GRITSBot X
Construction Guide

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Contents

1 Introduction

The GRTISBot X is an inexpensive, differential drive robot developed by the Georgia Robotics and Intelligent Systems Laboratory (GRITS Lab) in the Fall of 2018. It was originally designed for general multi-agent robot applications on the Robotarium [1, 2] to replace the GRITSBot [3]. The GRITSBot X is a small, versatile robot that can be deployed alone or in groups for hobby use, educational purposes, or research applications. The robot itself is almost entirely constructed of off the shelf components with a custom laser cut acrylic chassis and printed circuit board (PCB) being the only exception. The files to create these custom components (or have them fabricated externally) are found in the Github repository NEED CITATION WHEN MADE. A completed GRITSBot X can be seen in Figure 1.

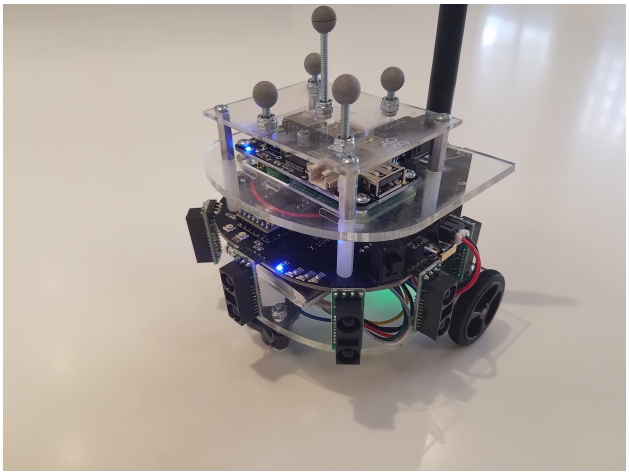

Figure 1: The completely assembled GRITSBot X with pearl tracking markers.

This document is meant as a step by step guide to construct a GRITSBot X with detailed photos and descriptions of required parts. The sections below will be broken into a short list of assembly steps with more detailed instructions on each step in the subsequent subsections. The details of each

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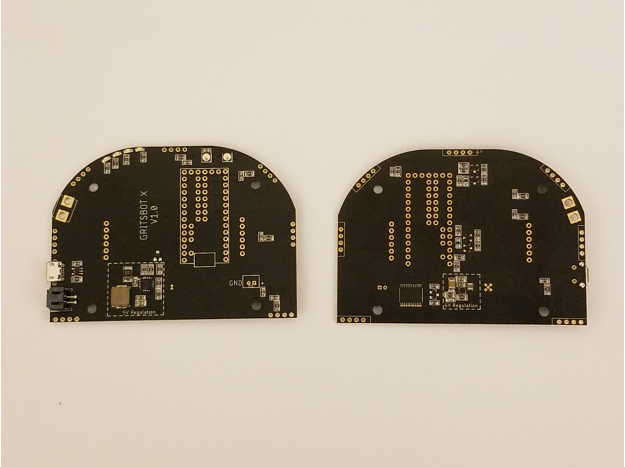


Figure 2: The main circuit board of the GRITSBot X after fabrication and partial assembly. This is the assumed starting point for PCB assembly.

step are also linked if you are viewing the PDF on a computer. If this is your first build of the GRITSBot X, it is highly recommended that the detailed sections are read in full. The members of the GRITS Lab are glad you have chosen to take the time to build this robot. If you have any questions feel free to reach out to the contact at the top of this guide.

2 Printed Circuit Board Assembly

An eagle file has been provided on the github for the main printed circuit board (PCB) of the GRITBot X. This guide assumes that the board has been sent out for fabrication and assembly. This means the external company that fabricated the board has also placed the surface mount components as seen in Figure 2. You can have this done at a variety of vendors, we have used Circuithub [4] and Advanced Circuits [5] in the past. The rest of this section will consider the through hole components that have yet to be placed.

Assembly of Piggyback Boards

A piggyback board is essentially a PCB that connects to another PCB. The GRITSBot X leverages two of these pre-made boards, the Teensy 3.2 microcontroller [6] and the Pololu Carrier with Sharp GP2Y0A60SZLF Ana-

log Distance Sensor [7]. The Teesny 3.2 is a microcontroller that handles the low level actuator control and sensor acquisition of the GRITSBot X. The Pololu Sharp IR distance carrier enables the easy use of the GP2Y0A60SZLF range sensor.

2.1 Teensy 3.2

2.1.1 Assembly Steps

1. Gather the required materials (Section 2.1.2).
2. Solder the first set of male breakaway headers to the board leaving the left side unpopulated (Section 2.1.3).
3. Mount and solder the surface mount header pins to the underside of the Teensy (Section 2.1.4).
4. Finish soldering the header pins to the Teensy by populating the left side (Section 2.1.5).

2.1.2 Required Materials

First, gather the required materials. The Teensy 3.2 microcontroller from PJRC, Figure 3, should come with the board and a 1×36 male breakaway header pin. If your Teensy did not come with male breakaway header pins, they are extremely inexpensive and can be purcased at a variety of locations.

First, break the 1×36 breakaway header into smaller sections as described in Table 1. You may notice the number of male headers here totals 37 not the 36 provided with the board. You may either find a spare (recommended) or not populate the VUSB through hole.

Number Required	Breakaway Dimension
2	1×14
1	1×5
1	1×3
1	1×1

Table 1: The dimensions of the male breakaway headers needed to assemble the Teensy 3.2 microcontroller.

We also require the surface mount pins available on the underside of the Teensy 3.2 as seen in the right side of Figure 3. This requires a 14 position

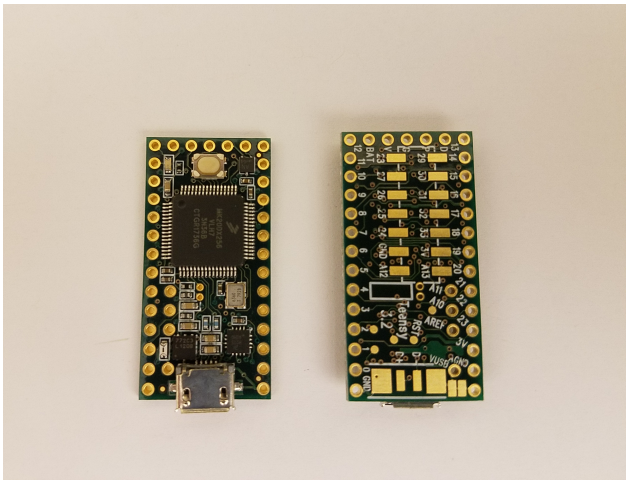


Figure 3: The Teensy 3.2 microcontroller top (**left**) and bottom (**right**) view.

surface mount header and broken perforated board pictured in the bottom of Figure 4. Now that we have all the parts we can begin soldering this board together.

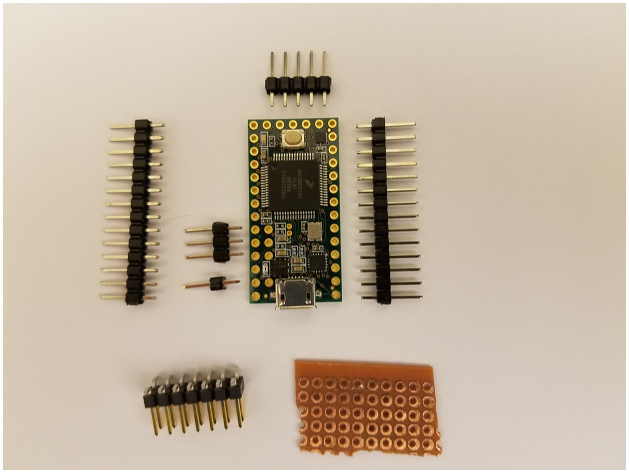
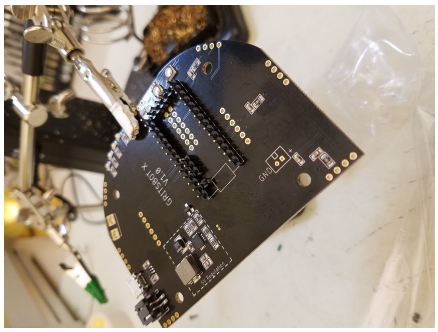


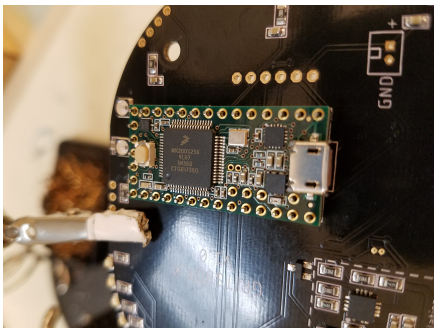
Figure 4: The parts needed to solder header pins to the Teensy 3.2 microcontroller.

