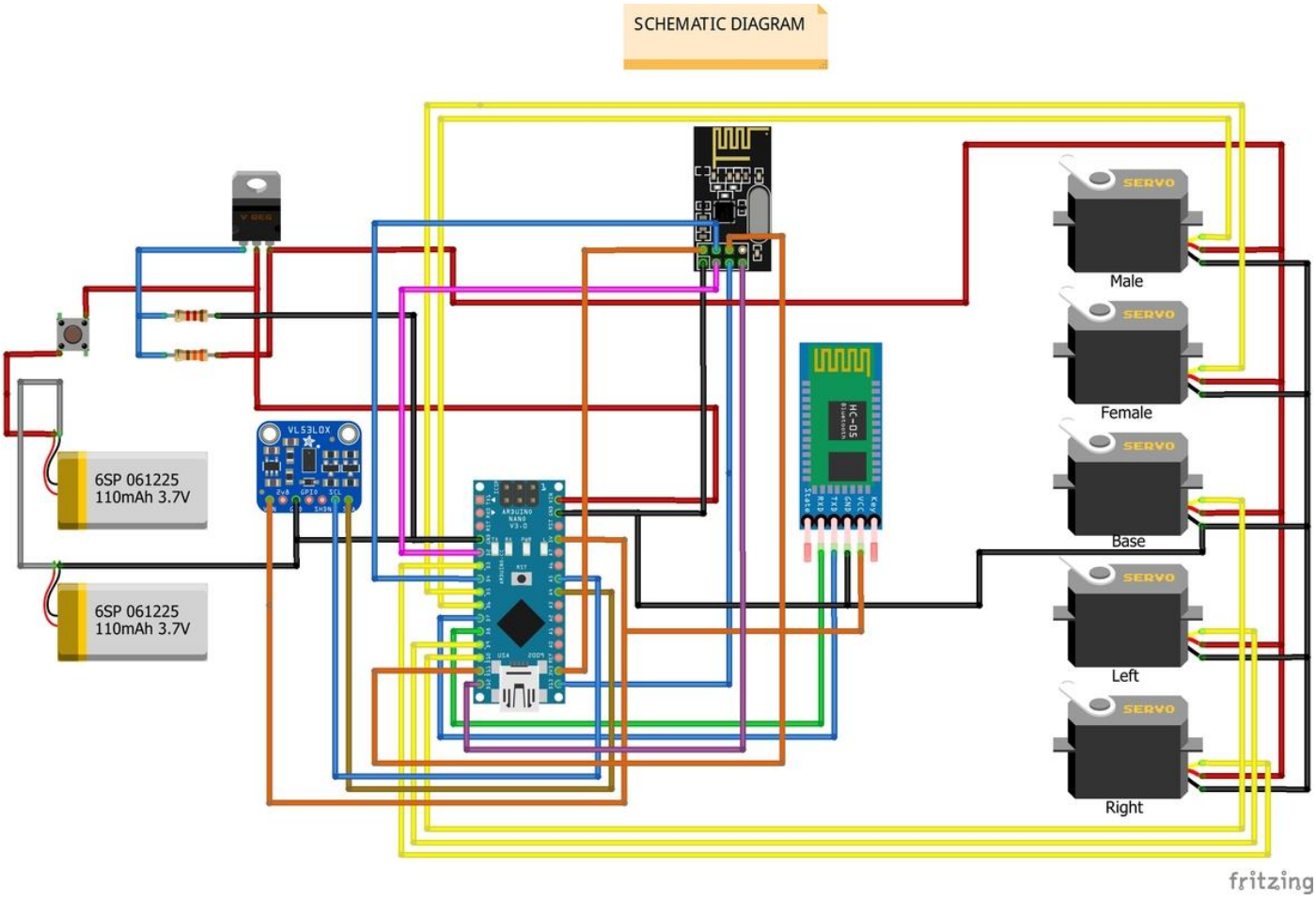
Assembly steps for Dtto v2 Module

Components required per module:

Quantity	Description
22	3D Printed Parts
1	Arduino Nano v3.0
1	HC-05 Bluetooth Module
1	NRF24L01+ Wireless Transceiver
24	Neodymium Disk Magnets (4x3mm)
2	TowerPro MG90S Servomotor (MG92B recommended)
3	TowerPro SG90 Servomotor
2	Li-Po Battery 3.7V 500mAh
1	LM317 Voltage Regulator
1	Latching Switch for power
40	M2x4mm countersunk screw
1	330 Ohms Resistor
1	1.2k Ohms Resistor
4	2.2k Ohms Resistor
3	Small Rubber Band

Final Schematic:



Step 1:

We need,

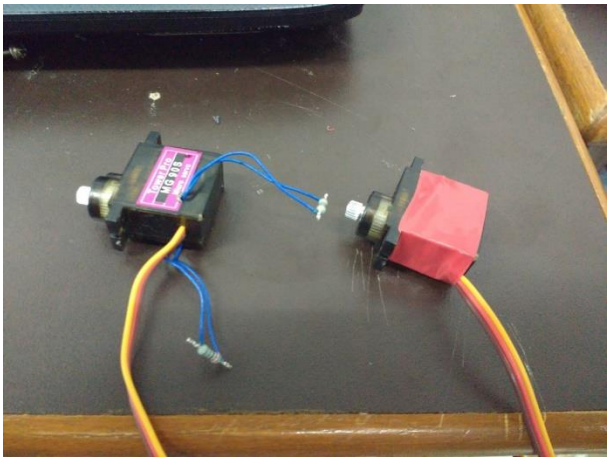
- 2 x Part 004-1

- 1 x Part 011-1

First of all, we have to ensure these 3 parts fit perfectly. It is very important that the 004-1 Parts rotate freely around the center. File them for any rough edges/surfaces. The smoother they are, the better the robot moves.

Step 2:

For modifying the servos, we used 2.2k ohm resistors at both the potentiometer ends as shown in this video. Also, we soldered thin 30 gauge wires inside the servo and brought it out to add resistors.



