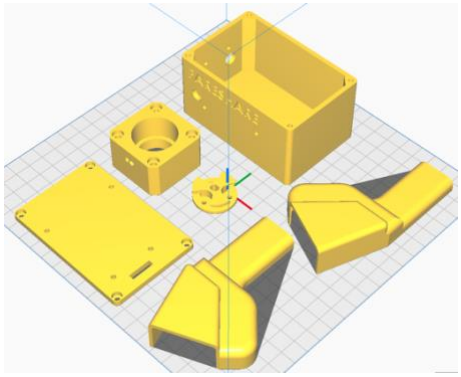
Part Name	Distributer	Alternate	Cost ($US)
1000uF Capacitor (through hole)	Mouser	Digikey	1.63
16G Needles (x2)	Fisher Scientific	Surgo	0.85
1M Ohm Resistor (through hole)	Mouser	Digikey	0.42
5-pin 2.54mm JST Female to Female Cable	Walmart	Amazon	1.30
5-pin 2.54mm JST Male header (x2)	Walmart	Amazon	0.14
3D printer filament	Amazon	Hatchbox	2.50
A4988 Stepper Motor Driver	Amazon	Digikey	1.20
Ball bearings (3mm x 8mm x 4mm) (x4)	Amazon	NewEgg	2.00
Barrel Jack PCB mount (3 pin)	Mouser	Digikey	1.25
Break Away Headers (2.54mm straight) (41 pins)	Sparkfun	Mouser	3.50
Custom PCB	JLCPCB	OSHpark	2.00
Dual lock (10cm)	Amazon	Mouser	1.50
Epoxy	Walmart	Amazon	6.12
Hook-up Wire (22 AWG)	Sparkfun	Amazon	2.95
M3 Screw (Hex Socket, 25mm) (x4)	Home Hardware	Amazon	2.75
M3 Screw (Hex Socket, 10mm) (x7)	Home Hardware	Amazon	3.25
M3 Screw (Hex Socket, 5mm) (x8)	Home Hardware	Amazon	3.50
M3 Nut (x3)	Home Hardware	Amazon	2.00
Masterflex® Microbore Pump Tubing, Platinum-Cured Silicone, 1.42mm ID, 3.12mm OD (16cm long)	Avantor	Fisher Scientific	2.30
Mini 4-pin Push Button	Mouser	Amazon	1.00
Micro SD Card (FAT16 or 32, 64MB to 32GB)	Amazon	Walmart	5.99
Nema 17 Stepper Motor (4 lead, 2A) (17HS19-2004S1)	Amazon	AliExpress	13.99
Power Supply (12V, 3A)	Amazon	Walmart	8.99
Qwiic Cable Kit	Sparkfun	Mouser	8.95
Qwiic OLED Display (0.91 in, 128x32)	Sparkfun	Mouser	10.95
Qwiic OpenLog	Sparkfun	Mouser	18.50
RedBoard Qwiic	Sparkfun	Mouser	21.50
RFID Chip Injector (2.12x12mm)	Amazon	AliExpress	6.99
RFID Glass Capsule (125kHz)	Sparkfun	Mouser	5.50
RFID Reader Breakout	Sparkfun	Mouser	2.10
RFID Reader ID-12LA (125 kHz)	Sparkfun	Mouser	32.50
Silicone Tubing 1.5mm ID x 3mm (140 cm)	Amazon	NewEgg	6.99
Stainless Steel Straw (straight 5mm OD)	Amazon	Whisk	0.60
Total			**$185.71**

PCB Ordering: Upload GERBER file to https://jlcpcb.com and order with default settings.

PCB Soldering: The figure below shows the PCB before (left) and after (right) soldering. The PCB is silk screened and labeled such that soldering orientation and positioning is clear.



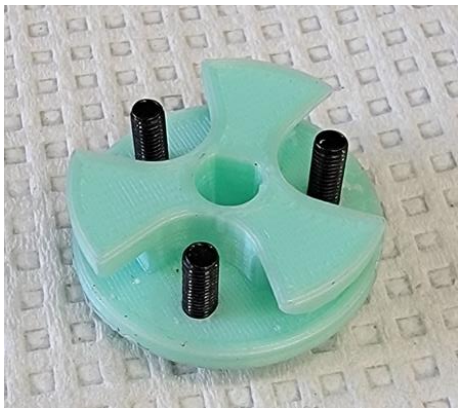
3D Printing: Print in the orientations shown below. The pump rotor and RFID housing should be printed with supports. All other components can be printed without supports. Print with standard PLA filament.