2.1.3 Creating Perpendicular Solder Points and the First Solder Pass

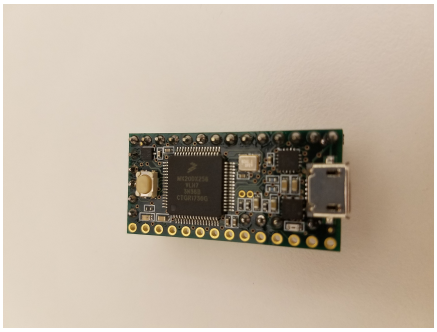
Using the main PCB as a guide, slide all the male breakaway headers (excluding the surface mount ones) into the PCB (Figure 5a) and place the Teensy 3.2 on top (Figure 5b) as shown in Figure 5. **Before soldering**, observe the proximity of the header pads to the main processor chip (big black square) connections. When soldering be very carful not to accidentally solder or bridge these connections. It is best to keep the iron and solder being applied on the outside perimeter of the board. At this point solder all of the header pins on the Teensy **except** the left side headers as seen in Figure 5c. It is extremely important that the left side header pins be left unpopulated for now so there is enough room for the soldering iron to attach the surface mount headers in the next step.



(a)



(b)



(c)

Figure 5: Creating perpendicular solder points for the Teensy 3.2 using the GRITSBot X main PCB.

2.1.4 Soldering the Surface Mount Headers

Now that the majority of the male headers have been soldered in place, we must now attach the surface mount headers. A major challenge here is mounting them so they align with the rest of the headers or the Teensy will not be able to fit into the main PCB of the GRITSBot X. To do this we will use the broken piece of perforated board, the 14 position surface mount header pins, and the Teensy that has been soldered so far (seen in Figure 6).

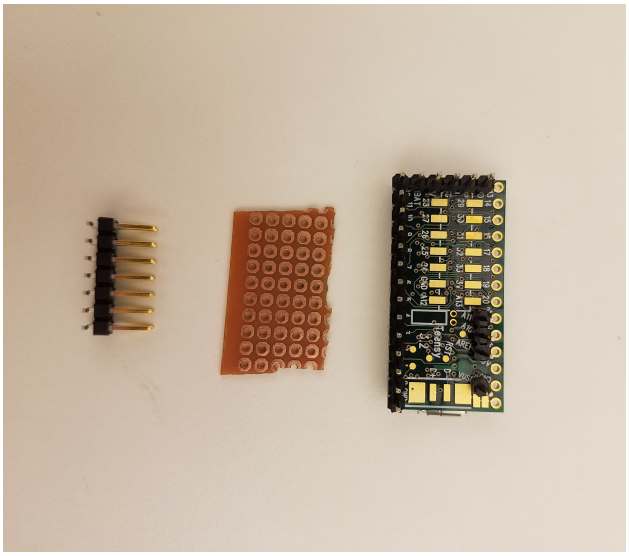
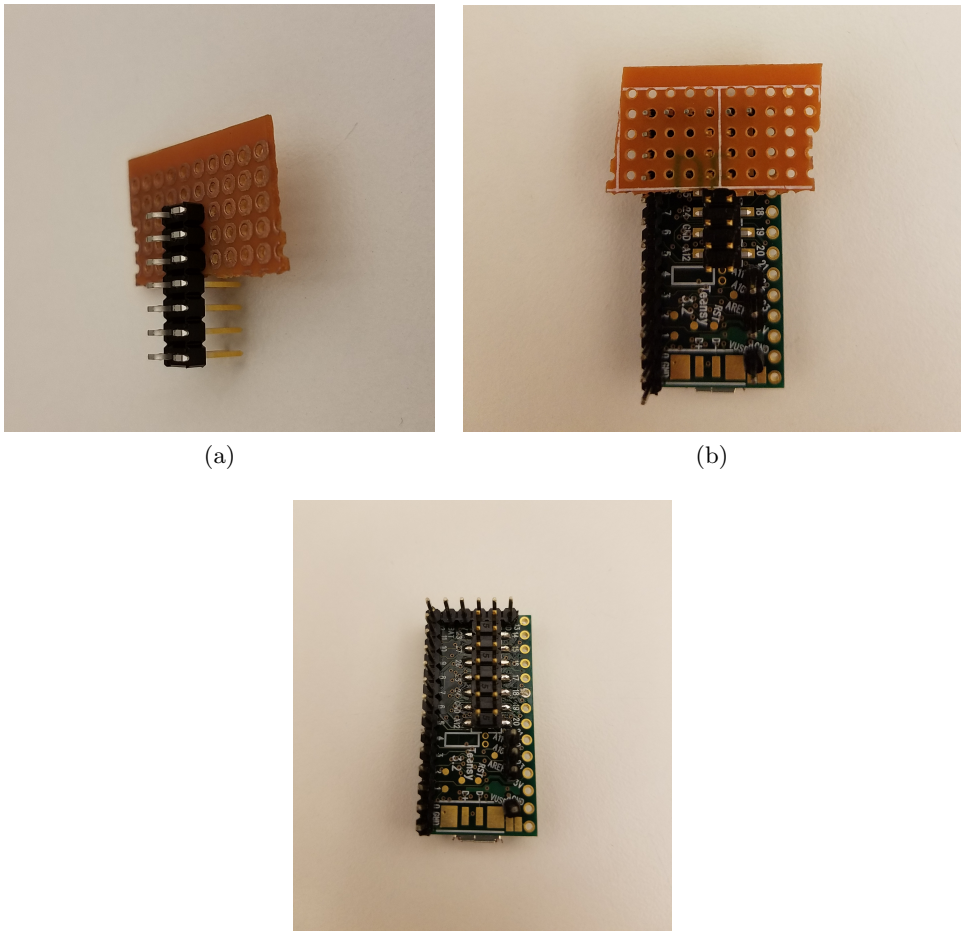


Figure 6: The 14 position surface mount header, perforated board, and Teensy required to make the underside pins of the Teensy accessible.

Insert the surface mount header pins into the broken perforated board leaving at least 6 pins exposed as seen in Figure 7a. Note, in this picture 8 pins are left exposed. Inset the Teensy into the same perforated board such that the surface pads of the Teensy are aligned with the surface mount header pins as seen in Figure 7b. Make sure the surface mount headers are pressed into the Teensy pads and solder the first few pad, header connections into place with the perforated board keeping them aligned. After the solder cools, remove the perforated board and solder the rest of the connections. Upon completion your board should resemble that in Figure 7c.



(a) (b)

(c)

Figure 7: Aligning and soldering the surface mount headers for the Teensy.