Directly adding the resistors inside was possible but involved a lot of hassle to fit it all back in the tiny case, so this was easier for us. After adding resistors, angles from 180 to 0 are between 140~130 to 22~28(vary slightly from motor to motor)

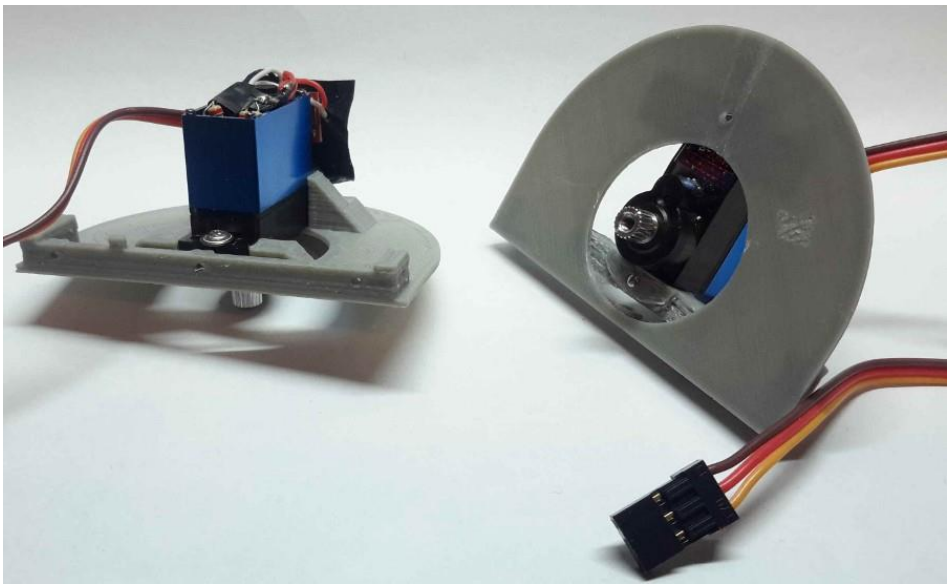
Step 3:

We need,

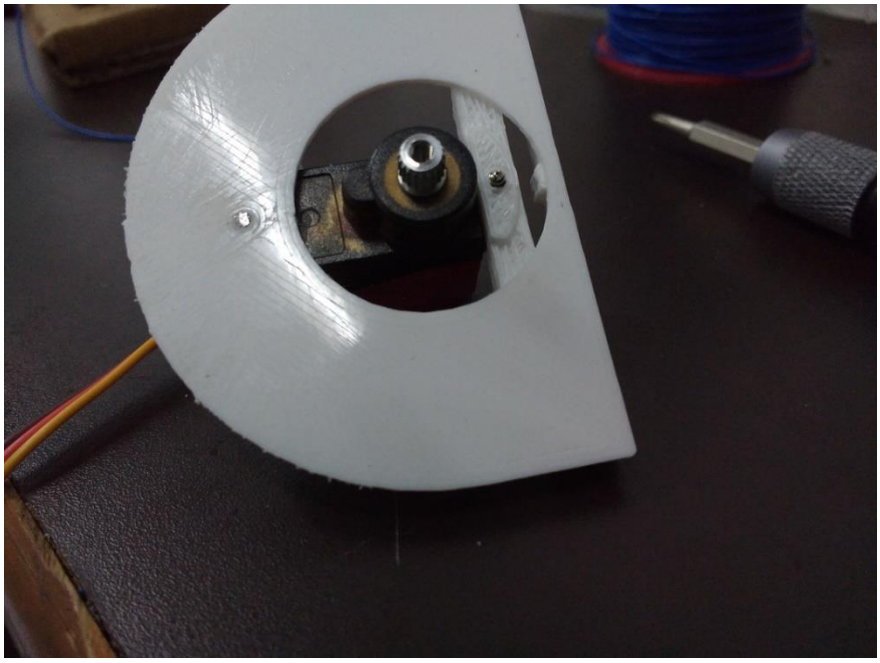
- 2 x Part 004-1

- 2 x MG92B Servomotors (step 3)

In this step we are going to fix the motors to the printed parts. The motor should fit correctly. We can use the screws that come with the motor, but we will have to cut them to the right length.



Upon screwing the servo to the hinge face, you will have to file the tip of the screw which comes out.



Step 4:

We need,

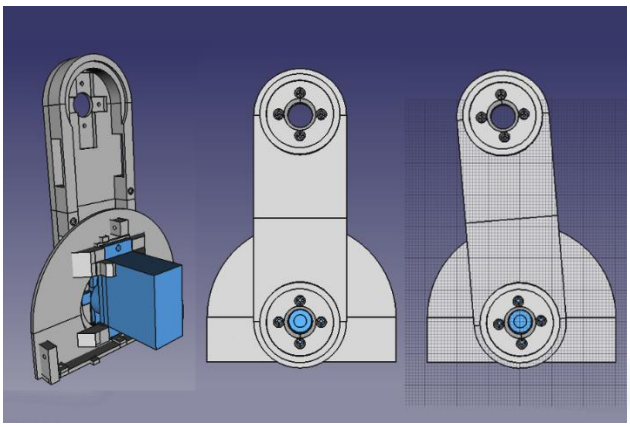
- 1 x Part 011-1

- 1 x Part 012-1

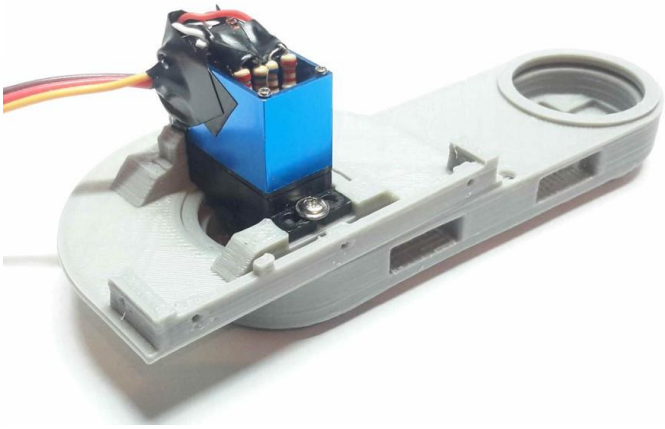
- 2 x Servo Arm (Cross)

Now we are going to fix the servo arms to the 3D printed part. This step is very important because we have to ensure that the servomotor is centered. If it is not centered, once assembled, the module motor won't be able to rotate all the way. The hinge must rotate from center to the sides at some angle in the range.

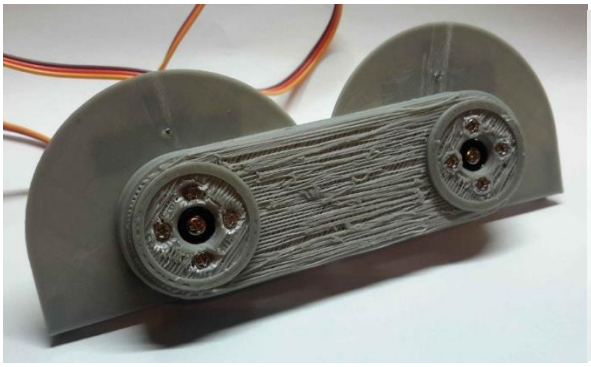
Once the servo worm is in a perfect position, it is helpful to use a hot soldering iron to just melt a tiny amount of servo worm with and into the hinge part so that it does not move when you screw the worm in.

