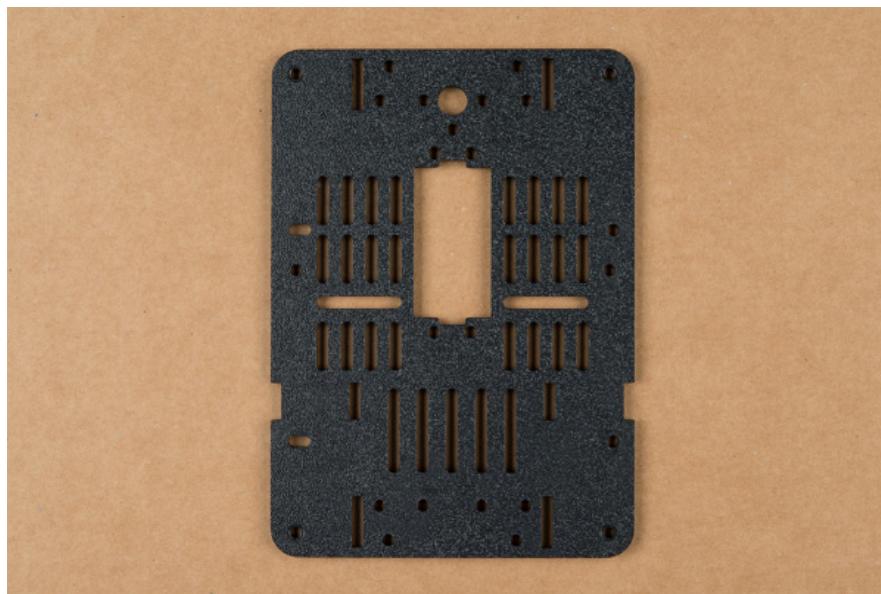


# Mobile Bot Assembly Instructions

## 1. Drivetrain Assembly

Note that much of this guide is pulled from a [tutorial provided by Sparkfun](#). If you have any questions during assembly don't hesitate to reach out to the TAs.

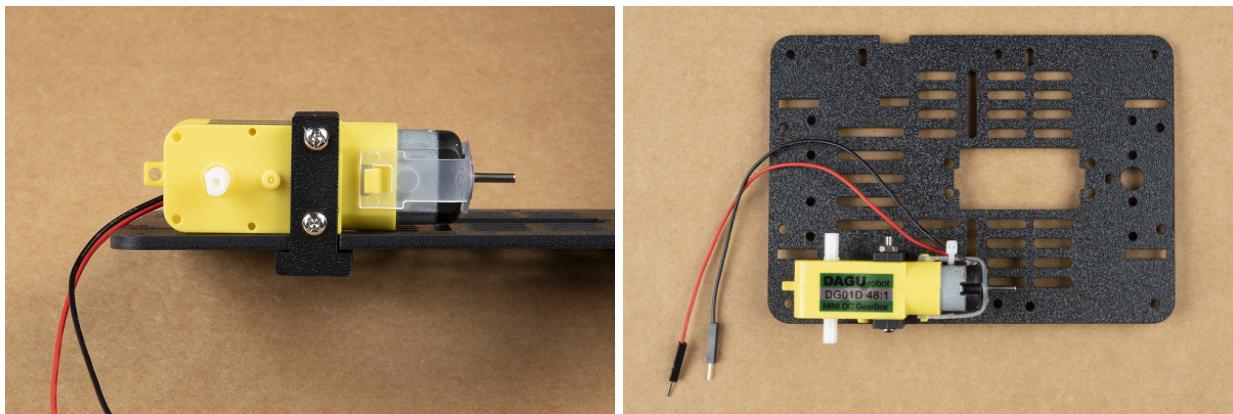
Grab one of the two baseplates (either one, they're identical).



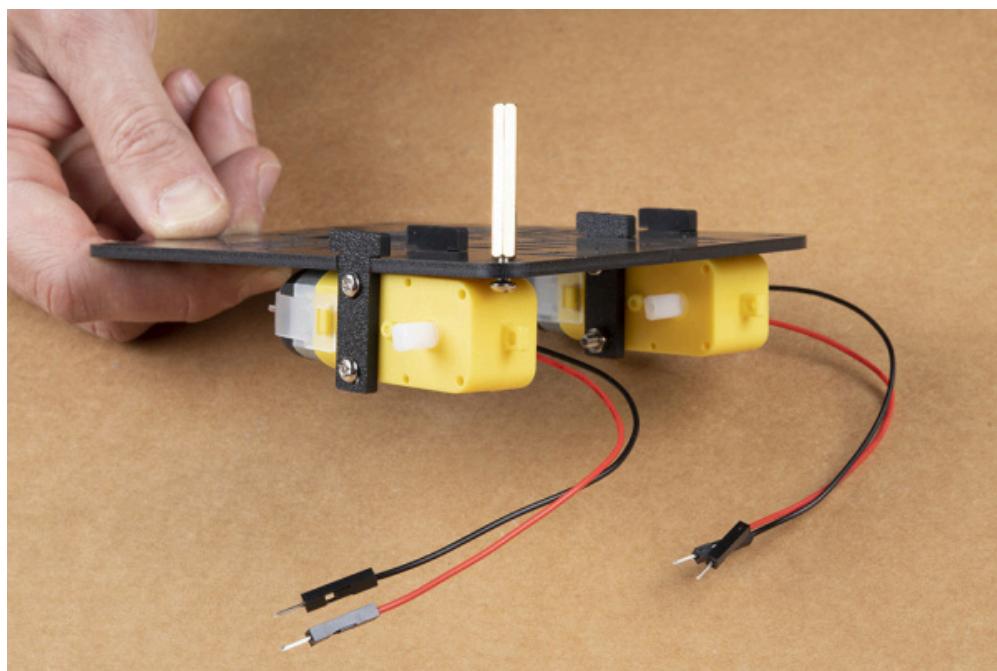
Push two of the included motor mounts through the designated holes in the base plate as shown below. Two more motor mounts will be attached on the outside of the base plate after the motor is installed.



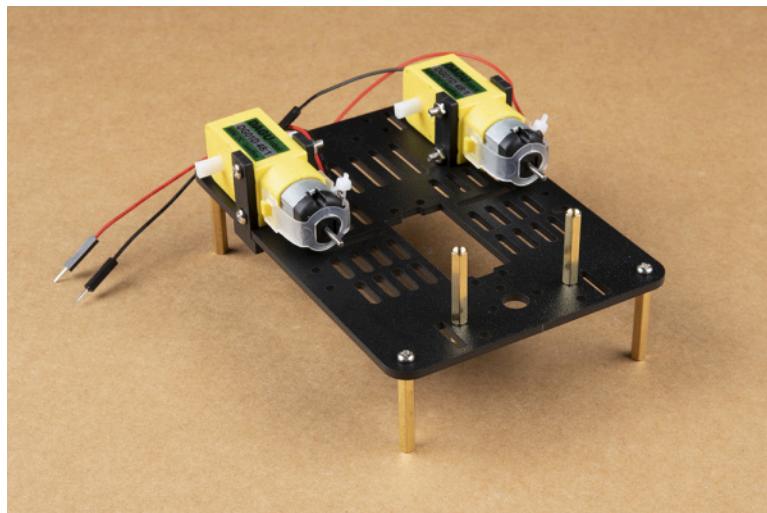
Attach the pair of motors using the long threaded machine screws (M3x30mm) & nuts. The motor will be sandwiched between an internal & external motor mount. Tighten the screws until they are snug. **If possible, hold the motors tightly against the baseplate as you finish tightening the bolts - otherwise, the motors may shift and rotate around a bit.** Note the orientation of the motor in the pictures below.