2.1.5 Finishing Soldering the Teensy

To finish the Teensy, insert it back into the main GRITSBot X PCB as a guide and solder the remaining male header pins on the left side of the board. **Again, before soldering**, observe the proximity of the header pads to the main processor chip (big black square) connections. When soldering be very careful not to accidentally solder or bridge these connections. It is best to keep the iron and solder being applied on the outside perimeter of the boards. After making the final solder connection, you're done! The top

and bottom of the finished Teensy should look like Figure 8. The Teensy microcontroller is ready to be permanently attached to the main PCB of the GRITSBot X. Check it for bridged connections or poor solder joints. For now, take the Teensy out of the main PCB of the GRITSBot and set it aside to be attached later.

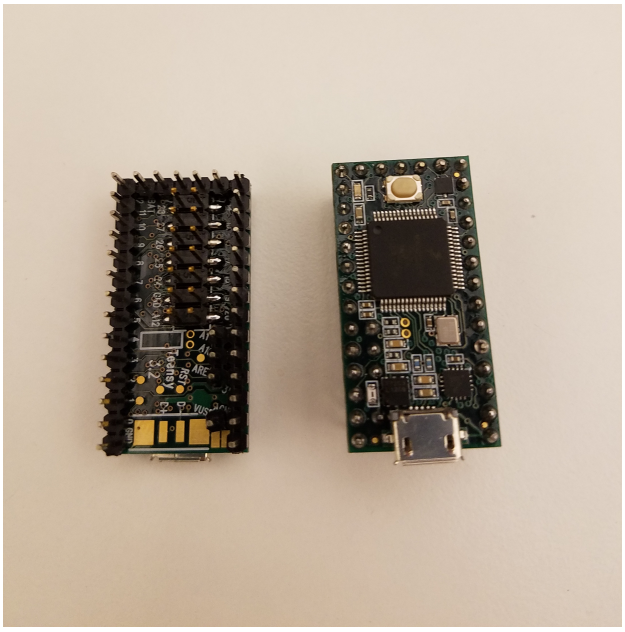


Figure 8: The Teensy with headers attached.

2.2 Pololu Carrier with Sharp GP2Y0A60SZLF Analog Distance Sensor

2.2.1 Assembly Steps

1. Gather the required materials (Section 2.2.2).
2. Cut the IR sensor down to size (Section 2.2.3).
3. Solder the right angle male header pins (Section 2.2.4).

2.2.2 Required Materials

Pololu provides the sensor attached to a custom PCB, male breakaway header pins, and right angle breakaway male header pins as seen in Fig-

ure 9. Only the sensor and right angle breakaway male header pins are needed for this. This means the normal breakaway header pins may be used for other projects (or for populating the VUSB pin on the Teensy).

The GRITSBot X uses seven of these sensors so we require seven of these kits and soldering described below will have to be performed on each of the sensors.

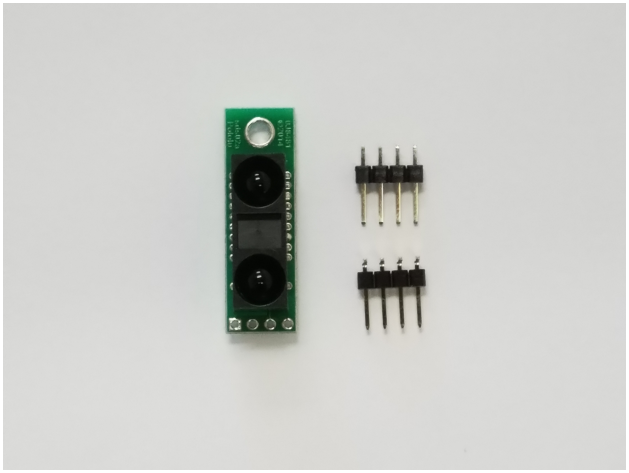


Figure 9: The materials required to assemble the Sharp infra-red piggyback board.

2.2.3 Cutting the Pololu Carrying Board

The Pololu carrying board, that supports the Sharp IR sensor used on the robot, comes with a screw mounting hole that we do not use for this robot. In order to keep the robot's center of gravity low, we must cut the excess PCB used for a screw mount. The aim is to make a flat cut right below the plastic black sensor casing where the screw hole is. There are a few ways to do this. This guide will discuss three options with their drawbacks,

- Use a pair of scizzors to cut the boards. This is the most time efficient and safe way to do this. The drawback is that it can be hard on your hands so wear gloves or take breaks between large amounts of cuts (if you are mass producing).
- Use a box cutter to slice at each side and then snap the board along the weakened line. This is agin relatively safe but you have a higher chance of cutting yourself. This method is also rather time consuming.

- Use a dremel or other machine cutter to cut the board. This method works but is not recommended unless the above two fail. NOTE: this will create dust that is possibly hazardous so wear breath protection. You should also place the sensor into a vice or some other type of holder. Do not hold it in your hand as the dremel will most likely catch and you can BADLY hurt yourself.

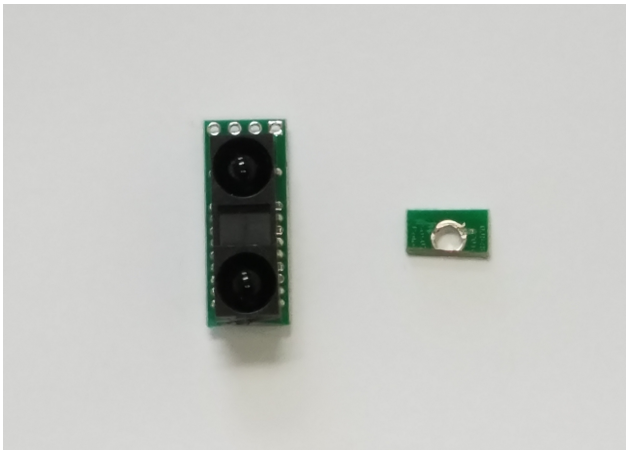


Figure 10: The Sharp IR sensor after being cut to size.

After cutting the sensor the sensor should look simlar to the one pictured in Figure 10.

2.2.4 Soldering the Header Pins

Soldering the right angle breakaway header pins to this boards is relatively straight forward. However, it is important to make these solder joints as perpendicular to the board as possible. To do this, first insert the long straight section of the breakaway header through the back of the board such that the right angle pins are on the opposite side of the sensor (seen in Figure 11a). Solder one pin connection. Lay the sensor face down and heat that connection while pushing the pins you are not heating (so you don't burn yourself) stright into the board such that they become perpendicular with the board. **Careful** not to leave the heat on this pin too long or you will melt the plastic holding it and cause misalignment of the right angle pins. If this happens the IR sensor cannot be inserted into the GRITSBot X's main PCB.

After aligning the pins properly using the single solder point. Solder the rest of the pins and cut the excess with a wire cutter. The resulting sensor should look like Figure 11b.

(a) (b)

Figure 11: Sharp infra-red distance sensor with headers properly attached.

2.3 Populating the GRITSBot X Main PCB

2.3.1 Assembly Steps

1. Gather the required materials (Section 2.3.2).
2. Solder the Teensy microcontroller, JST PH 2-Pin male header, and power switch (Section 2.3.3).
3. Solder the motor jumper cables (Section 2.3.4).
4. Solder the IR sensors (Section 2.3.5).

2.3.2 Required Materials

All of the parts should now be ready to populate the main PCB of the GRITSBot X. To start we will add the Teensy 3.2, JST PH 2-Pin male header (power jumper for the Raspberry Pi), and main power switch. The materials you will need are pictured in Figure 12.

2.3.3 Soldering the Top Through Hole Components

To start, first solder the Teensy into the main board (into the only spot where it fits). Make sure the Teensy is parallel with the main PCB of the

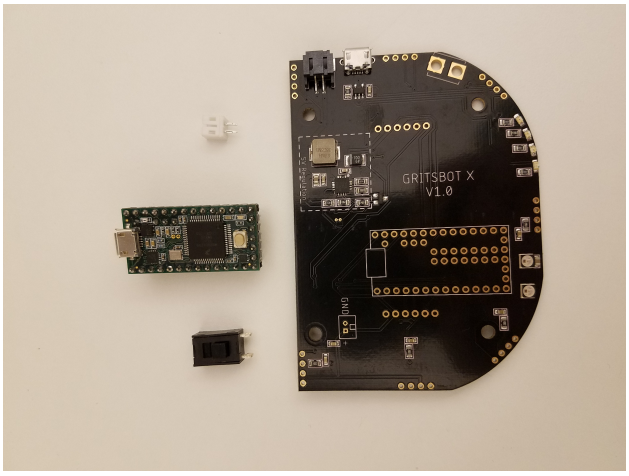


Figure 12: The materials for the first solder pass of the main PCB of the GRITSBot X.