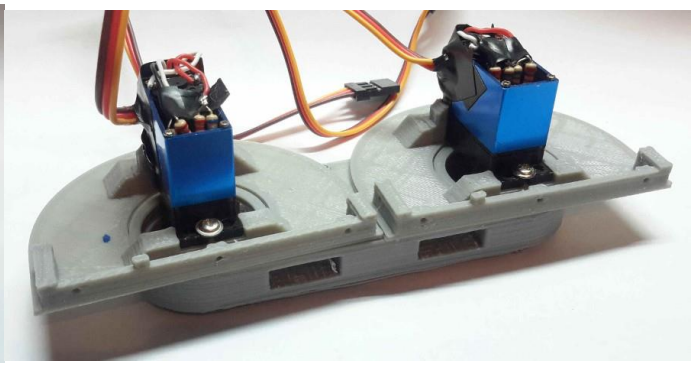


This is a critical part, so be sure to get a well centered configuration. Once we get a well centered part, we have to be completely sure that we got a correct configuration. Note down the center and side position angles somewhere as these would be entered later in the Dtto program.



Once we finish with one servomotor, we can proceed to fix the other one.





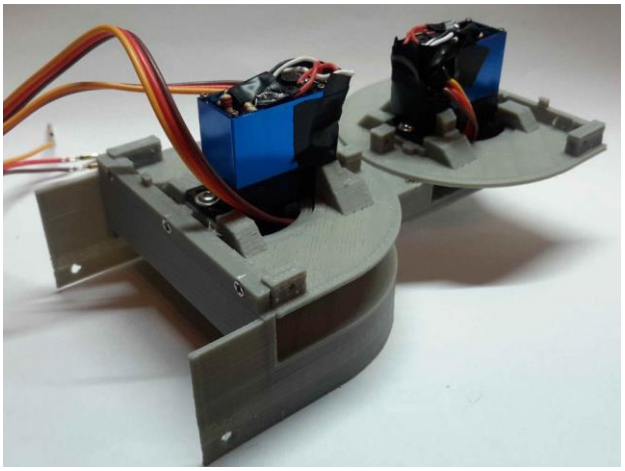
At this moment, the module does not have a male or female part assigned. We will choose one half and we will name it Male. The other will be the Female half. Then, we have to put the cables of the female motor through the hole in the central part, to the male part. You have to ensure that the cables allow a free rotation of the parts.

Step 5:

We need,

- 1 x Part 003-1

Now we will start to assembly the male half of the module. First of all we have to ensure that the hole in the part 003-1 fits with the previously assembled part 012-1. Once sanded, we can attach the part 003-1 to the part 004-1 using 3 screws.



Step 6:

We need,

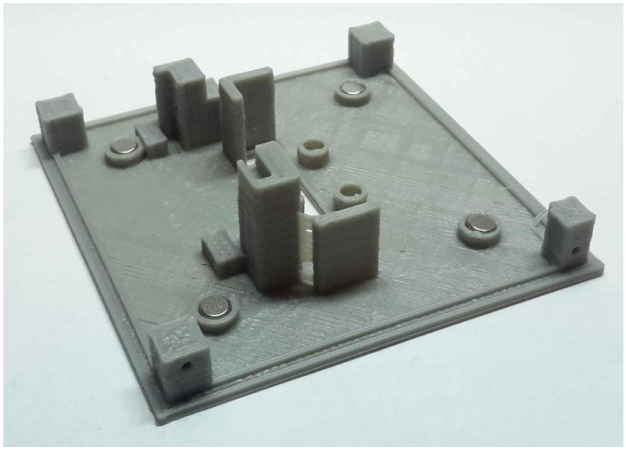
- 1 x Part 005-1

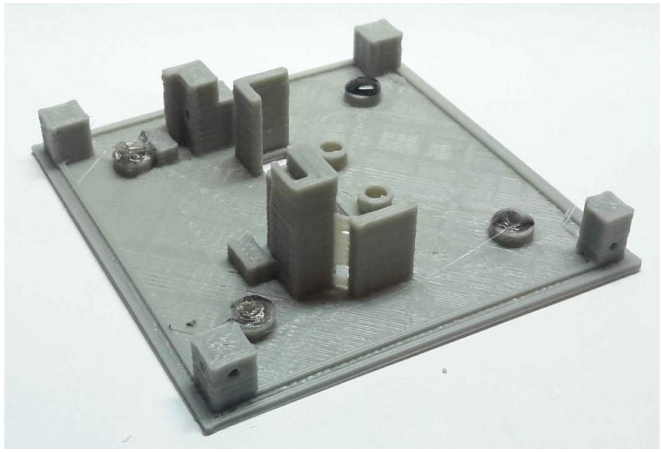
- 1 x Part 007-1

- 1 x Part 009-1

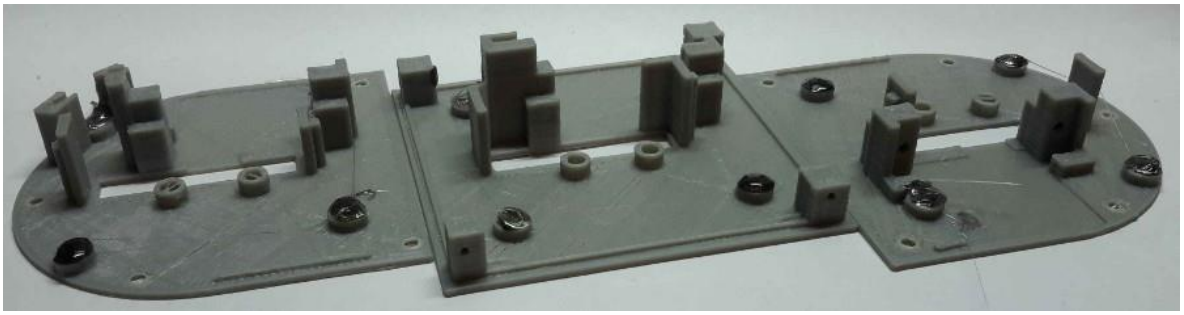
- 12 x Neodymium Magnets

In this step we will put the magnets on the male parts. It is very important to put all the magnets in the male part with the north pole facing the inside of the module. We put the magnets in the holes, and then we put a drop of glue sticking it to the part. For this procedure, we like to use hot melt glue.





We repeat the procedure for the 3 parts.



Step 7:

We need,

- 1 x Part 006-1

- 1 x Part 008-1

- 1 x Part 010-1

- 12 x Neodymium Magnets

As we did in the previous step, we will put the magnets in the female parts. Now, remember to put all magnets with the north pole facing the outside of the module. If we do this correctly, the male parts won't stick between them, but a male and a female part will be magnetically attracted.