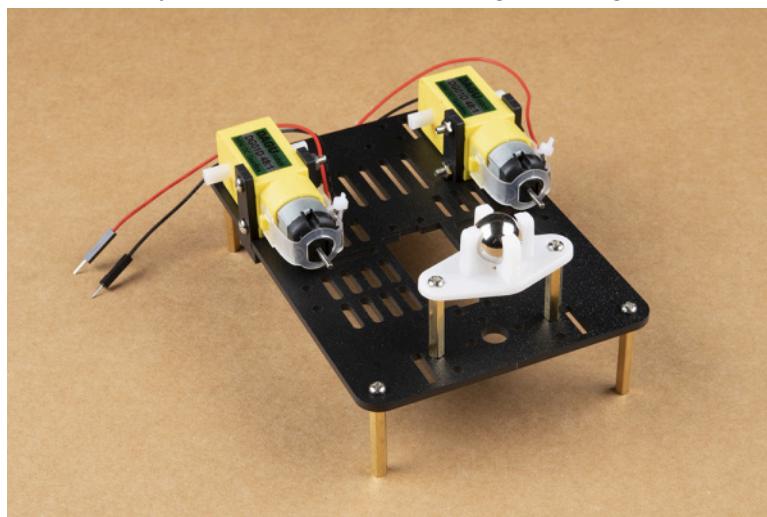
Once both motors are attached, flip the base plate over & attach the four longer brass churros (standoffs) at each corner of the base plate using the shorter threaded screws. These four churros are packaged together, and should be attached to each of the four corners of the baseplate. **Use the short (M3x6mm) screws** - we'll need the medium (M3x10mm) screws later.



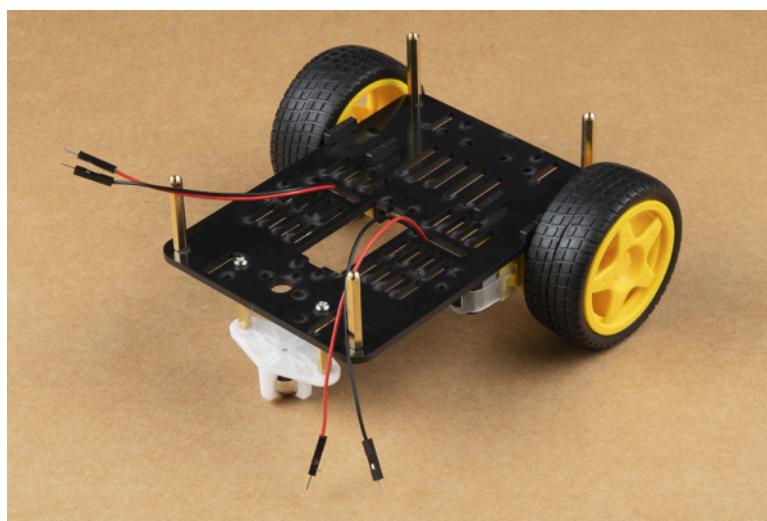
Attach the two shorter churros as shown.



Attach the caster ball assembly to the shorter churros, again using the shorter screws.



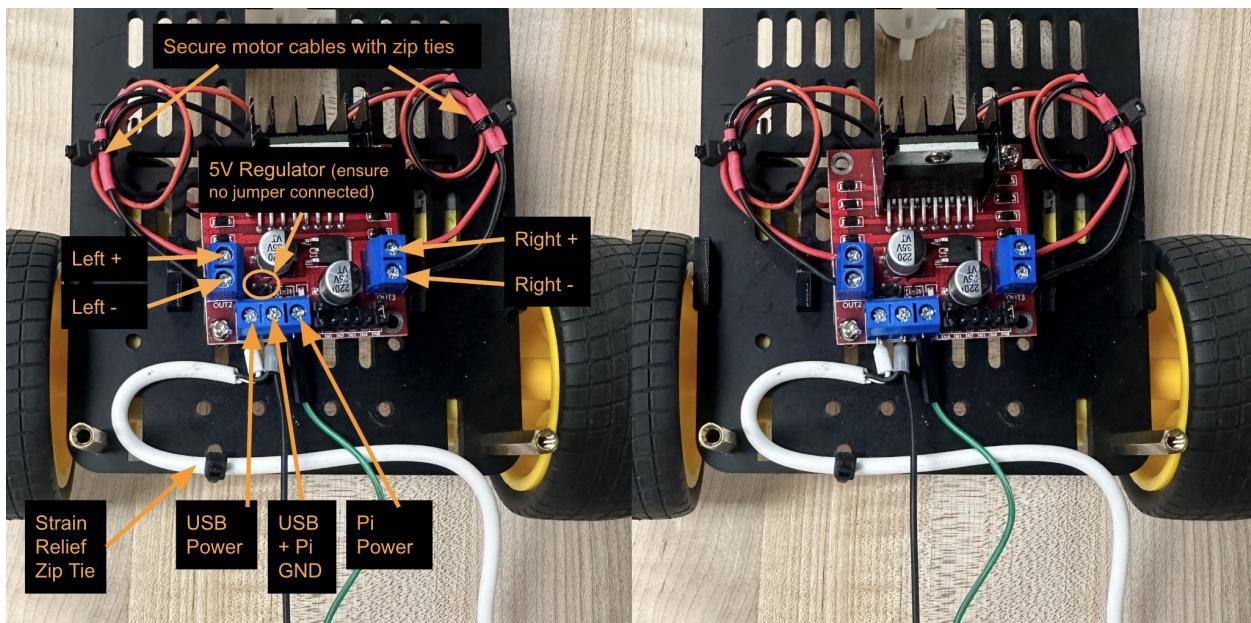
Finally, press the wheels onto the motor axles.



## 2. Electronics Assembly

### 2a. Motor Drivers (L298)

Next, wire up the lower portion of the bot, as shown below. To start, attach the motor controller board to the lower baseplate using a pair of the medium screws (M3x10mm) & nuts included in the chassis kit. Use diagonally opposing screw holes, but **do not tighten the screws too much to avoid bending/stressing the board**.



#### Motor Wires

You'll have to use the screw terminals on the motor controller board to hook up the 4 motor leads (left/right plus and minus). You'll want to unscrew each terminal until you can fit the wire into the socket, insert the wire, and re-tighten the screw until snug. If done properly, you should be able to tug on the wire without it disconnecting from the terminal.

After the pins are secure, be sure to zip tie the motor cables down to prevent them from getting caught in the tires. You do not need to follow the zip tie placements in the image exactly but be sure to prevent securing the cables too close to the front of the bot (front being where the ball bearing is) as we will need that space open in the future.

#### Power Wires

The power splits into motor power (via USB cable to battery) and logic power (via black/green jumper cables to Pi). The USB cable is pre-cut, so the positive (**red or white = 5V power**) and negative (**black = GND**) leads are broken out.

Note the ground (GND) is shared between both sides. Thus 4 wires (battery 5V power, battery GND, Pi GND, Pi regulated 5V) are seated in 3 terminals. The kits explicitly crimp the black jumper cable (GND to Pi) together with the black USB wire (GND to battery), as seen on the photos. If your USB cable does not have a black jumper wire crimped in, let us know.

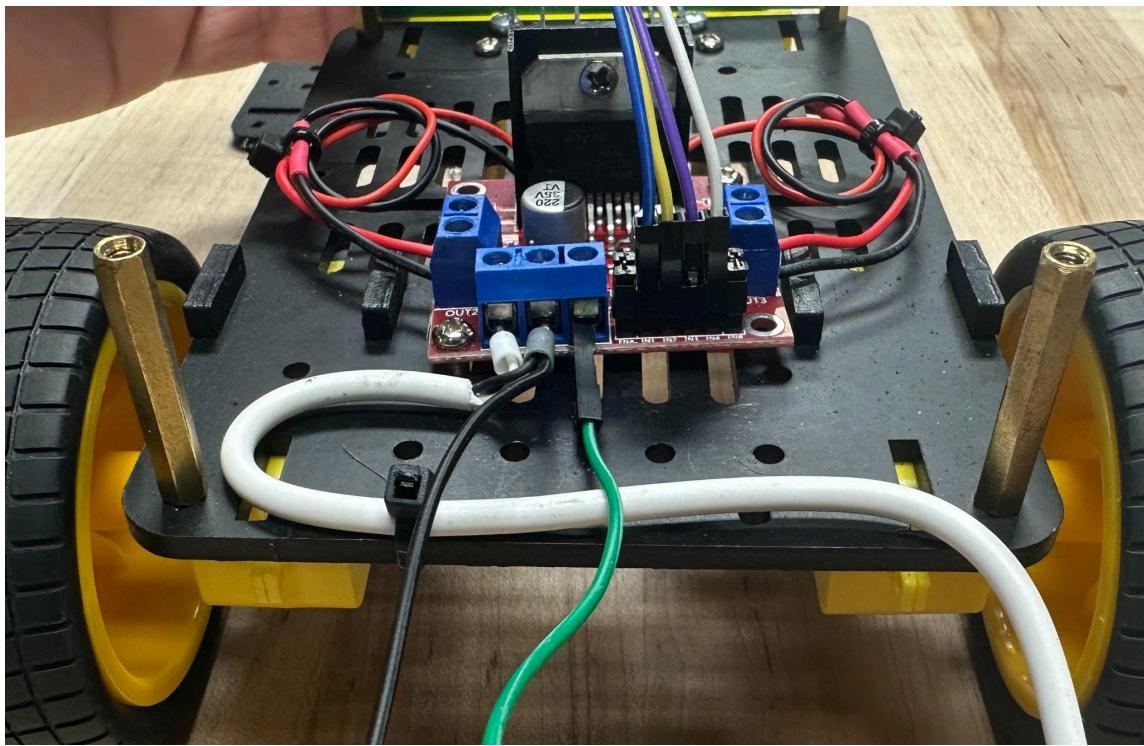
Please use a zip tie to secure the USB power cable against baseplate (to provide strain relief), as shown! You will probably pull on this cable many times (unplugging the battery).