GRITSBot X. To do this, lightly press the main chip of the Teensy into the main PCB. If this is not done, the connecting USB wire between the Teensy and Raspberry Pi (that will be added later) will not fit.

Next, place the ST PH 2-Pin male header (power jumper for the Raspberry Pi). It should be placed to the lower right of Teensy. The three openings on the side (meant for latching the female wire) should be facing the flat side of the board. You may have to press relatively hard as the tolerance of the drill for the main PCB may not be wide enough.

Finally, place the switch into the board (in the large holes to the left of the Teensy. Make sure the switch is facing the outside of the board and apply a large amount of solder. After finishing this, your board is ready to go minus the motors. Make sure all your solder connections are good and there are no cold joints or insufficient wetting. Figure 13 shows the top and bottom view of a completed board.

2.3.4 Soldering the Motor and Encoder Leads

The next parts to solder are the motor leads. This guide assumes you have purchased the micro metal gear motors with encoders attached from DFRobot. The row of six through holes correspond to the encoder attachments found on the DFRobot micro-metal gear motor. However, these pins are typically found in all quadrature shaft-encoders. From the top (curved edge) of the board to the bottom on both sides, the pins are: motor lead 1,

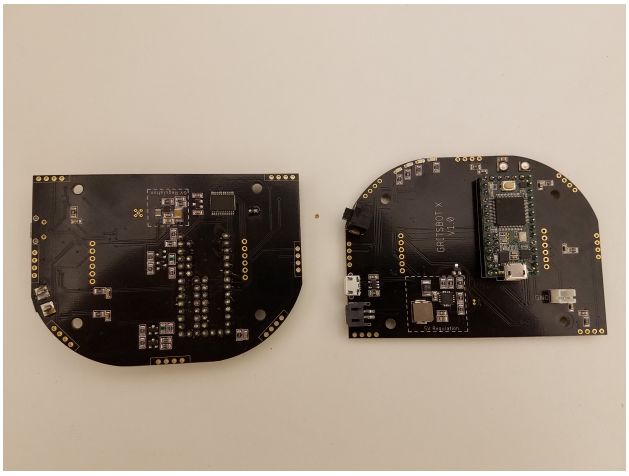


Figure 13: The GRITSBot X main PCB after mounting the Teesny microcontroller, JST PH 2-pin male header, and power switch.

ground, encoder output channel 1, encoder output channel 2, 5 volts, and motor lead 2. Make sure when soldering these they align with your motors correctly. This guide does not trim the motor leads shipped from DFRobot with the motors and instead coils the excess inside the robot. If you want you may cut the wire down to a smaller size but the stranded wire may be hard to keep from fraying out into a short when all six leads are attached. The wires connecting these motor leads are very small and can be tricky to attach without leaving too much excess exposed wire (which can lead to a short). A trick to make attaching these easier is to fill the through holes with solder and then heat the individual pad and insert the motor lead through the liquid solder. This allows you to slightly press and melt the insulation of the wire lead into the board which leaves no exposed metal. After attaching the motor leads, the bottom of the board should look like Figure 14.

2.3.5 Soldering the IR Sensors

Finally we will attach the IR sensors around the perimeter of the main PCB. Hang the sensors on the GRITSBot X main PCB such that the sensor hangs below the board (the side with the motor cables). To solder this, it is easier to solder the the pins from the angled side first and let the capillary action pull the solder through. You will also want to solder one pin and make sure the sensor is perpendicular to the main PCB. After the sensor is perpendicular, solder the other four pins and continue to populate the other

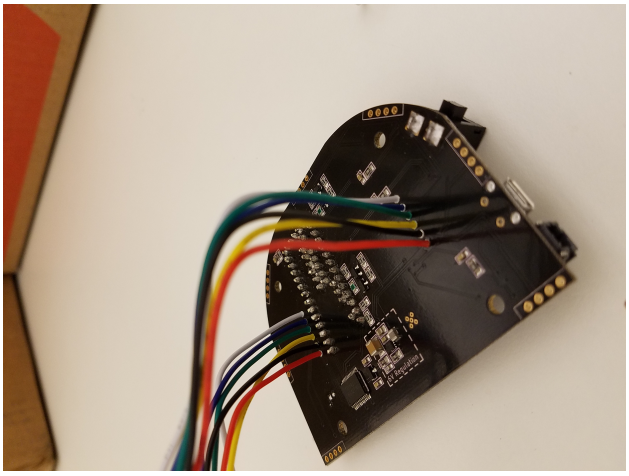


Figure 14: The GRITSBot X main PCB after mounting the motor leads.

six sensor slots.

2.4 Wire Leads to the Raspberry Pi Zero W

To compliment the Teensy microcontroller on the main PCB of the GRITSBot X, the robot also uses a Raspberry Pi Zero W. This board is powered through the GPIO pins of the board. To achieve this solder the JST PH 2-Pin Cable - Female Connector to pin numbers 4 and 6 where 4 is the positive lead and 6 is the ground lead. Make sure this connection is donw with the correct polarity, if it does not you will destroy the Raspberry Pi Zero W.

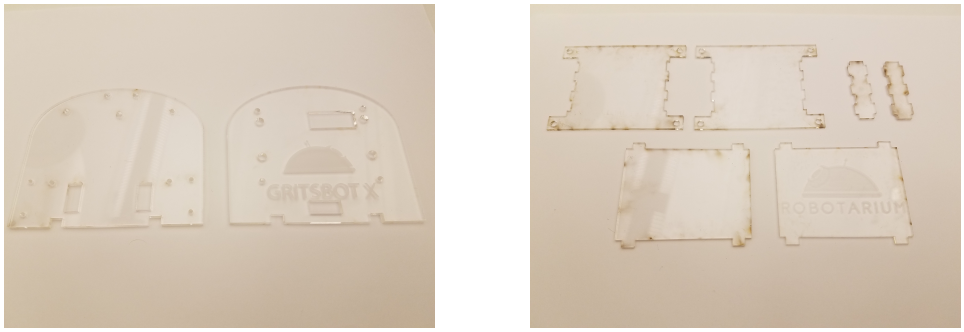
3 Chassis Assembly

Now that the main PCB of the GRITSBot X is assembled, it needs a chassis to be placed in. This section will detail how to manufacture and assemble the main chassis of the GRITSBOT X. The files associated with the production are available and editable. The Github repository contains Solid Works part files (SLDPRT), Adobe Illustrator files (AI), and PDF files. The PDF files should be able to be used for direct laser cutting of the chassis. The AI files may be used to edit the position of the cuts and duplicate the cuts for more to be produced at once. The SLDPRT files are what may be edited to change the chassis. Feel free to make whatever changes you would like

to the design of the robot. This guide will assume that the construction is being done on the files provided.

3.1 Laser Cutting the Chassis

The chassis of the GRITSBot X are cut from 1/8 inch thick and 1/16 inch thick acrylic. The final cut pieces can be seen in Figure 15. The files, $GRITSBotX\_1\_8.ai$ and $GRITSBotX\_1\_16.ai$ are files ready to produce the chassis through a 3D printer. The $GRITSBotX\_1\_8$ is meant to create the 1/8 inch thick acrylic parts and the $GRITSBotX\_1\_16$ is meant to create the 1/16 inch thick acrylic parts. Note, these are sized for a 36×24 inch printer and in some cases the document side must be changed. Other alterations may have to be made for the specific laser cutter you are working on to cut and etch the right places in the file.