Step 8:

We need,

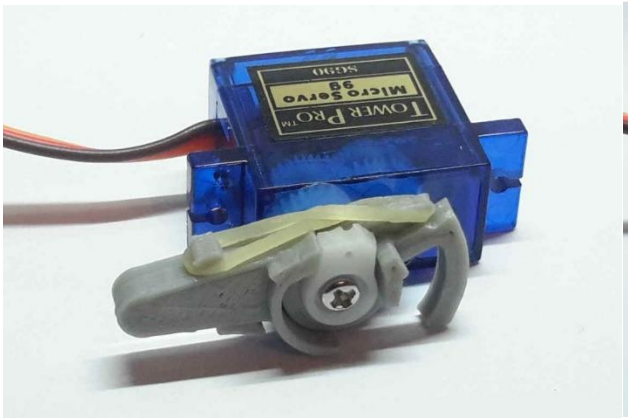
- 3 x SG90 Servomotors

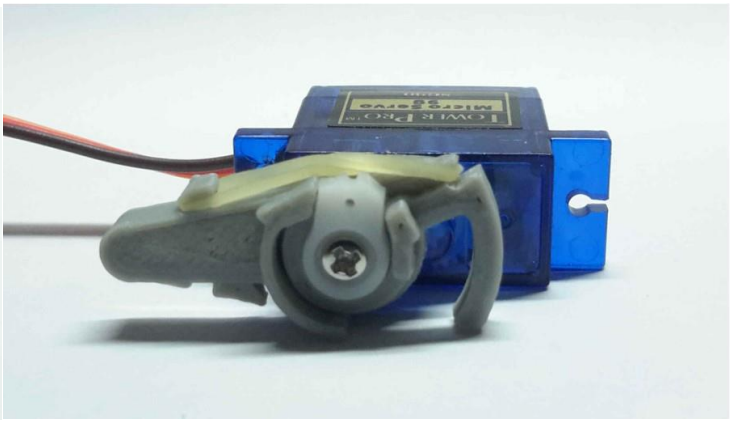
- 3 x Part 013-1

- 3 x Part 014-1

- 3 x Small Rubber Band

In this step we will prepare the coupling mechanism that holds the modules of the robot together. We first insert the servo arm (cut as in the pic) through the two printed parts. We have to ensure that these parts rotate freely around the servo arm. We put the servo in the 90º position (servo.write(90)), and then we screw the parts like in the picture, using the screw that came with the servo. Finally, we put the rubber band between the two parts.





We repeat the procedure with the 2 SG90 servomotors left.

Step 9:

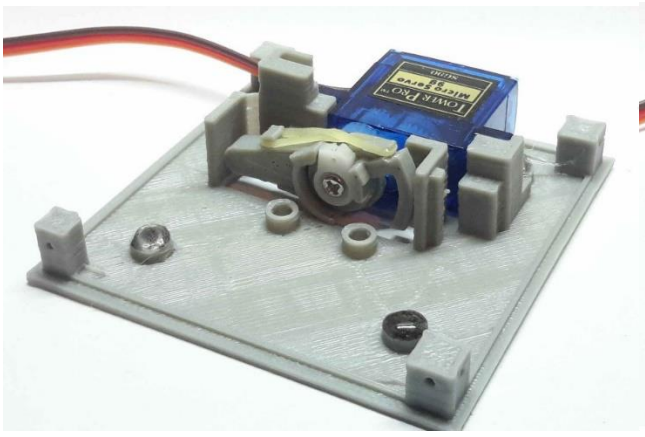
We need,

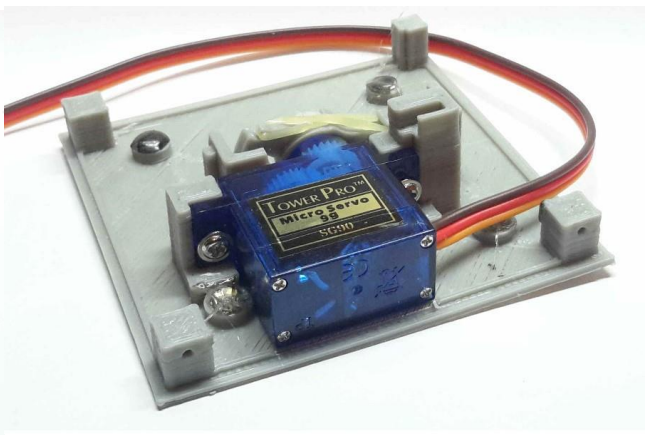
- 1 x Part 005-1 (step 7)

- 1 x Part 007-1 (step 7)

- 1 x Part 009-1 (step 7)

In this step we will fix the servos that form the coupling mechanism to the printed parts. First we will insert the servo in the correct position. Then, using the 2 screws that came with the servo, we will fix it to the part.





We will repeat the procedure for the 2 parts left.

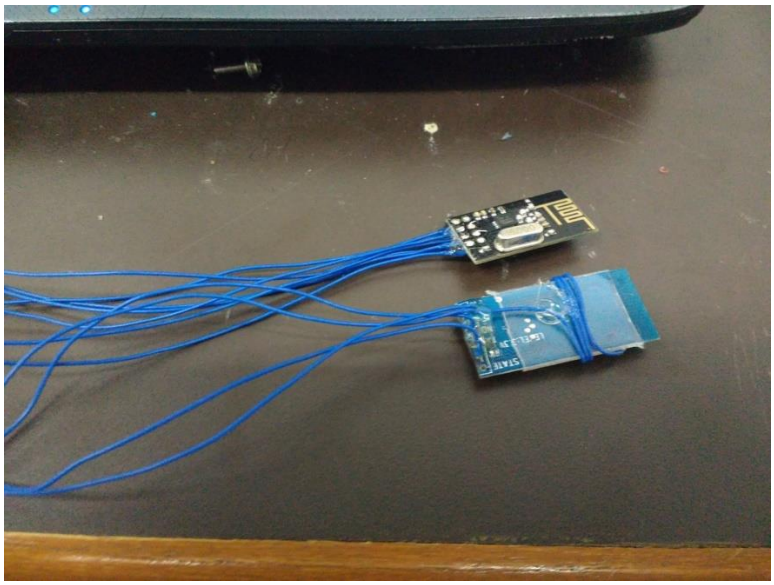
Step 10:

We need,

1 x HC-05 Bluetooth module

1 x NRF24L01 radio module

In this step we will prepare the Bluetooth and the radio module. We will have to remove the pin headers to solder wire directly, thus reducing the total volume of the modules. We used the thin 30 gauge insulated wires used for the servo modification again for wiring the HC-05 and nRF24 modules. It's thin and fits and bends easily inside the tightly packed modules.