For reference, if you ever use L298 controllers elsewhere, note that we have removed the jumper for the internal 5V regulator. We are applying external 5V logic power, so do not want the internal regulator.

### Signal Wires

Finally, you will have to use four female to female jumper cables of different colors and attach one end to each of the four input ports on the motor controller labeled "IN1" through "IN4". Consistent with the wiring table (in Section 2c) we are using blue/yellow/purple/white as the four colors.

The completed motor driver wiring will look like:

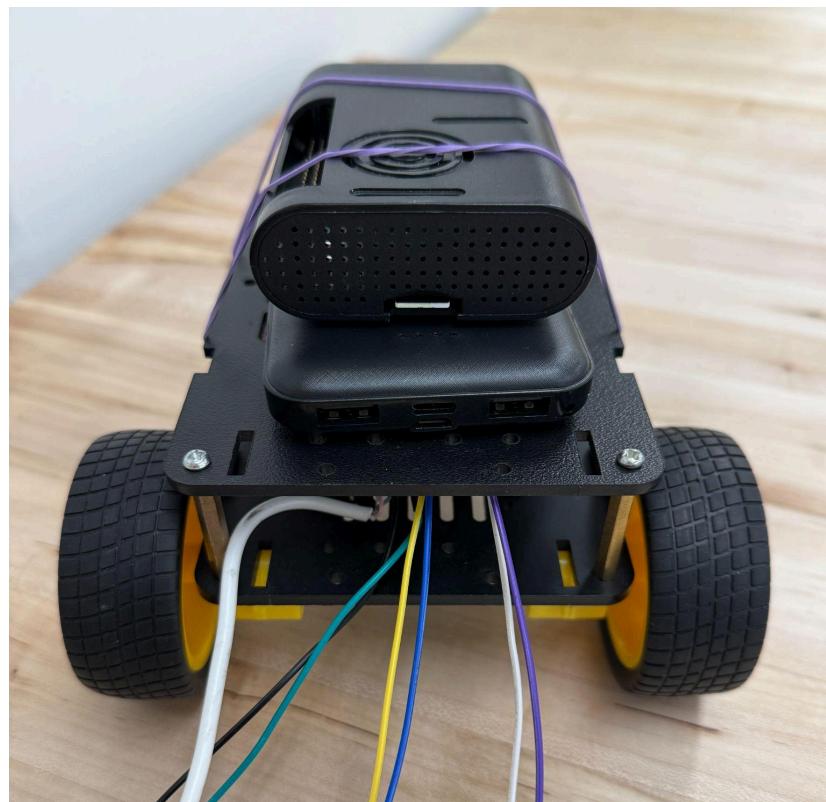


## 2b. Raspberry Pi

Next, we'll set up the Pi.

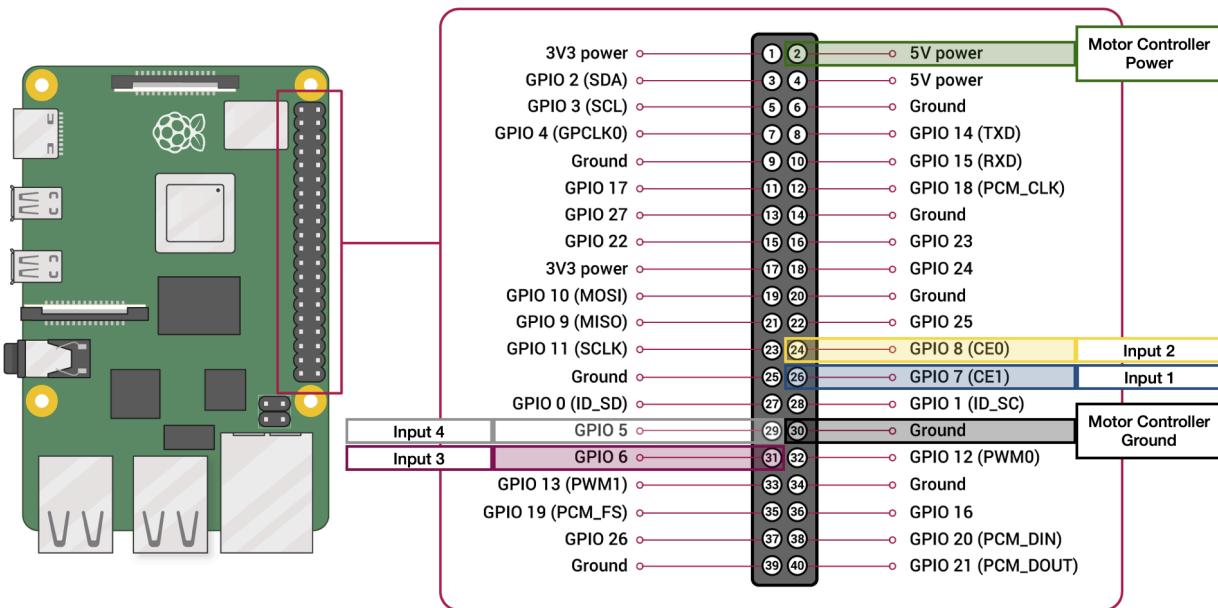


Secure the battery bank to the top of the upper baseplate, and the Pi to the top of the battery bank. **Best to use rubber bands so you can remove/place the battery easily.** Finally, attach the upper baseplate to the rest of the robot using the shorter screws and the four churros, through the holes highlighted w/red arrows (below).



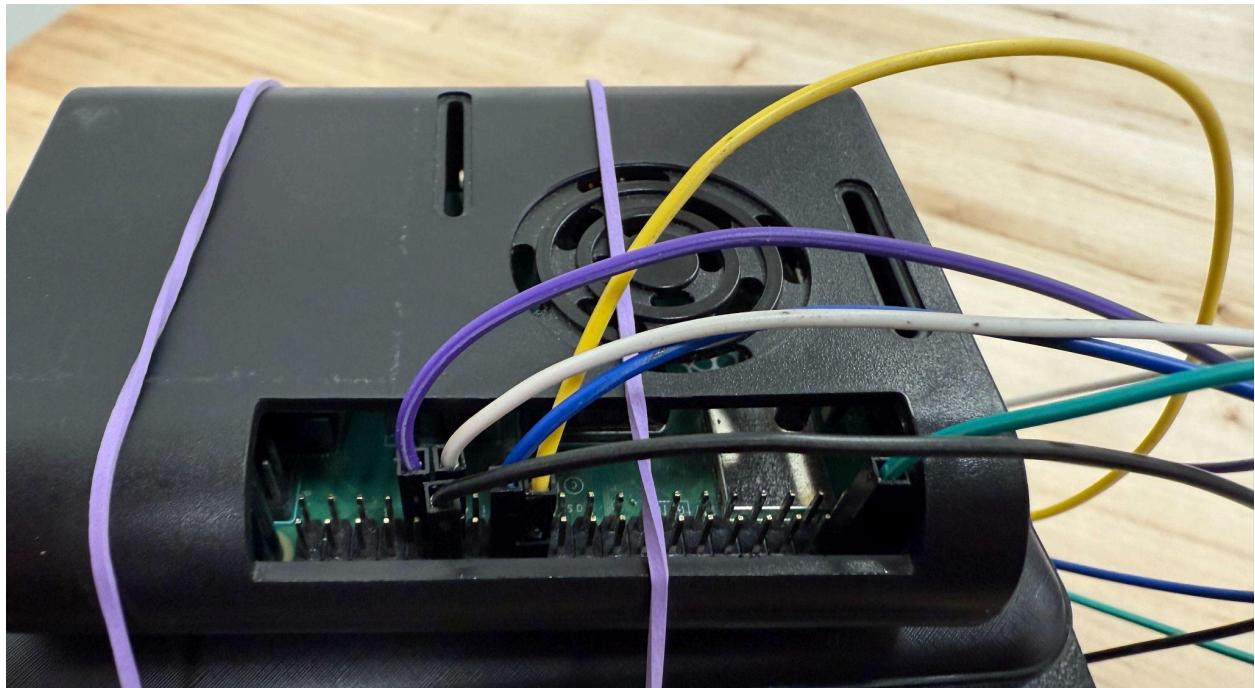
## 2c. Pi I/O Wiring

Now we need to attach the motor controller inputs to the Pi's GPIO (general purpose I/O) pins. Make sure to avoid the 5V power! The pinouts are:



Input wire name	Input wire color (color in image)	GPIO Pin (Channel)
Motor Controller 5V Power	Green	2 (5V Power)
Motor Controller 5V Ground	Black (if present)	30 (Ground)
Motor Controller Input 1	Color1 (blue)	26 (GPIO 7)
Motor Controller Input 2	Color2 (yellow)	24 (GPIO 8)
Motor Controller Input 3	Color3 (purple)	31 (GPIO 6)
Motor Controller Input 4	Color4 (white)	29 (GPIO 5)

The completed Pi wiring should look like:



## 2d. Pi Power

The Pi is powered via the USB-C plug on the side, not the 4 USB slots. Use the USB-A to USB-C cord to connect to the free USB port on the battery pack.

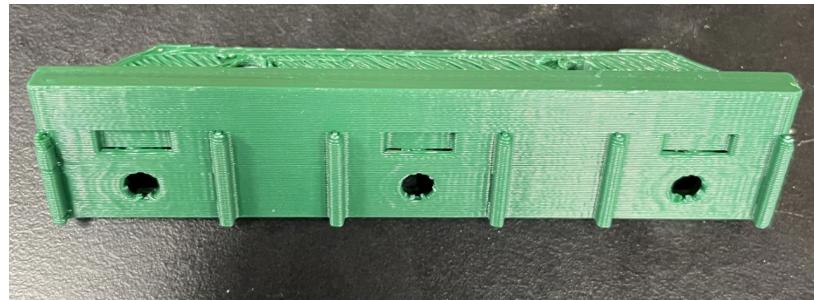
Note that you can not simultaneously use and recharge the battery packs. So please grab a fresh battery pack when you start working and charge another pack during that time (see the Battery Procedure).

TO TURN OFF OR SWITCH POWER, please “sudo poweroff”, wait 10 seconds, then unplug. Simply unplugging may corrupt the SDcard and force a brand new re-install. **Also unplug the motor controller from the battery pack when not in use!**

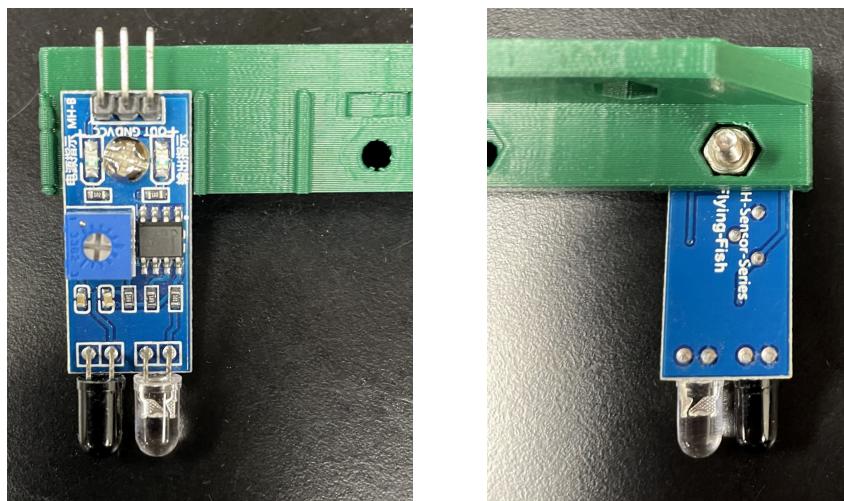
## 3. IR Sensors

### 3a. The Mount

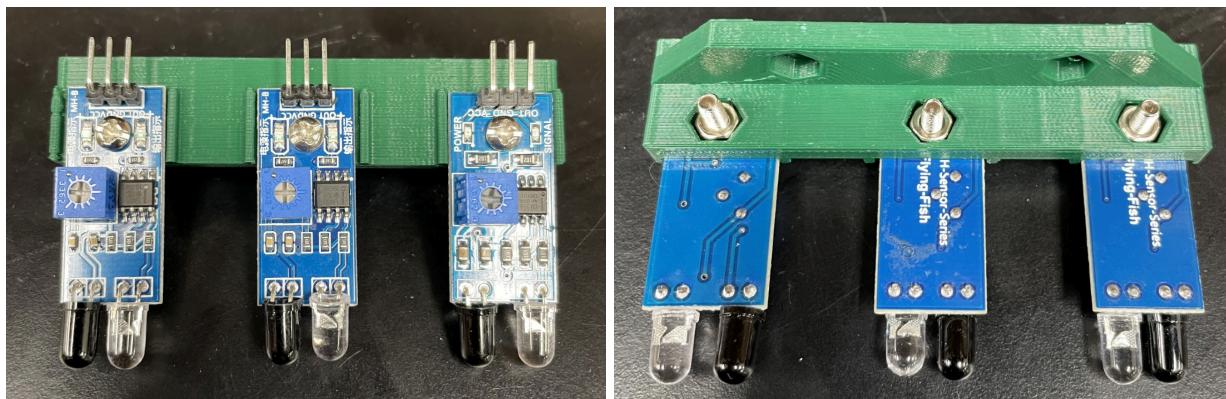
We start with the mount. **Your mount is white**, even though the following photos show green or yellow mounts.



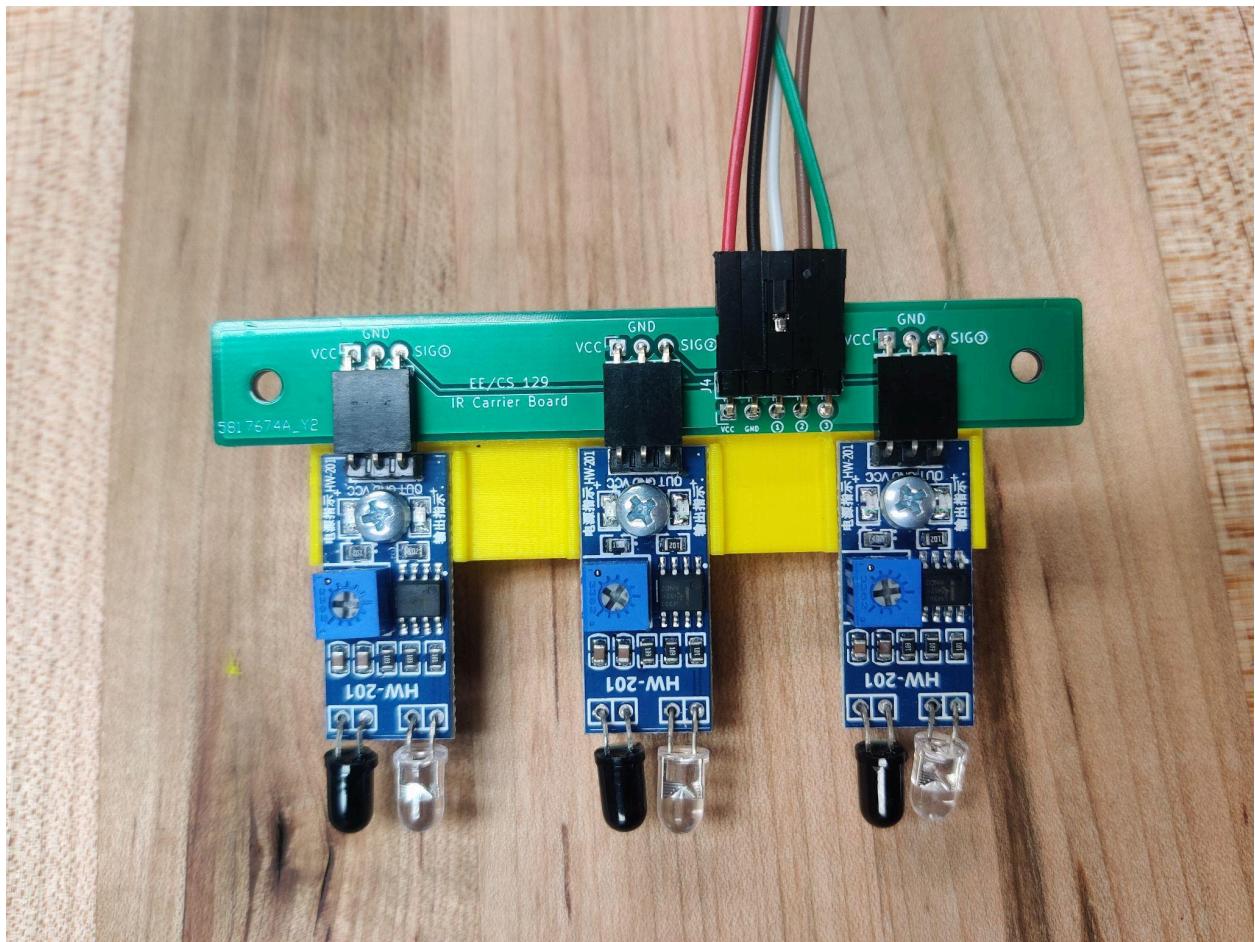
Secure an IR sensor by lining up the opening in it with one of the openings of the mount, where a screw (M3x10mm) is put the the opening and a nut is used to secure it on the other side, as:



Then secure the others in the same manner.

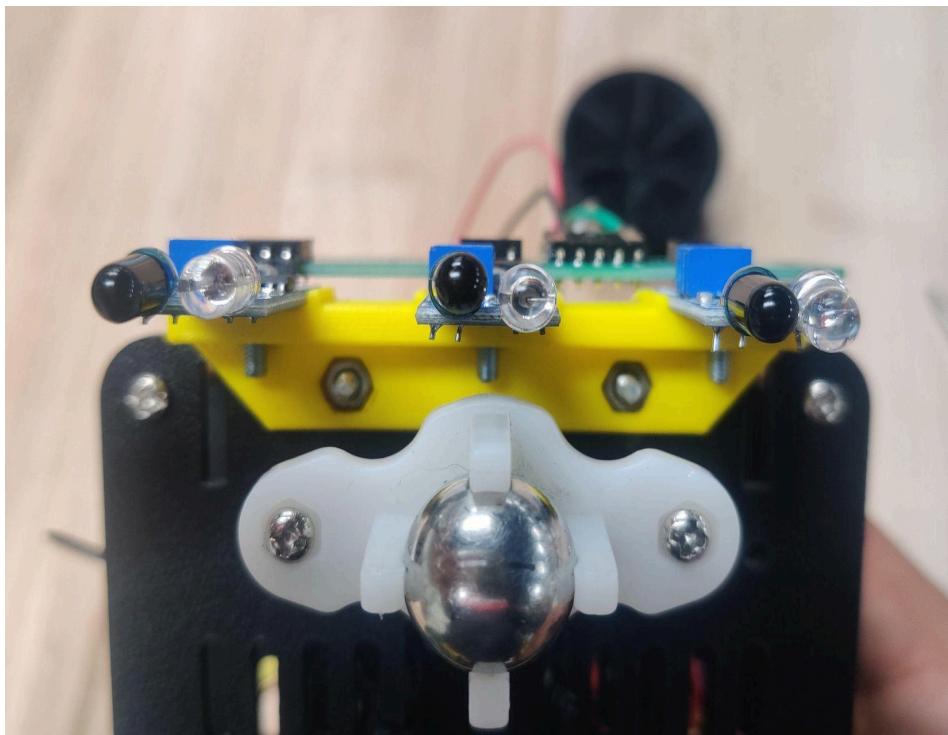


Now attach the PCB board onto the setup, ensuring that all 9 pins (3 on each sensor) correctly fit into the PCB board.

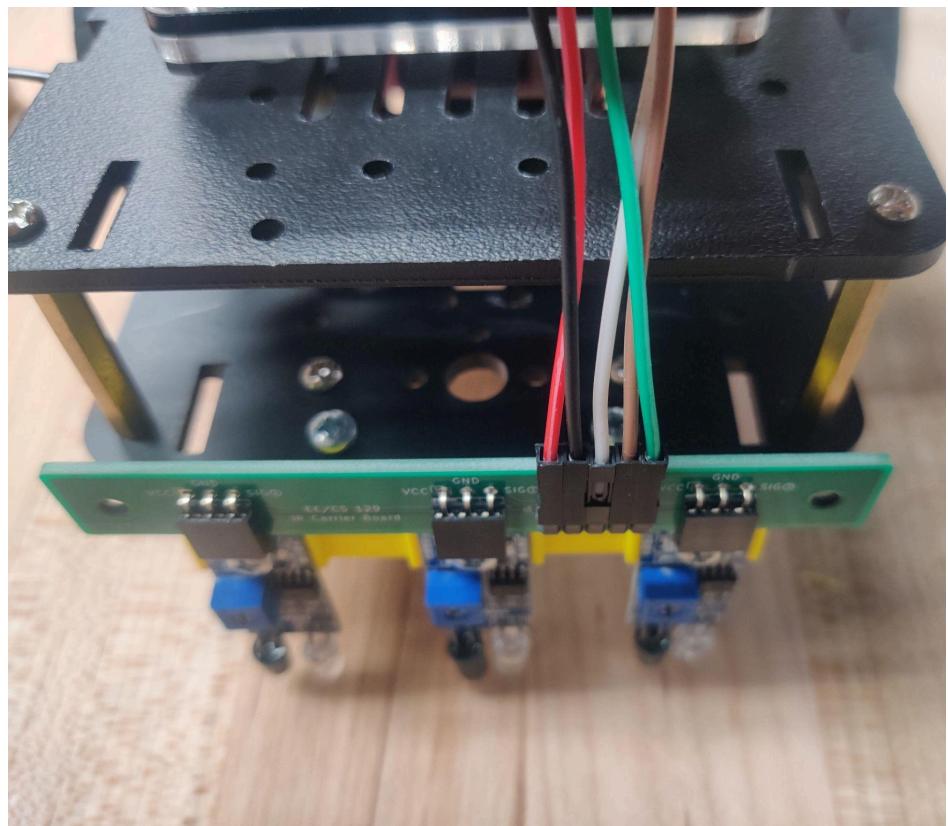


Now we will secure this to the bottom of the robot. First, remove the top plate (if you need to disconnect any of the cables from the Pi in order to do so, please do, and reattach them after).

Put the mount underneath the front of the bottom plate and line it up with the existing openings in the plate. Secure it with two screws (M3x10mm) and nut as shown below (you may need to remove the ball bearing to make room to secure the mount then reattach it after).



Bottom View

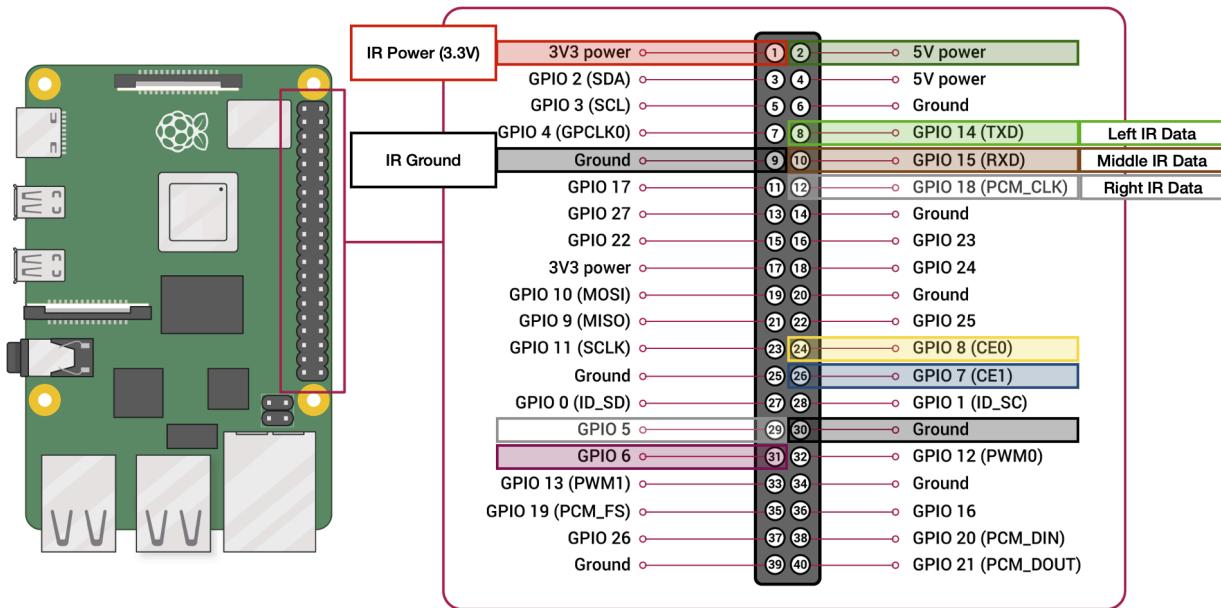


Top View

### 3b. Connecting to the Pi

The next step is to connect the data channels to the IR sensors. Take the 5 colored female to female 8 inch jumper cables (red, black, white, brown, green) and connect them to the 5 male pins on the PCB board as shown above.