(a) 1/8 inch thick acrylic chassis parts. (b) 1/16 inch thick acrylic chassis parts.

Figure 15: The 1/8 (a) and 1/16 (b) inch thick, custom cut acrylic chassis parts for the GRITSBot X.

Now that the acrylic chassis is cut for the GRITSBot X, the final assembly can begin!

3.2 Assembling the Base

3.2.1 Assembly Steps

1. Gather the required materials(Section 3.2.2).
2. Assemble the motors and wheels (Section 3.2.3).
3. Put together the Tamiya caster wheel (Section 3.2.4).

4. Attach the motors and caster to the base plate(Section 3.2.5).

3.2.2 Required Materials

As with the other sections, the first step is to gather the required materials. These are pictured in Figure 16 and listed in Table 2.

Part	Number Required
Acrylic Base Plate	1
Wheel	2
Micro-Metal Gear Motor	2
Motor Bracket Assembly	2
Tamiya Caster Assembly	1
Compression Spring	3
M3-20 Screw	3
M3 Locknut	3

Table 2: The parts required to assemble the base of the GRITSBot X.

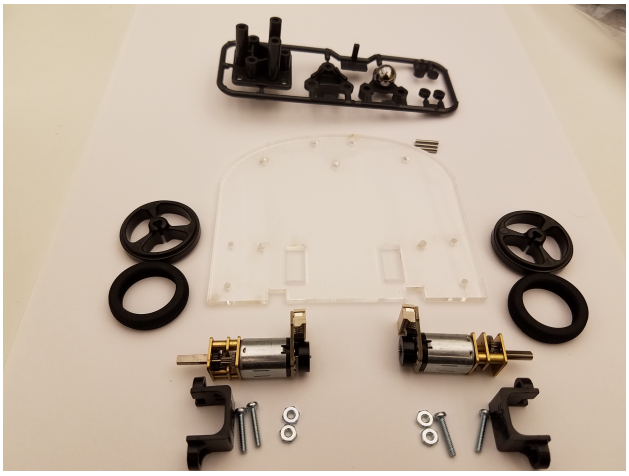


Figure 16: The materials needed to construct the base of the GRITSBot X.

The acrylic base plate should have been laser cut in the previous step. The base plate can be recognized by the three screw holes in a triangular formation in the middle of the curved side of the chassis. This serves as the foundation of the GRITSBot X. The two wheels should come in one package from Pololu with the rubber tires separate from the plastic rims. The micro-metal gear motors from DFRobot come individually with corresponding

jumper wires (not pictured here). Do not discard those, they will be used later. The motor bracket assembly from Pololu should come as a pair with the nuts and screws pictured. If the screws and nuts are lost they can easily be replaced, they are $\#2-56x7/16''$ screws with $\#2-56$ nuts. The Tamiya caster assembly come in packs of two. You only need one of the two and can keep the other for spare parts or keep this in mind when mass producing. The compression springs are meant as a pseudo suspension on the front caster to alleviate rattling and noise while the M3-20 screw and locknut keep the caster firmly attached to the base.

3.2.3 Motor and Wheel Assembly

The motor and wheel assembly is fairly straight forward but for consistency between robots details and tips are provided in this section. First, place the tires around the plastic rims. The tires are pretty elastic and can be stretched rather far. The tires on the rims should look like Figure 17 when finished.

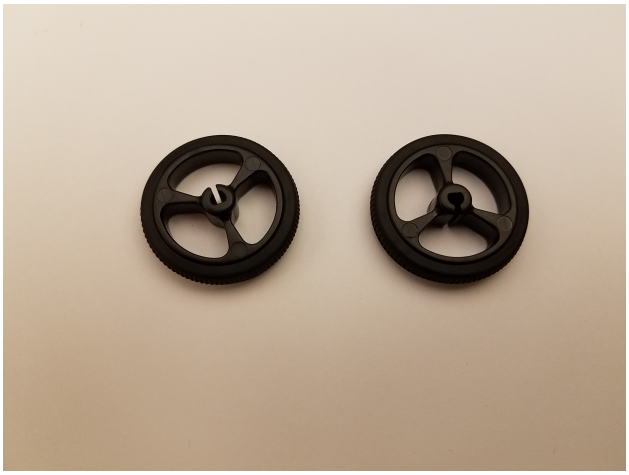


Figure 17: GRITSBot X wheels fully assembled.

These assembled wheels attach to the motors through a D-shaft. It is important to note the wheels have a flat side and side that sticks out. When pressing the wheel onto the D-shaft of the motor, make sure the flat side of the wheel is facing away from the motor. An easy way to attach the wheel to the D-shaft is to press the motor onto a flat surface through the wheel as pictured in Figure 18. If you assemble this way, be careful the encoder PCB is fragile and the magnetic disc can easily be moved. You are most likely to

bend or break off the hall effect sensors (black rectangles sticking out of the PCB), so be careful where you place your hands/fingers when doing this.

(a) Pressing the motor D-shaft into the wheel.

(b) Side view of the motor and wheel assembly.

Figure 18: The motor and wheel assembly pressure fit together.

3.2.4 Tamiya Caster Ball Assembly

Since we are dealing with an *differential drive* platform we need an additional, holonomic point of contact to passively stabilize the system. The GRITSBot X uses a Tamiya caster ball assembly with springs that provide a pseudo-suspension for this point of contact. Assembly instructions come with the Tamiya pack but an altered set of instructions will be provided here.

First, only the parts pictured in Figure 19 are needed. The springs, M3-20 screws, and M3 lock-nuts pictured at the bottom of the figure are not included in the kit. Figure 20 shows a picture representation of the assembly steps. A written explanation follows.

First, place the metal ball into the plastic caster shell. Place the three metal cylinders on top of the caster ball such that they fall into the rectangular slots in the plastic as seen in Figure 20a. Cover this assembly with the second plastic piece provided by the caster kit. The cover should be placed so the triangle of the cover fits in the cutout of the caster ball holder as seen in Figure 20b. There should be no gap between the cover and the caster container. Now that the caster is together, place the three M3 screws through the assembly such that the head of the screw is on the caster ball holder side of the assembly. Place the three springs around the screws. Put the three plastic rings over the springs. The screws with spring and plastic

Figure 19: The parts required to construct the caster ball assembly.

ring assembly should look like Figure 20c. Push the screws through the holes of the acrylic base and lock them in place by threading them through the lock nuts. Make sure the screw is deep enough into the lock nut that the assembly will not come apart but not so tight that the spring is extremely compressed. This will be adjusted once the wheels are on to level the base.

If done correctly, the assembly should look like Figure 20d. Test to make sure the caster is free moving by running your hand along the ball. It should move freely. If it doesn't, it's possible one of the metal cylinders came loose during assembly and is restricting the motion. If this is the case, the caster must be reassembled.

3.2.5 Attaching the Motors and Caster to the Base Plate

Finally, attach the motors to the base of the chassis. This is done by placing the motor bracket over the exposed gear box of the micro-metal gear motor as seen in Figure 21b. Note the plastic motor bracket has a rounded and rectangular surface as seen in Figure 21a.

Make sure the rounded surface rests on the hull of the motor and the rectangular surface rests on the gear box. This motor bracket should be put onto the motor such that the open side is on the same side as the motor connections for the encoder. Place the nut into the hexogonal space on the bracket and thread the screw through the acrylic into the motor bracket. Tighten the caster nuts as appropriate to make the chassis base as level as possible. The final assembly should look like Figure 22.

(a) The caster holder with metal ball and cylindrical bearings inside.

(b) Caster ball assembly with top plate properly inserted.

(c) Caster assembly with screws, springs, and plastic rings inserted.

(d) The finished caster assembly attached to the bottom acrylic plate of the GRITSBot X.