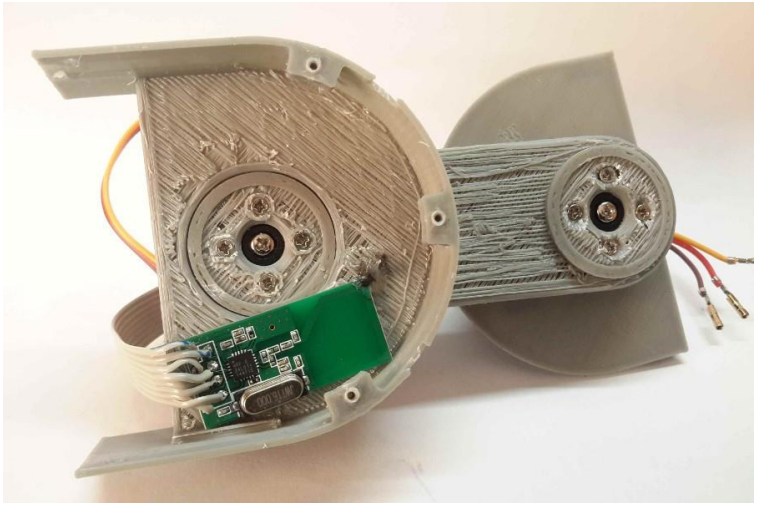


Step 11:

We need,

- 1 x NRF24L02 radio module (step 11)

Now we are going to stick the radio module to its final position. Due to the lack of space and the need to reduce weight, we decided to simple stick the module with some hot melt glue. We have to be sure that the module doesn’t make contact with the moving part in the center. The cables go to the other side of the module.

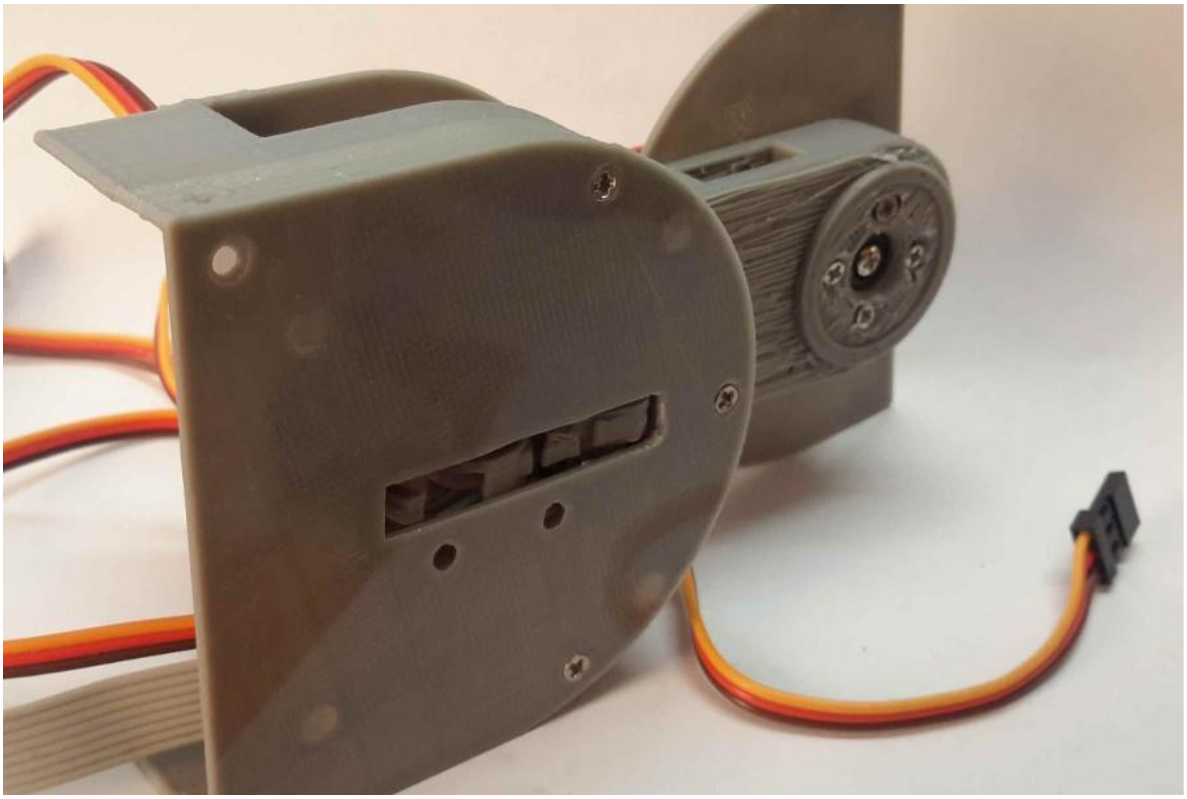


Step 12:

We need,

- 1 x Part 009-1 (step 10)

Using 3 screws, we mount the motor-equipped part 009-1 to the body of the module. Ensure that the servo cables don’t contact the coupling mechanism.

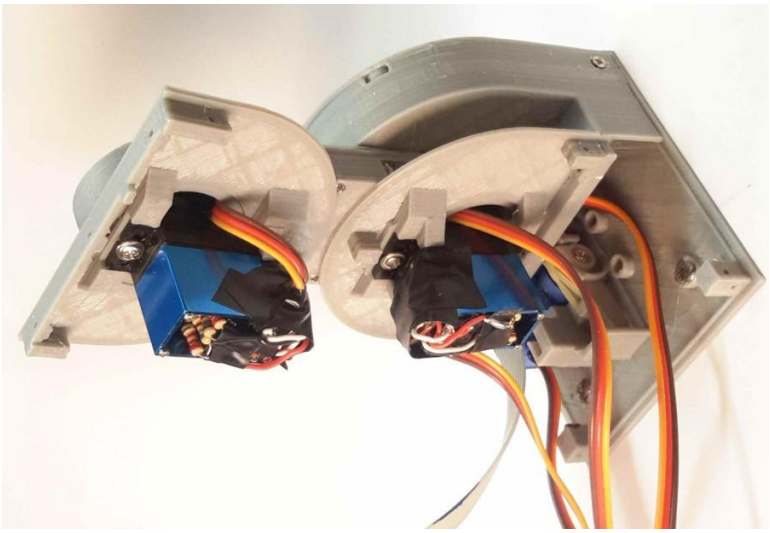


Step 14:

We need,

- 1 x Part 005-1 (step 10)

In this step we will mount the “base” of the robot, the part 005-1, with the previously mounted motor. We need 4 screws for this step.