Note the white, brown and green wires correspond to the IR 1, IR 2 and IR 3 signal, and the red and black wires are the IR Power (3.3V) and the IR Ground.

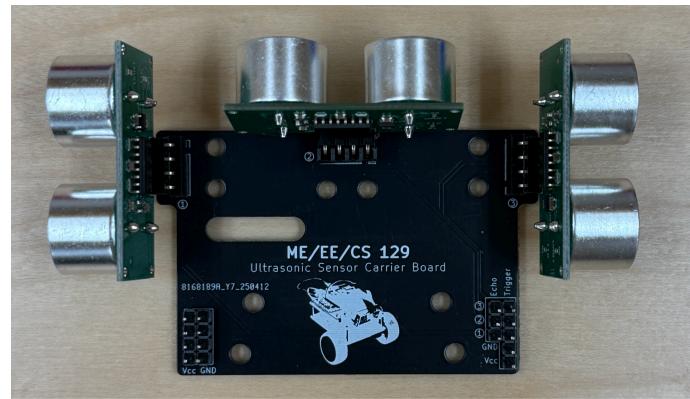


Input wire name	Input wire color (color in image)	GPIO Pin (Channel)
Motor Controller 5V Power	Green	2 (5V Power)
Motor Controller 5V Ground	Black (if present)	30 (Ground)
Motor Controller Input 1	Color1 (blue)	26 (GPIO 7)
Motor Controller Input 2	Color2 (yellow)	24 (GPIO 8)
Motor Controller Input 3	Color3 (purple)	31 (GPIO 6)
Motor Controller Input 4	Color4 (white)	29 (GPIO 5)
IR Board Power (3.3V)	Red	1 (3V3 Power)
IR Board Ground	Black	9 (Ground)
Left IR Data Channel (3)	Green	8 (GPIO 14)
Middle IR Data Channel (2)	Brown	10 (GPIO 15)
Right IR Data Channel (1)	White	12 (GPIO 18)

## 4. Ultrasonic Sensors

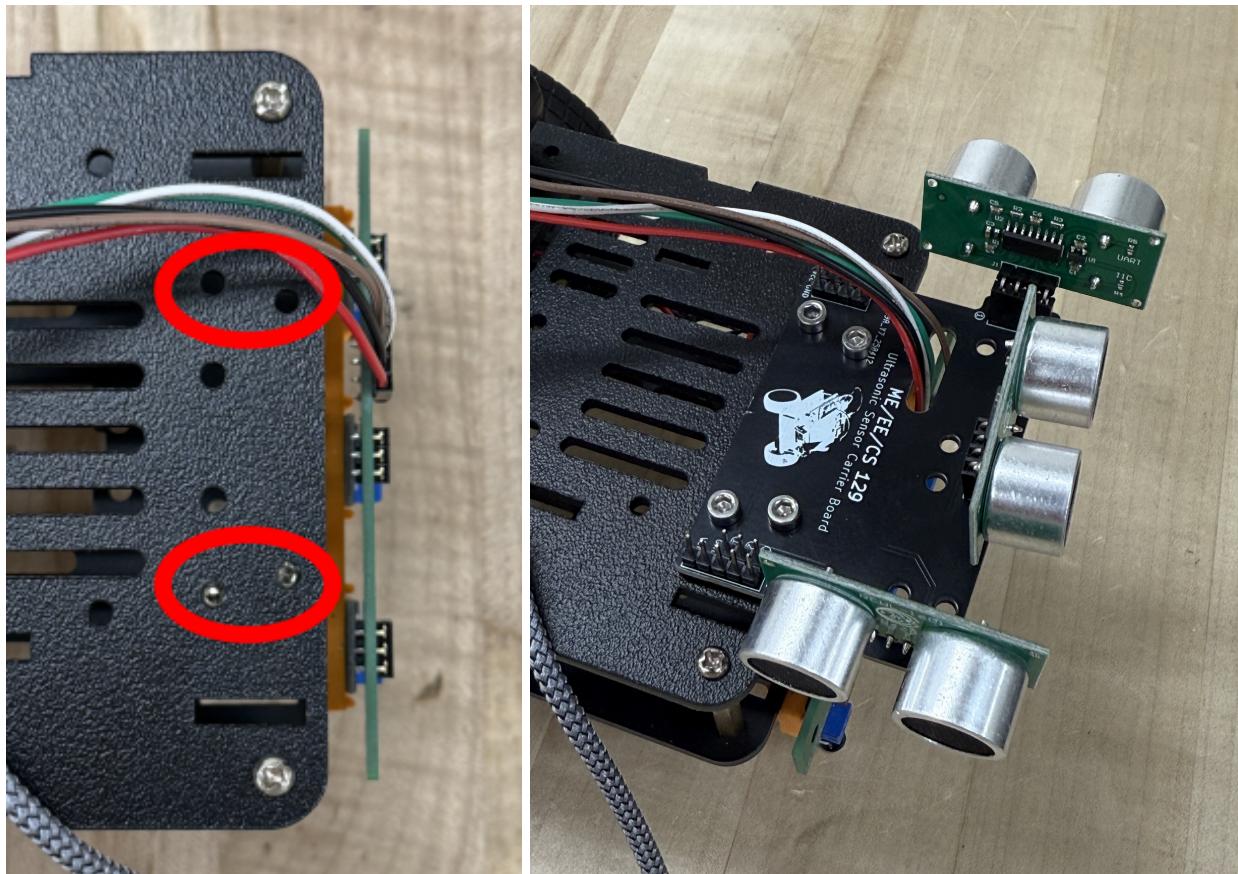
### 4a. The PCB

We start with the PCB with the ultrasonic sensors attached. Please ignore the bottom-left block of 4x Vcc and GND power output pins (for future use). For now, we will need only the block on the bottom-right (3xEcho, 3xTrigger, GND, and VCC)



The following assembly is possible without removing the robot's top plate or making any changes. **However, it will make your life much easier to use the pass-through hole to wire the IR sensors (as shown below).** If you prefer, you are welcome to take off the Pi and detach the top plate. If you detach cables, refer to the previous sections when re-wiring.

Secure the PCB to the front of the top plate with the four provided nuts and screws, using the through-holes in the top plate indicated below. It will look as follows:



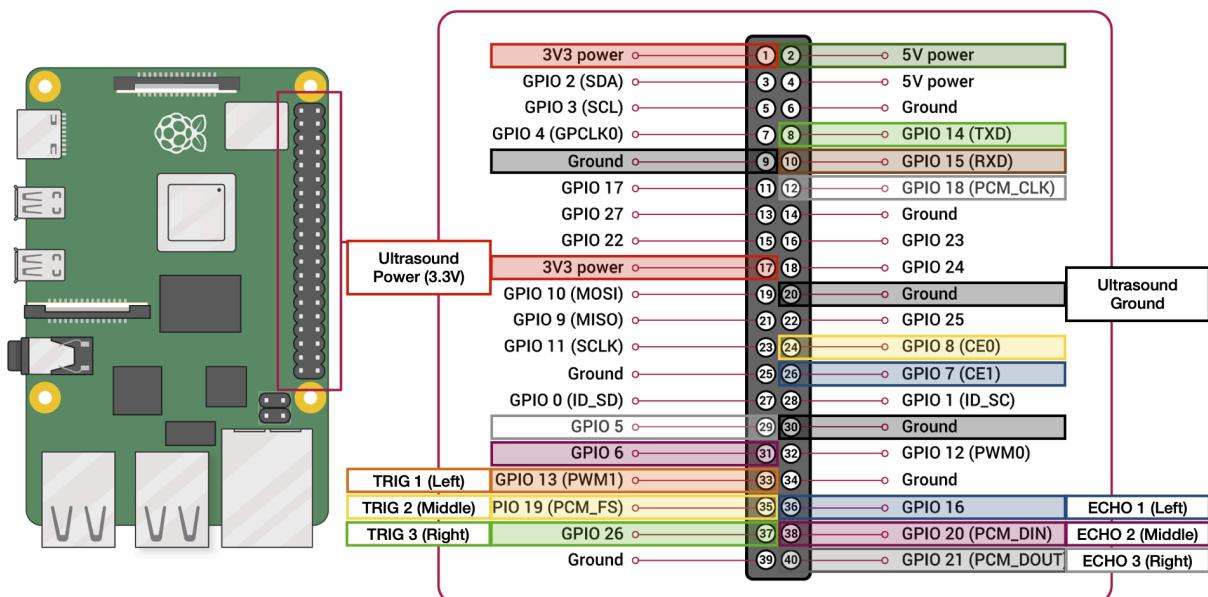
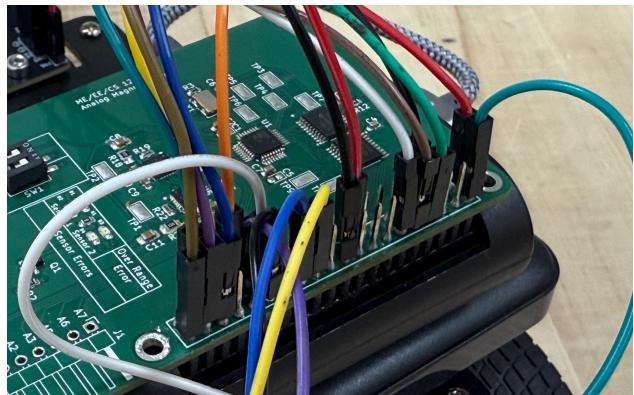
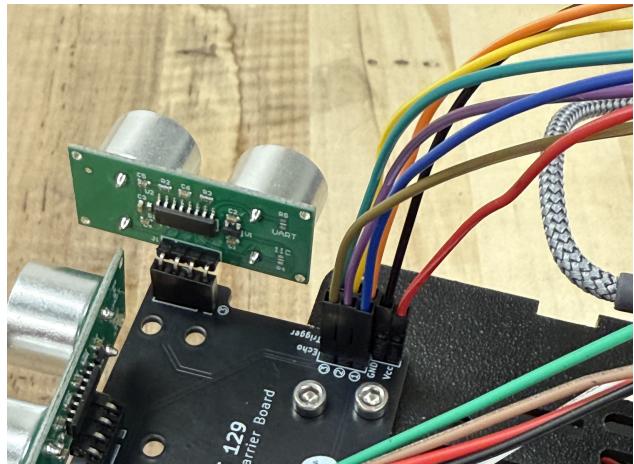
## 4b. Connecting to the Pi

To make the electrical connections, we start at the PCB end. We will need to connect: Vcc (3.3V), GND, and three each of TRIGGER and ECHO channels. We will use the female to female 8 inch jumper wires: red for power, black for ground, and six colored (orange, yellow, green, blue, purple, and gray below) for signals.

Connect the cables to the right side headers on the PCB, with the following colors:

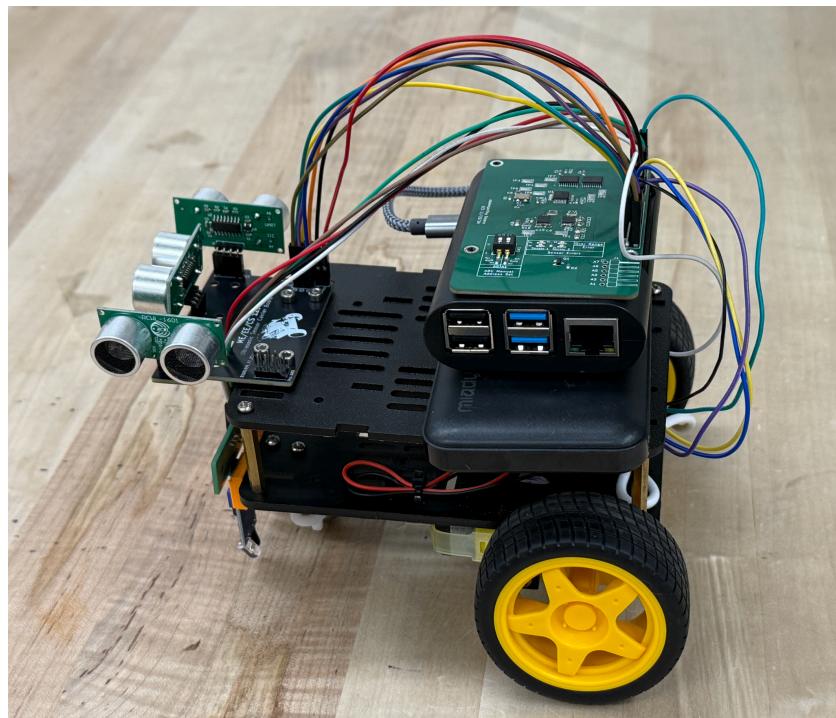
- Orange for Trigger 1
- Yellow for Trigger 2
- Green for Trigger 3
- Blue for Echo 1
- Purple for Echo 2
- Grey for Echo 3
- Red for Vcc
- Black for GND

Finally, we have to connect the other female ends of the power, ground, echo, and trigger channels to the Pi (new cables labeled). The full pinout is shown above to the right.



Below is the full list of connections up to this point, with the new ones highlighted in yellow:

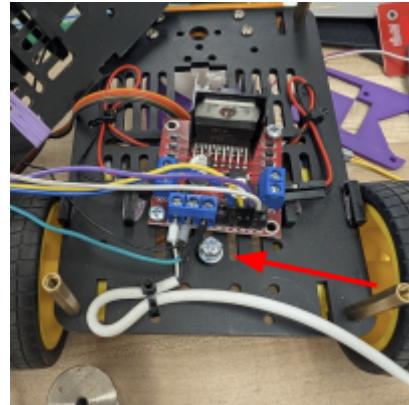
Input wire name	Input wire color (color in image)	GPIO Pin (Channel)
Motor Controller 5V Power	Green	2 (5V Power)
Motor Controller 5V Ground	Black	30 (Ground)
Motor Controller Input 1	Color1 (blue)	26 (GPIO 7)
Motor Controller Input 2	Color2 (yellow)	24 (GPIO 8)
Motor Controller Input 3	Color3 (purple)	31 (GPIO 6)
Motor Controller Input 4	Color4 (white)	29 (GPIO 5)
IR Board Power (3.3V)	Red	1 (3V3 Power)
IR Board Ground	Black	9 (Ground)
Left IR Data Channel (3)	Green	8 (GPIO 14)
Middle IR Data Channel (2)	Brown	10 (GPIO 15)
Right IR Data Channel (1)	White	12 (GPIO 18)
Ultrasound Board Power (3.3V)	Red	17 (3V3 Power)
Ultrasound Board Ground	Black	20 (Ground)
Ultrasonic 1 Trigger (Left)	Orange	33 (GPIO 13)
Ultrasonic 2 Trigger (Middle)	Yellow	35 (GPIO 19)
Ultrasonic 3 Trigger (Right)	Green	37 (GPIO 26)
Ultrasonic 1 Echo (Left)	Blue	36 (GPIO 16)
Ultrasonic 2 Echo (Middle)	Purple	38 (GPIO 20)
Ultrasonic 3 Echo (Right)	Gray (white-ish)	40 (GPIO 21)



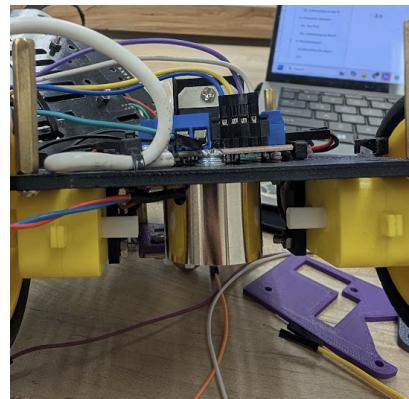
## 5. Electromagnet

### 5.a Mounting the Electromagnet

We'll be mounting the electromagnet to the bottom plate of your robot. Place the screw against the back of the center slot on your bottom plate (see picture). You may have to move your motor driver slightly to make it fit. The screw is slightly too big to fit through the slot, so you may have to use some force to thread it through. You should be able to secure the electromagnet onto the bottom of the plate, as shown in the pictures. Note, if the screw is wedged too tightly to turn, you should be able to spin the magnet to tighten.