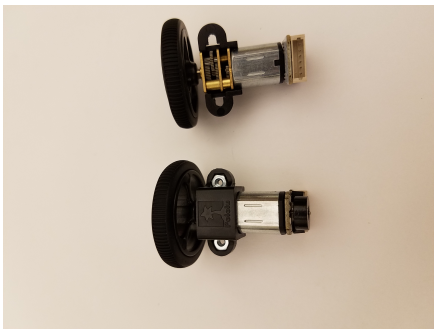
Figure 20: Process to put together the caster assembly.

3.3 Putting Together the Battery Bracket

3.3.1 Assembly Steps

1. Gather the required materials (Section 3.3.2).
2. Snap together the acrylic battery box (Section 3.3.3).
3. Attach the spacers for mounting the battery box and PCB (Section 3.3.4).

(a) The rectangular opening (left) and curved opening (right) of the motor mounting brackets.



(b) Brackets properly attached to the micro metal gear motors.

Figure 21: Attaching the brackets to the micro-metal gear motors properly.

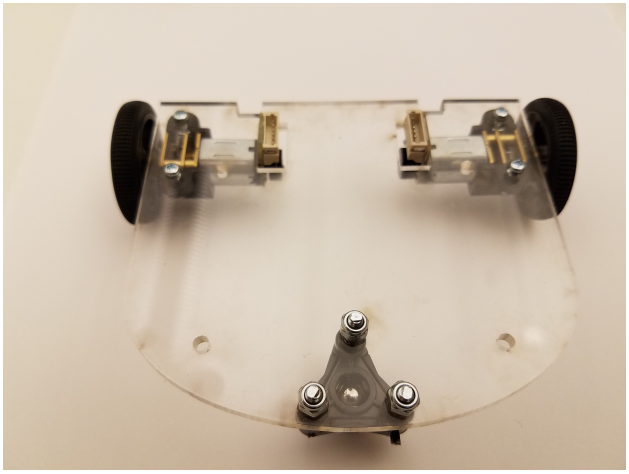


Figure 22: The chassis base of the GRITSBot X.

3.3.2 Required Materials

The battery box assembly is fairly straight forward. The battery box housing is a pressure fit box created by the four 1/16 inch acrylic parts cut earlier and pictured in the top of Figure 15b. The housing is then supported and attached to the robot by threaded hexagonal spacers. The full list of materials needed is shown in Table 3.

Part	Number Required
Acrylic Battery Bracket Top/Bottom	2
Acrylic Battery Bracket Side	2
4-40, 5/16 inch Female to Female Hexagonal Standoff	4
4-40, 5/16 inch Male to Female Hexagonal Standoff	4
4-40, 3/16 inch Nylon Male to Female Hexagonal Standoff	4

Table 3: The parts required to assemble the battery bracket of the GRITSBot X.

3.3.3 Snapping Together the Battery Box

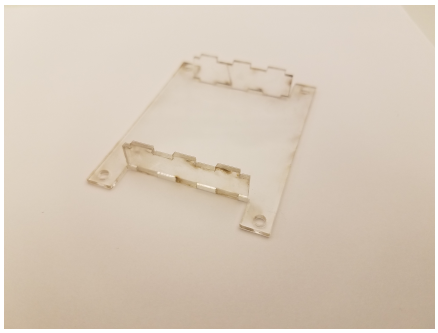
The battery box is assembled through pressure/press fitting tabs together to form a box. It should be noted this is a fairly delicate (1/16 inch acrylic is brittle and fragile) and precise process. If your laser cutter cuts wider or narrower paths than the one at Georgia Tech, the tab widths may have to be altered.

To begin, press fit two of the side pieces into a top/bottom piece as seen in Figure 23a. Note, if this seems to tight to do or the tabs don't hold together, the tab widths needs to be adjusted for your laser cutter. The best process to do this is to press in the center tab followed by the outside tabs. Try not to snap the acrylic during this.

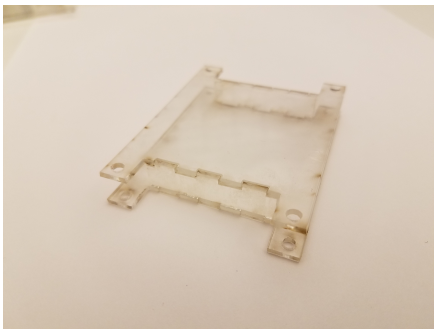
Finally, press fit the top piece into the assembly just snapped together as seen in Figure 23b. It is much easier to press fit one side at a time. The joints should rotate fairly easily so you can press one at a time. pressing the assembly into the side of a table or book spine helps tremendously.

3.3.4 Attaching the Mounting Spacers

Finally, attach the hexagonal spacers to the battery box so it may be mounted to the base of the GRITSBot X and support the PCB in the next steps. Place the four 5/16 female to female hexagonal spacers between the battery bracket (this can be done one at a time. Screw the four 5/16 male to female hexagonal spacers into one side of the female to female spacers between the battery bracket. On the other side screw the four 3/16 male to female nylon hexagonal spacers into the battery bracket. The resulting assembly should look like Figure 24.



(a) Battery bracket sides pressure fit into a top/bottom.



(b) Final battery bracket assembly.

Figure 23: Pressure/Press fitting together the battery bracket for the GRTISBot X.

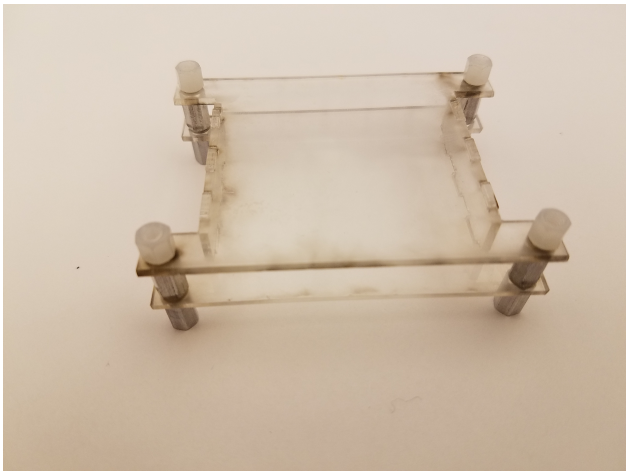


Figure 24: The finished battery bracket assembly with hexagonal stand off supports attached.

3.4 Attaching the Cassis Base, Battery Bracket, and PCB

3.4.1 Assembly Steps

1. Gather the required materials (Section 3.4.2).
2. Attach the battery box to the chassis base (Section 3.4.3).
3. Attach the PCB to the chassis base assembly (Section 3.4.4).

3.4.2 Required Materials

Connecting the chassis base, battery bracket, and PCB is, again, straightforward and just requires screwing the parts created previously together. The full list of materials needed are in Table 4.

Part	Number Required
Assembled Chassis Base from Section 3.2	1
Assembled Battery Bracket from Section 3.3	1
Finished PCB from Section 2	1
4-40, 1/4 inch Screw	4
4-40, 3/4 inch Nylon Male to Female Hexagonal Standoff	4
3.7V 2500mAh Adafruit Li-Po Battery	1

Table 4: The parts required to combine the chassis base, battery bracket, and PCB of the GRITSBot X.

3.4.3 Attaching the Battery Box to the Chassis Base

The battery bracket assembly (Figure 24, assembly instructions in Section 3.3) attaches directly to the chassis base (Figure 22, assembly instructions in Section 3.2) Screw the four 4-40, 1/4 inch screws, through the bottom of the four remaining holes in the acrylic base plate into the four 4-40, 5/16 inch hexagonal standoffs. If done properly, the battery bracket, chassis base assembly should look like Figure 25.