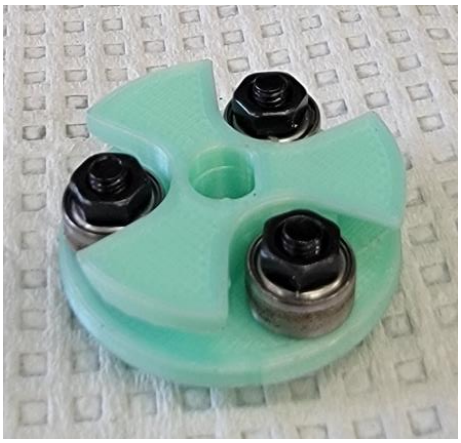
Pump Assembly:

1. Cut two 1cm pieces of needle by slowly rotating and cutting evenly so as not to crimp.

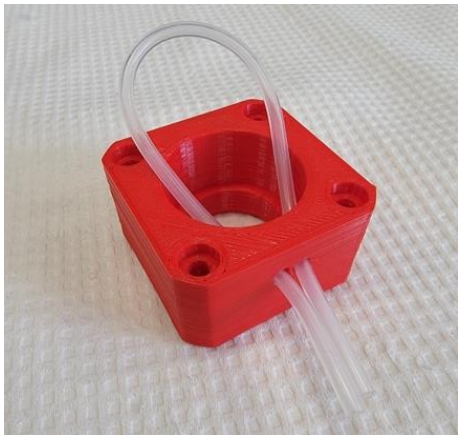
2. Screw M3X10 screws through the holes of the rotor



3. Place bearings on screws and secure with M3 nuts. Ensure the nuts are not too tight so as to allow the bearings to turn without any friction.

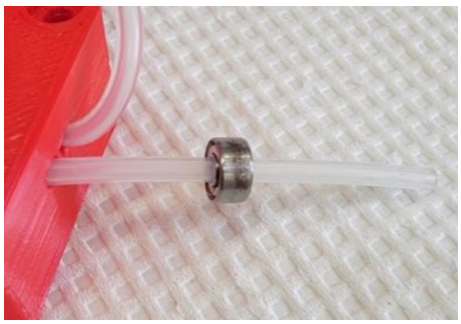


4. Thread 15cm segment of Masterflex tubing through pump case.



5. Wrap the tubing around the rotor and push the rotor into the pump housing while keeping tension on the tubing. Once inside the housing, manually rotate the rotor a bit and pull on each side of the tubing until the rotor is straight and the tubing wraps around each bearing.

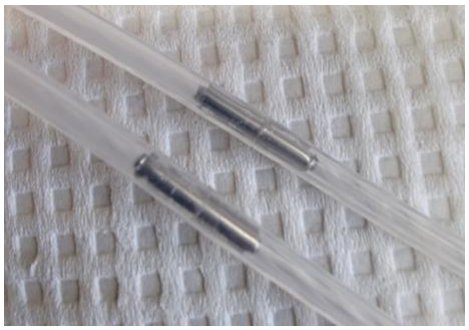
6. Thread another bearing onto the left (with tubing facing you) exiting tube.



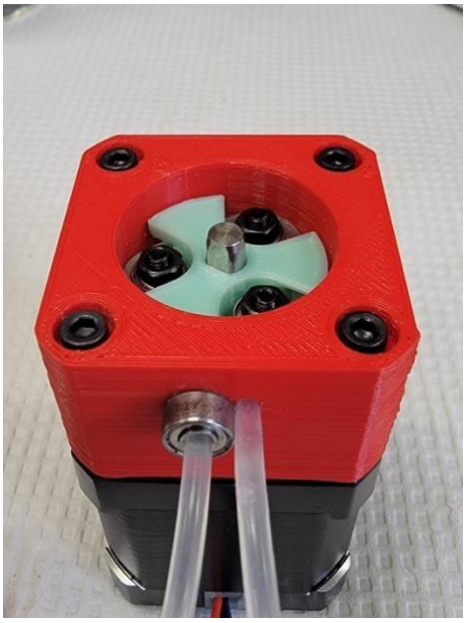
7. Bring bearing up to pump housing and epoxy or super glue to both tubing and housing. This will keep the tubing from being pulled through the rotor or shifting.

8. Insert needle segments halfway into tubing ends.

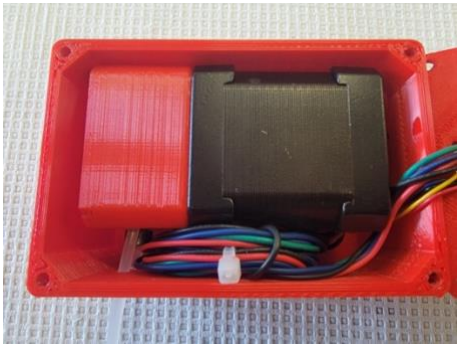
9. Place super glue where needle exits tubing and insert needle ends into two 70 cm segments of silicon tubing (cheaper tubing), gluing tubes together.