Step 15:

We need,

- 1 x LM317 Voltage Regulator

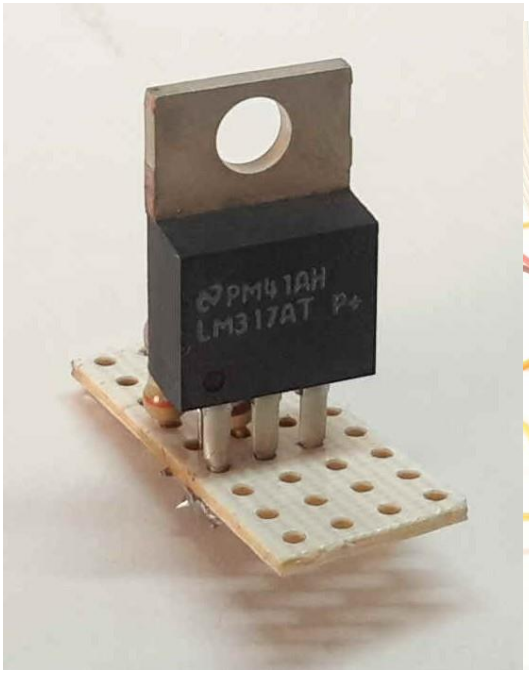
- 1 x 1200 Ohm Resistor

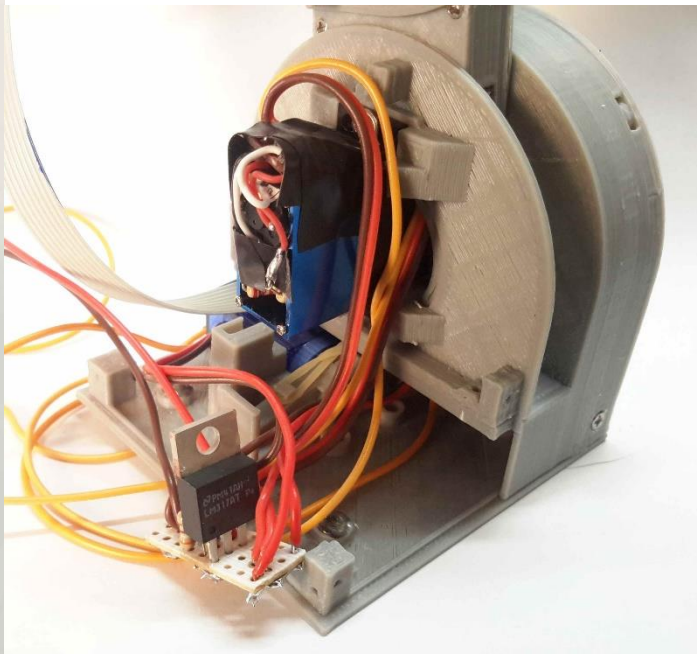
- 1 x 330 Ohm Resistor

Now we will configure our voltage regulator. Since we basically need the regulator for powering the servomotors, and since they can operate between 5 and 6 volts, we will set the regulator to the closer to 6 volts we can. We can use any other voltage regulator we want, considering the minimum current needs.

The LM317 Voltage regulator allows us to adjust the output voltage using some resistors. You can find the details and the math in its datasheet, widely available. Refer to the datasheet to be sure of the connections. The resistors that we choose were 330 and 1200 Ohms, resulting 5.8 volts. We can also use 100 and 390 Ohms, resulting in 6.1 volts. Check the schematics.

We need to power 5 servomotors with the output voltage from the regulator, so we need a small board to solder up the regulator, the resistors and the cables. The dimensions of the board shouldn't exceed 1*2.2cm, and it should fit in the module as in the next pictures.

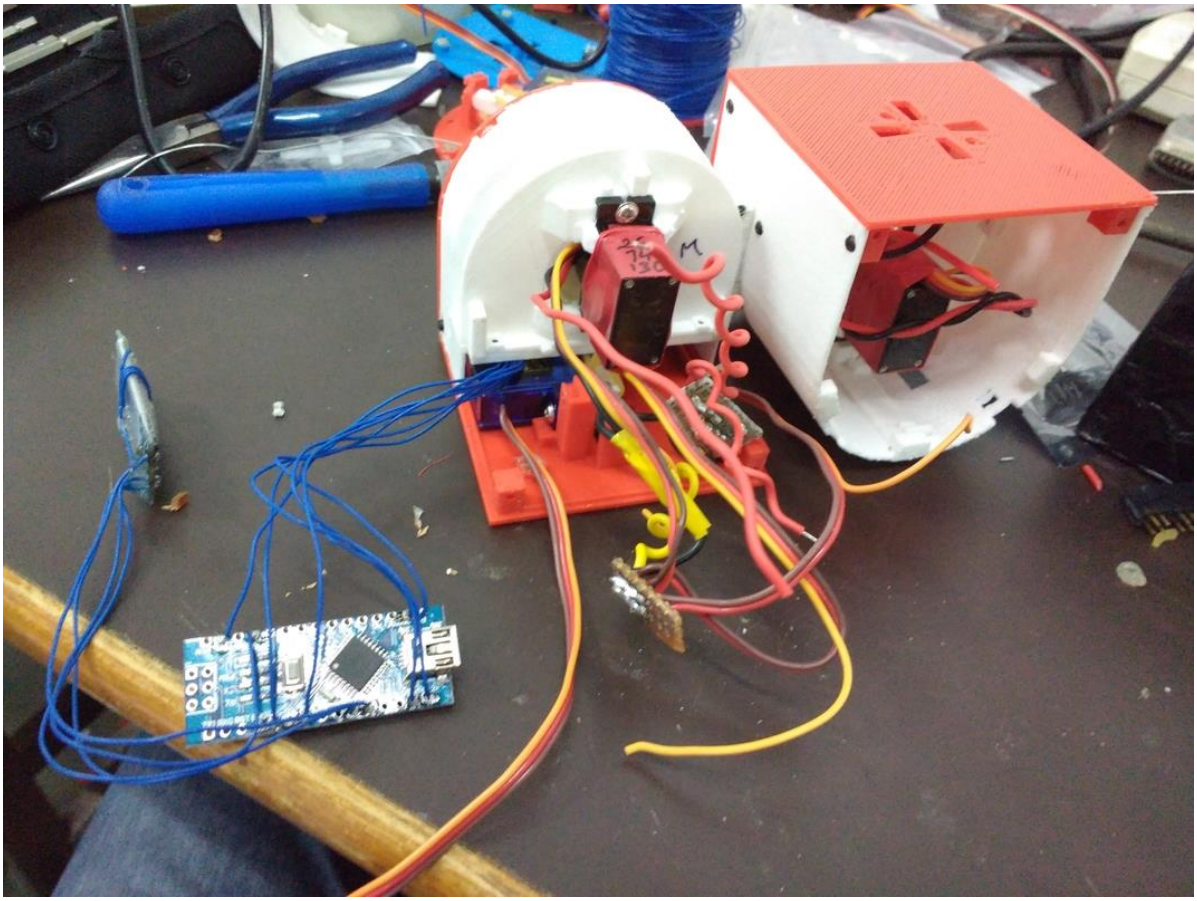




If we check the schematics of the module, we can see that we can use the board to connect the cables that come from the batteries (switch), and the ones that connect to the Arduino.