3.4.4 Attaching the PCB

Attaching the PCB is a little trickier simply because the motor leads danging from the PCB must be attached to the motor and the battery lead must be run in a somewhat smart way. The PCB aligns with the chassis shape, the round part of the board should line up with the round part of the chassis when attached. The top of the PCB has the Teensy micro-controller on it. After orienting it correctly, the four holes on the board should line up with the four 4-40, 3/16 inch nylon hexagonal stand offs. Before securing the PCB into place, run the motor leads around the side of the battery box, underneath it, along the base acrylic, and out between the motor connections. The left lead from the PCB should insert into the left motor and right lead from the PCB should insert into the right motor. Note, there is a tab on the

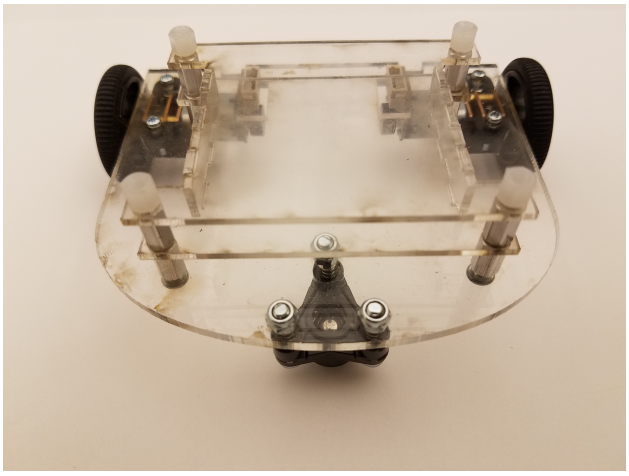


Figure 25: The base chassis with batter bracket attached.

connection so it should only insert one way but can be forced in the wrong way which will break the robot if powered on this way!

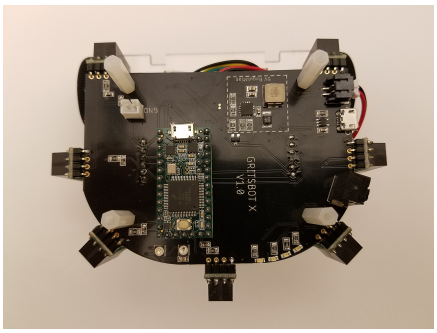
To clean up the excess wire push it back underneath the battery bracket such that there is enough room to insert the 3.7V Li-Po battery into the battery box. Insert the battery such that the lead comes out the back (flat side of the chassis) of the robot. Run the lead under the battery bracket (above the base acrylic) and out the left side of the robot to the battery connector (black plastic connector towards the back left corner of the PCB). Note, make sure the lead of the battery is bent away from the wheel so it does not get caught and stall the robot or wear away the insulation. The wiring should look like **??** when finished.

If done correctly the robot with the PCB in place should look like Figure 26.

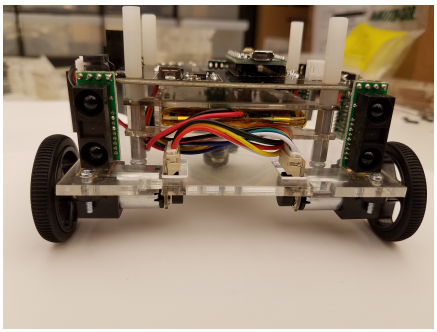
3.5 Assembling and Attaching the Chassis Cover

3.5.1 Assembly Steps

1. Gather the required materials (Section 3.5.2).
2. Attach the Raspberry Pi to the Zero4U through the top acrylic plate (Section 3.5.3).
3. Attach the chassis top assembly to the base assembly (Section 3.5.4).



(a) Top view of the GRITSBot X with PCB attached to the chassis base.



(b) Back view of the GRITSBot X with PCB attached to the chassis base.

Figure 26: The GRITSBot X without top assembly.

3.5.2 Required Materials

The chassis is nearly assembled and thus, there are not many materials needed for this step. The few needed are listed in Table 5.

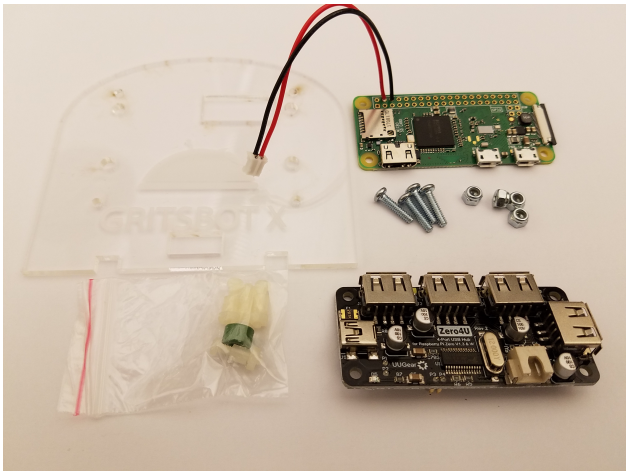


Figure 27: The parts required to assemble and attach the chassis cover of the GRITSBot X.

3.5.3 Attaching the Peripheral Circuit Boards to the Top Chassis

pictured in Figure 28 and

Part	Number Required
Assembled Chassis Base from Section 3.4	1
Acrylic Top Plate	1
Raspberry Pi Zero with Soldered Leads from Section 2.4	1
Zero4U 4-Port USB Hub Kit	1
Tracking Hat	1
4-40, 1/2 inch Screw	4
4-40 Locknut	4
4-40, 1/4 inch Screw	4
4-40, 5/8 inch Male to Female Hexagonal Standoff	4

Table 5: The parts required to assemble and attach the chassis cover of the GRITSBot X.

The first step in this assembly is to attach the Raspberry Pi Zero W [8] to the Zero4U 4-port USB hub [9]. This allows the Raspberry Pi Zero W to connect to the Teensy using a readily available on-the-go (OTG) USB cable as well as extend its wireless communication capabilities with a USB Wi-Fi antenna or other peripherals with limited current draw.

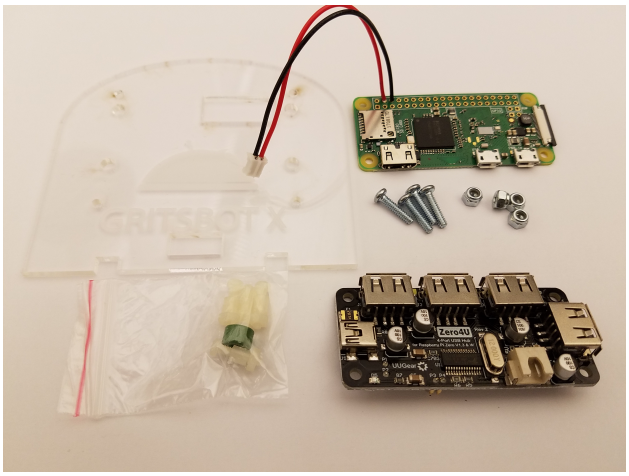
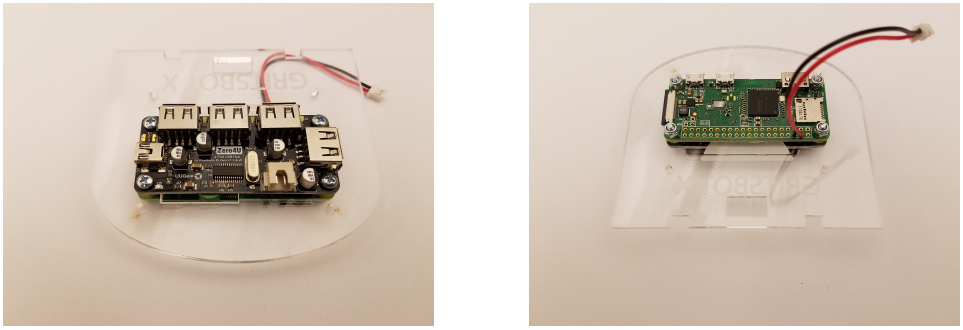


Figure 28: The parts required to assemble and attach the chassis cover of the GRITSBot X.