10. Place pump assembly onto motor with tubing facing the same direction as motor wires and, using M3x25mm screws, fix in place.



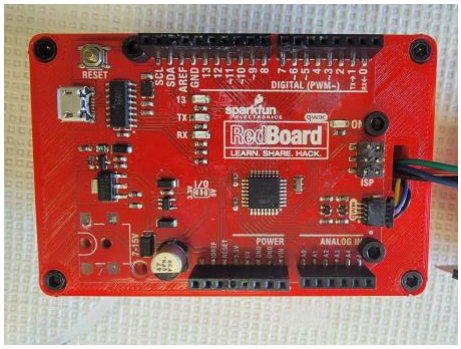
11. Place assembly into box, feeding tubing through input and output holes, and wrapping most of the motor wiring together, placing it in the space between the motor and the wall of the box. Spray the bearings and inner tubing generously with an all-purpose lubricant.



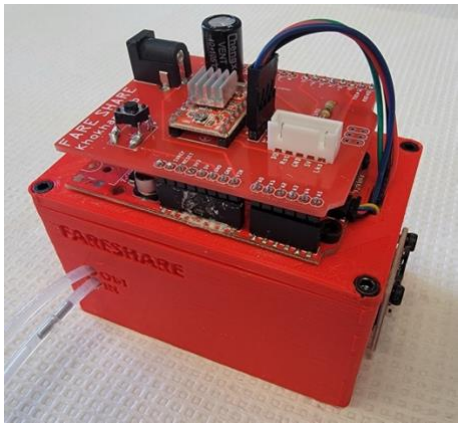
12. Attach OLED display to side of box with M3x4mm screws and thread 10cm Qwiic cable from the left port on the OLED into box.

13. Attach data logger to the side of the box with M3x4mm screws and connect Qwiic cable from OLED into right port of data logger. Connect left port to 5cm Qwiic cable.

14. Attach RedBoard to box lid with M3x4mm screws. Feed motor wiring and Qwiic cable from data logger through square channel in lid. Connect Qwiic cable to RedBoard. Connect lid to box with M3x10mm screws.

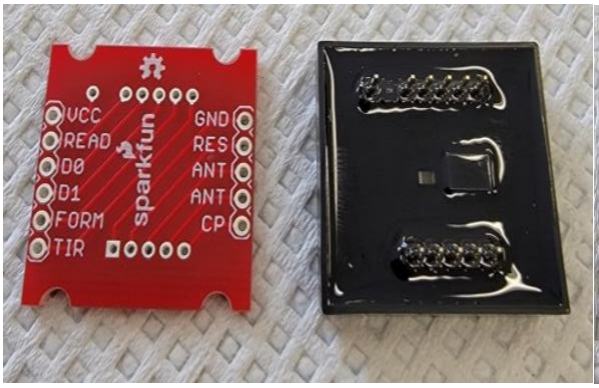


15. Plug PCB into RedBoard and connect motor wires to PCB motor pins with the black wire closest to the resistor.

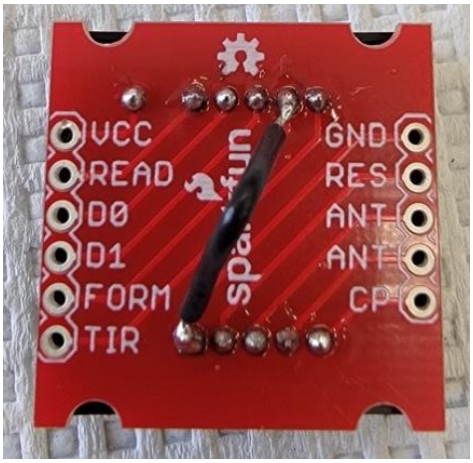


RFID Housing Assembly:

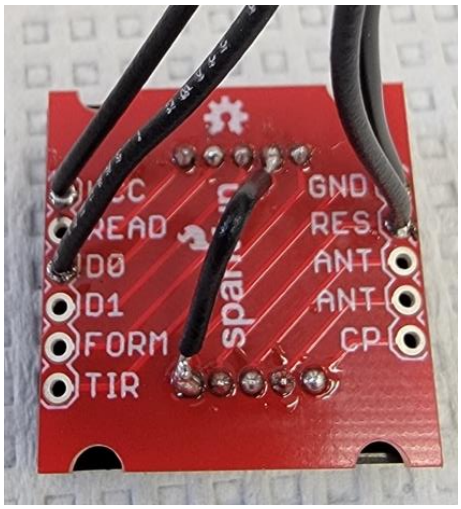
1. Solder RFID Breakout Board to RFID Reader.