Step 16:

Next, attach the female faces and base to the female half and leave one side open. Also solder the Radio and Bluetooth modules to the Arduino (Refer Schematics).

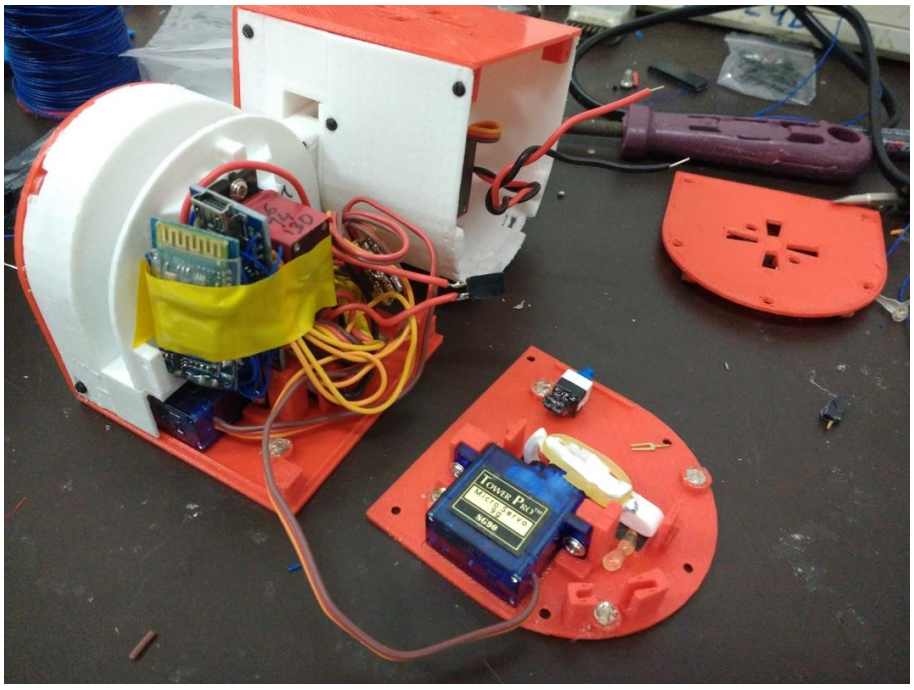


Use soldered connections or proper connectors everywhere, do not use breadboard jumpers! They are notorious for causing issues. Also, all the servo VCC and GND pins were put together using perf board.

Step 17:

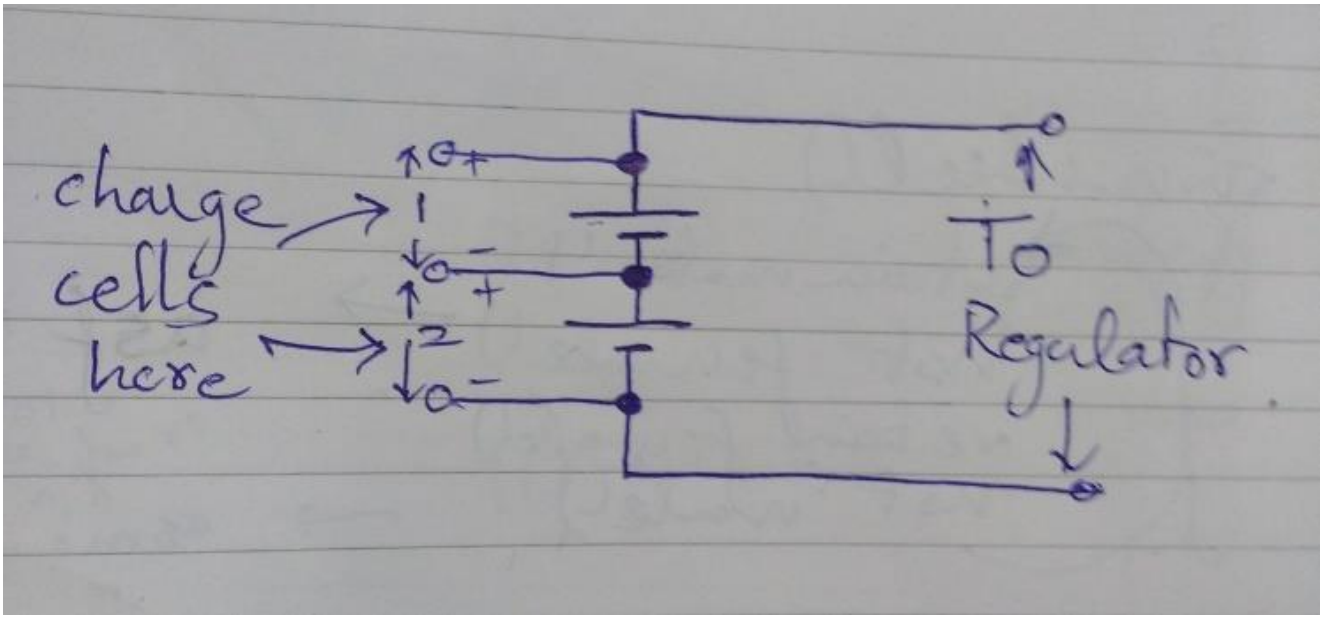
Attach the power switch to the male face just beside the magnet as shown. Make sure that the switch doesn't come outside the face.

The power switch wasn't soldered directly but connected using a pair of male and female header pins. This enables the bot to be easily disassembled.