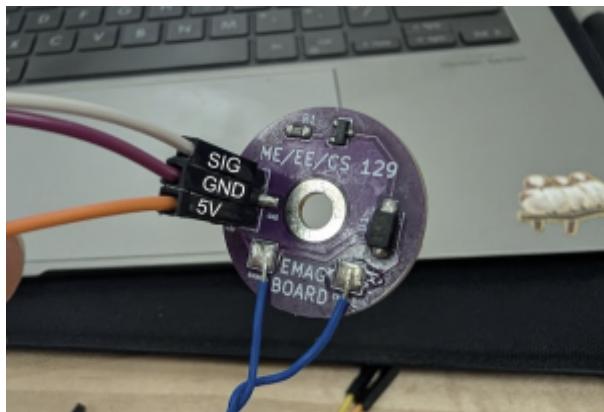


Finally (after connecting the wires - see below), zip-tie the loose electromagnet board and wires to the robot. Please make sure the wires are not dragging or getting caught in the motor/wheels.



### 5.b Connecting to the Pi

You should have 3 loose female-female jumper wires in your bag (colors may vary). Connect them to the 3 pins on the electromagnet board: from the top down, they are SIG, GND, and 5V. Then, connect SIG to pin 28, GND to pin 6, and 5V to pin 4. See also below and Section 7 (Final Wiring).



Input wire name	Input wire color (color in image)	GPIO Pin (Channel)
Magnet Signal SIG	Varies (white in image)	28 (GPIO 1)
Magnet Ground GND	Varies (purple in image)	6 (Ground)
Magnet 5V Power	Varies (orange in image)	4 (5V Power)

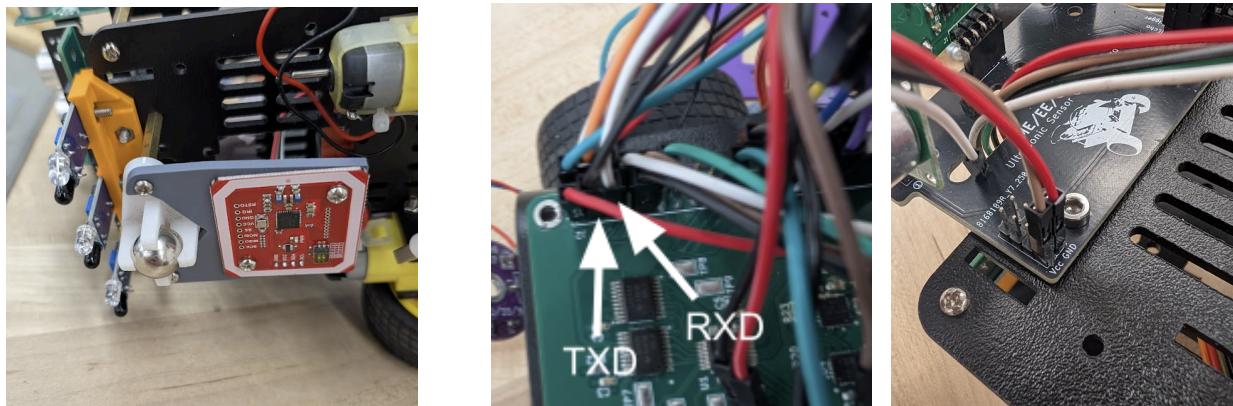
## 6. NFC Reader

### 6.a Mounting the NFC Reader

We'll be mounting the NFC reader onto your front bearing. First, we'll need the screws from your current bearing mount, so unscrew it and check that they are 6mm long (if not, grab 2 from the red basket on the back counter). Then, assemble the NFC reader mount using the screws and the two given nuts according to the pictures. For convenience, you can now plug in your 4 connected wires to the 4 pins - take note of which color enters each pin (GND, VCC, TXD=SDA, and RXD=SCL).



Now, reassemble the front bearing with the NFC reader underneath (otherwise, your robot will no longer be level!) You should have two long screws in your bag to use for this.

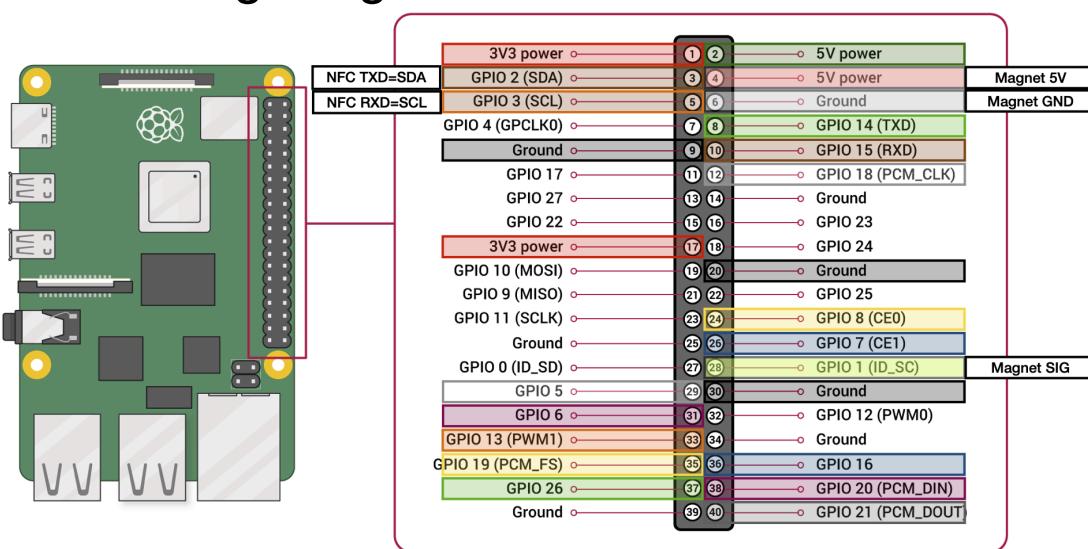


### 6.b Connecting to the Pi

We wire the signals to the Pi and grab Power/Ground from the ultrasound board: Connect the two wires from TXD=SDA and RXD=SCL to the Pi's pins 3 and 5, respectively. Then connect the VCC and GND wires to the corresponding columns on the left side of the ultrasonic board.

Input wire name	Input wire color (color in image)	GPIO Pin (Channel)
NFC TXD = SDA	Varies (black in image)	3 (GPIO 2 = SDA)
NFC RXD = SCL	Varies (white in image)	5 (GPIO 3 = SCL)
NFC VCC 3.3V	Varies (brown in image)	Ultrasound Board VCC
NFC GND	Varies (red in image)	Ultrasound Board GND

## 7. Final Wiring Diagram



Input wire name	Input wire color (color in image)	GPIO Pin (Channel)
Motor Controller 5V Power	Green	2 (5V Power)
Motor Controller 5V Ground	Black	30 (Ground)
Motor Controller Input 1	Color1 (blue)	26 (GPIO 7)
Motor Controller Input 2	Color2 (yellow)	24 (GPIO 8)
Motor Controller Input 3	Color3 (purple)	31 (GPIO 6)
Motor Controller Input 4	Color4 (white)	29 (GPIO 5)
IR Board Power (3.3V)	Red	1 (3V3 Power)
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Ultrasound Board Ground	Black	20 (Ground)
Ultrasonic 1 Trigger (Left)	Orange	33 (GPIO 13)
Ultrasonic 2 Trigger (Middle)	Yellow	35 (GPIO 19)
Ultrasonic 3 Trigger (Right)	Green	37 (GPIO 26)
Ultrasonic 1 Echo (Left)	Blue	36 (GPIO 16)
Ultrasonic 2 Echo (Middle)	Purple	38 (GPIO 20)
Ultrasonic 3 Echo (Right)	Gray (white-ish)	40 (GPIO 21)
Magnet Signal SIG	Varies (white in image)	28 (GPIO 1)
Magnet Ground GND	Varies (purple in image)	6 (Ground)
Magnet 5V Power	Varies (orange in image)	4 (5V Power)
NFC TXD = SDA	Varies (black in image)	3 (GPIO 2 = SDA)
NFC RXD = SCL	Varies (white in image)	5 (GPIO 3 = SCL)
NFC VCC 3.3V	Varies (brown in image)	Ultrasound Board VCC
NFC GND	Varies (red in image)	Ultrasound Board GND