2. Solder a wire between the FORM and GND pins.



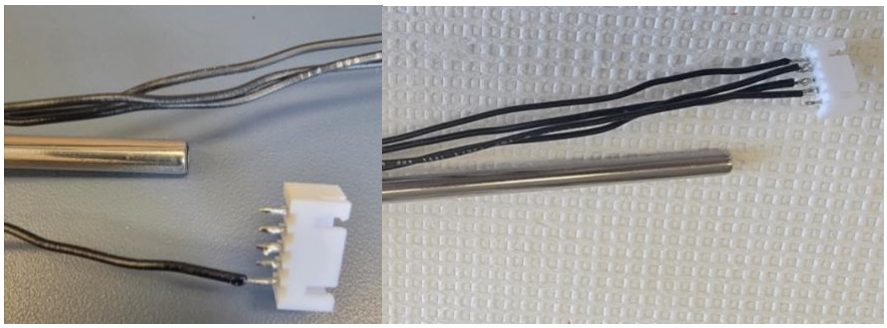
3. Solder 30cm segments of wire to Vcc, D0, GND, and RST through hole pins. Label these wires at the unattached ends so you can identify them later on once they are encased.



4. Epoxy the metal straw into one half of the RFID housing with 0.5cm of straw projecting past the straw channel. Using glue or command strips, secure RFID sensor

inside housing and thread wires through wire channel. Epoxy the other half of RFID housing together.

5. Cut the wires such that they are 2cm longer than the straw and, with the same orientation as the plugin on the PCB, solder each wire to a JST header.



6. Strip 15cm off a 20cm wire. Wrap the stripped section around the tip of the straw and secure with electrical tape. Cut the wire to line up with the remaining pin on the JST header and solder.

7. Use electrical tape to secure all wire to the straw.

Load libraries: In the Arduino IDE select Tools>Manage Libraries. In the library manager, download Adafruit GFX Library, Adafruit SSD1306, SparkFun Qwiic OpenLog, and CapacitiveSensor.

Addition of RFID Tags to Code: Upload FARESHARE.ino to RedBoard Qwiic. Open serial monitor and place new RFID tag under RFID sensor. The serial monitor will display the new tag ID. Copy this ID and use it to replace the ID on line 38 of the code. Do this for each tag in the following lines for as many rats as are being tracked. Add one additional tag that will be used for priming the pump tubing with fluid when starting an experiment. **Note:** FARESHARE can track as many animals as needed; however, the OLED display only has room to show the overall results of the first four rats.

Pump Calibration: Each assembled peristaltic pump will be slightly different due to small inconsistencies in 3D printing and assembly. Therefore, to ensure each pump delivers an accurate volume and at the same rate, the pumps must be calibrated by the following instructions:

1. Place the input tube into a container of water and the output into a beaker that is at least 10mL.
2. Prime the line using the push button.
3. Place the beaker with the output tube onto an analytical scale.
4. Place an RFID tag by the RFID sensor and tap the straw with your finger to activate the motor. Time how long it takes for FARESHARE to deliver 10g of water.
5. Plug this time in seconds into the following formula: $Scale_{motor} = \frac{420}{time}$ and set the motor_scale variable on line 83 to this new value and upload the new code. This will ensure each device takes the same amount of time to dispense fluid (~7 minutes for 10mL).
6. Tare the scale and fill it to 10g again with the pump.
7. Plug the volume reading on the FARESHARE OLED display into the following formula: $Scale_{flow} = \frac{10}{volume}$ and set the flow_scale variable on line 81 to this new value and upload the new code.

Operating instructions

1. Prior to starting experiments, remove any .csv or .txt files from the SD card. Insert the SD card into the SD card slot on the Qwiic OpenLog. **Note:** The Qwiic OpenLog SD card logger used in FARESHARE is compatible with 64MB to 32GB microSD cards in either FAT16 or FAT32 formats.

2. Attach straw section of FARESHARE to inside of cage with type 400 dual lock, feeding top of straw through the cage top.
3. Connect wires to PCB via 5-pin JST cable.
4. Place input tube into fluid reservoir and tape in place
5. Plug power supply into the wall and connect the barrel connector to the barrel jack on the PCB. **Note:** Ensure SD card is in reader prior to plugging as files are created when device powers up.
6. Press the reset button on the Arduino to begin the experiment. **Note:** make a note of the time that the experiment is started as the timestamps for each drinking bout are measured in milliseconds following this moment.
7. Place the priming tag onto the RFID sensor to operate the pump until fluid has fully filled the line.
8. Place output tube ~6cm into straw and tape in place.
9. Allow rats to drink as long as desired.
10. When experiment is complete, unplug FARESHARE and remove SD card.