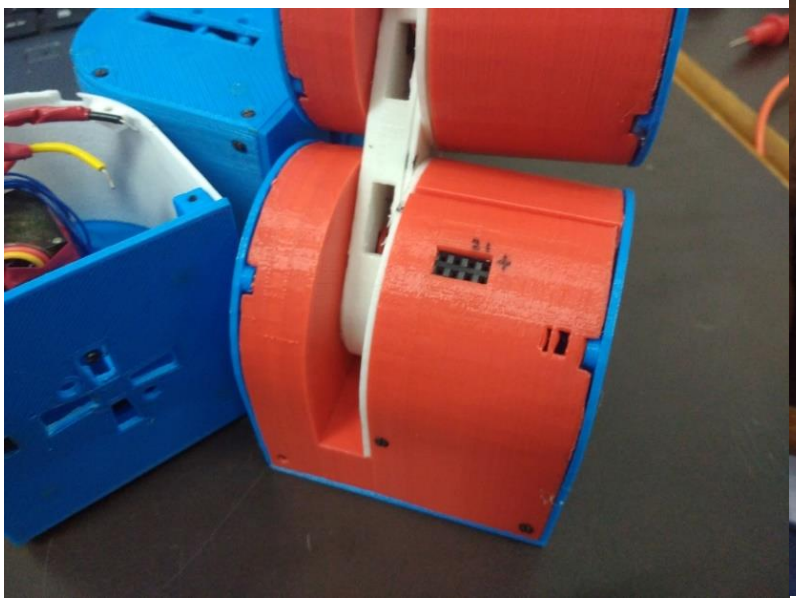


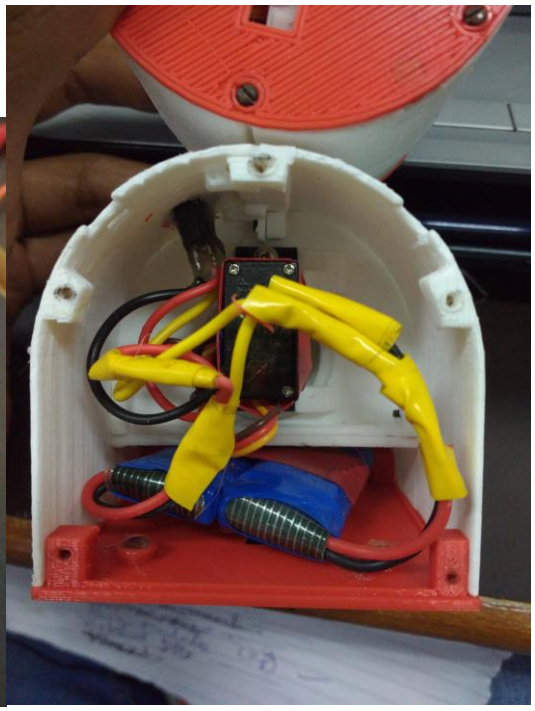
Step 18:

This is the internal circuitry for the female half:

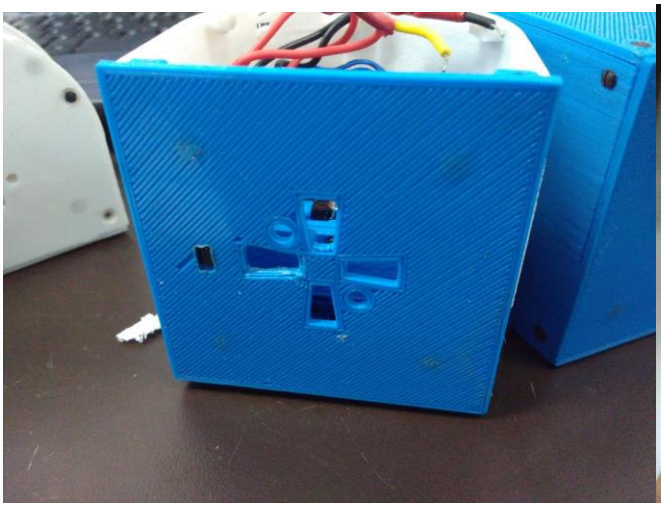


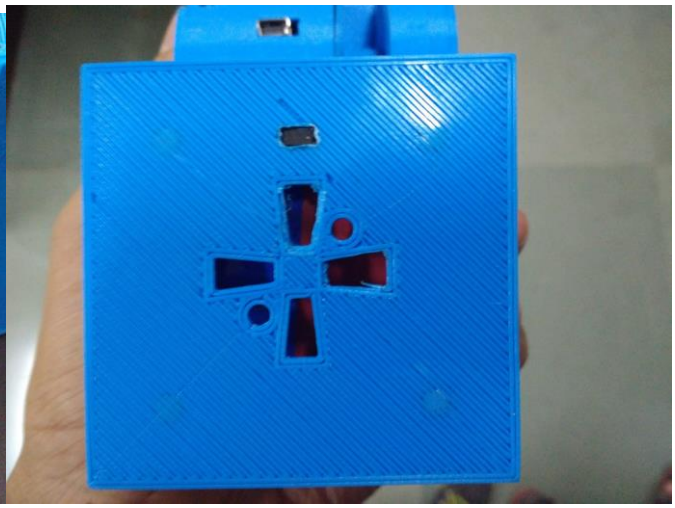
For charging of the batteries externally, we brought out the battery terminals externally at the female part using double rowed female headers, and add the covers part-001 and part-002.



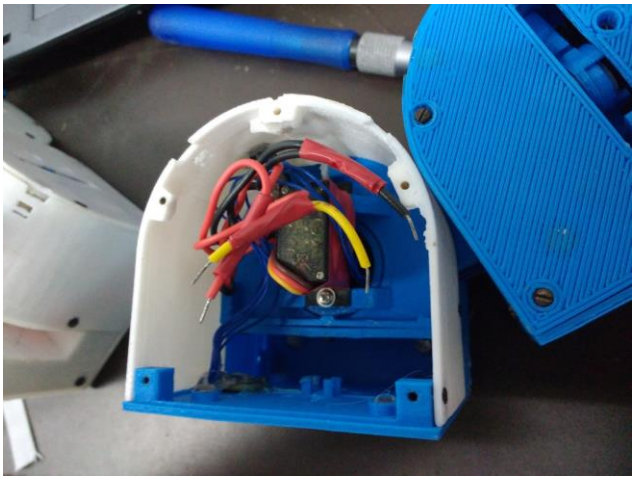


Step 19:



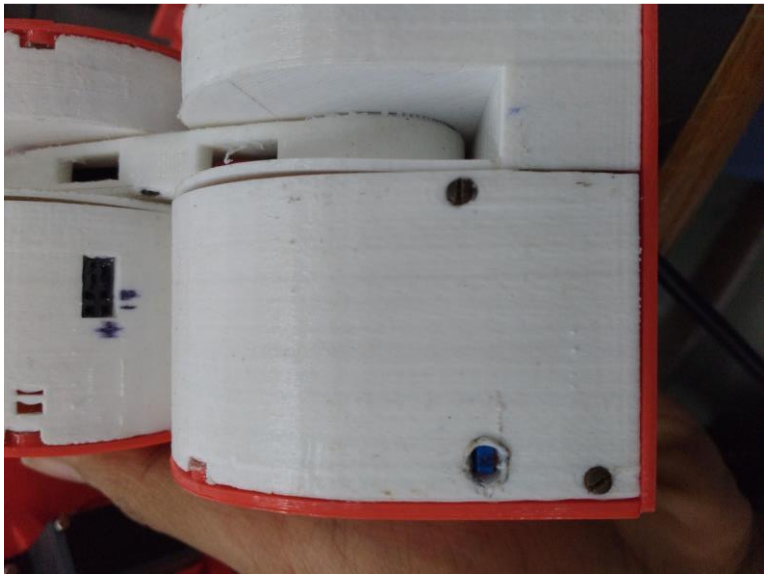


The VL53L0X Tof sensor is added to the female base face. Just cut a rectangular notch about the size of the sensor and hot glue it in place. Send the VCC, GND, SDA and SCL wires through the hinge to the other side and solder it to the Arduino Nano.



Step 20:

Lastly, close off the male part of the module and using a soldering iron/drill, make a hole for the power switch carefully at the right position.



That's it!