The parts needed for this are pictured in Figure 28. Insert the four 4-40,

1/2 inch screws through the Zero4U such that the head of the screw is on the same side as the USB ports. Slide the four plastic spacers provided with the Zero4U kit onto the screws. Slide the green ferrite ring around the two pins that are parallel to the long edge of the board [10]. Place the screws through the four wider holes in the acrylic top plate. The Zero4U board should be on the top of the acrylic plate (the side with the etching or the side with the off center rectangular cut on the right with the curved surface being the front). Finally, place the Raspberry Pi Zero W on the other side and thread the screws through the corresponding four screw holes. The metal pins from the Zero4U should align with the exposed pads on the opposite side of the USB ports on the Raspberry Pi. If done correctly, the assembly should look like Figure 29.



(a) Top view of the chassis cover. (b) Bottom view of the chassis cover.

Figure 29: The GRITSBot X chassis cover.

3.5.4 Attaching the Chassis Cover to the Base Chassis

The final step is to attach this chassis cover to the base built in Section 3.4. The parts needed for this are pictured in Figure 30.

First, insert the power jumper from the Raspberry Pi Zero into the JST connector in the lower right of main PCB of the GRITSBot X. It should only fit one way but can be forced in the wrong way. Note, if this wire is plugged in the wrong way with the robot powered on, the Raspberry Pi Zero W will probably be destroyed and other components on the PCB can also be destroyed. Make sure the plastic tab on the end of the jumper cable aligns with the hole on the PCB. Figure 31 pictures the jumper plugged into the PCB correctly.

After plugging in the Raspberry Pi Zero W place the top acrylic onto

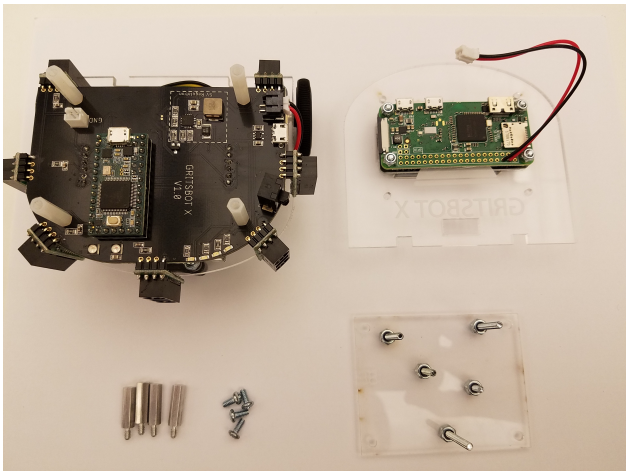


Figure 30: The parts required to the chassis cover to the base of the GRITSBot X.

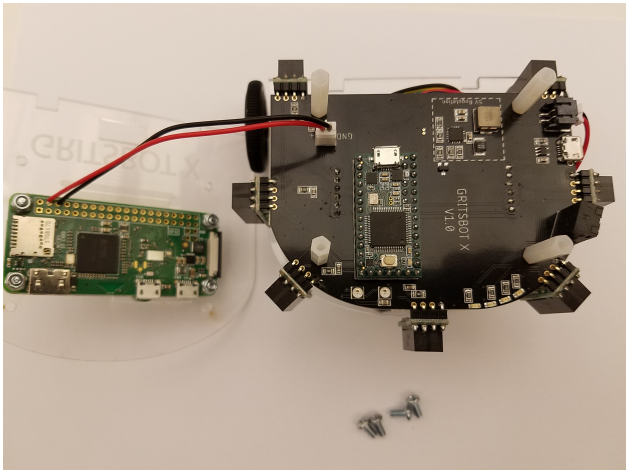


Figure 31: The Raspberry Pi Zero W correctly plugged into the main PCB of the GRITSBot X.

the standoffs and secure it with the four 4-40, 5/8 inch male to female hexagonal standoff. The outer shape of the top plate should align with the bottom plate and the Raspberry Pi Zero W should be on the interior of the robot. If done correctly, the robot without its finishing touches should look like Figure 32.

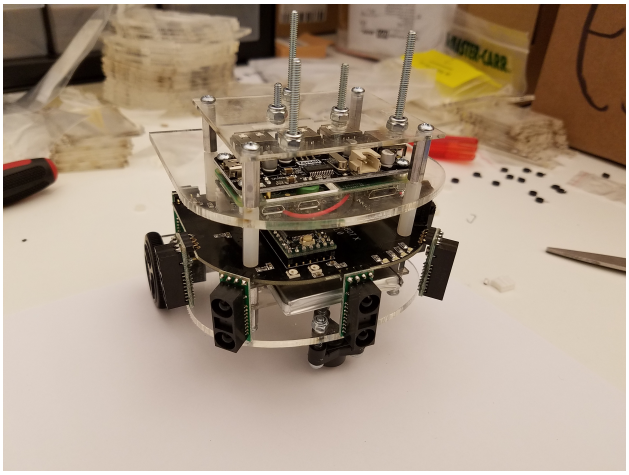


Figure 32: The chassis base with chassis cover attached.

3.6 The Final Touches

3.6.1 Assembly Steps

1. Gathe the required materials (Section 3.6.2).
2. Plug in the periferal electronics (Section 3.6.3).
3. Attach the charging plate (Section 3.6.4).
4. CELEBRATE FINISHING! (Section 3.6.5).

3.6.2 Required Materials

The final step is to connect the Teensy and Raspbeery Pi Zero W so they can communicate over serail, add a Wi-Fi antenna to boost signal reception, and attach the charging plate. A picture of the required materials is in Figure 33 with a table listing them in Table 6.

3.6.3 Attaching Periferal Electronics

First connect the short micro USB noodle cable between the middle usb port on top of the robot and the micro USB port on the Teensy board inside the robot (Figure 34a). Next insert the micro usb connector of the Digiyes Qi charging receiver into the connector next to the battery connection on the PCB (Figure 34b). You robot should resemble that in Figure 34 at this

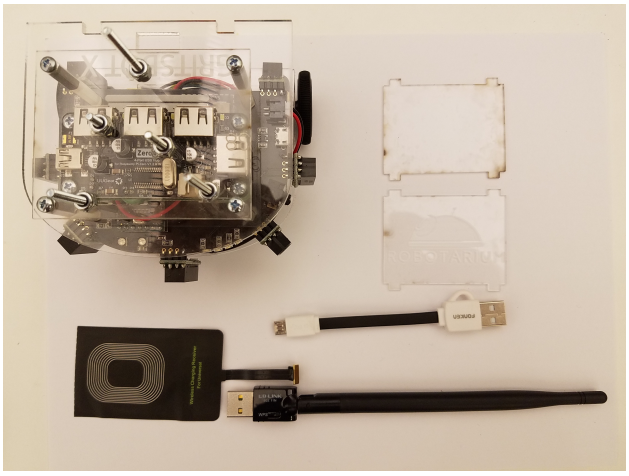


Figure 33: The materials needed to finish the assembly of the GRITSBot X.

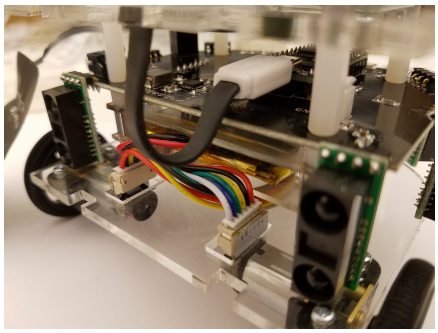
Part	Number Required
Assembled GRITSBot X from Section 3.5	1
Acrylic Charging Back Plate	1
Acrylic Charging Front Plate	1
Digiyes Qi Charging Reciever	1
Short Micro USB Noodle Cable	1
LB-Link Wireless USB Adapter	1

Table 6: The parts required to finish the assmbly of the GRITSBot X.

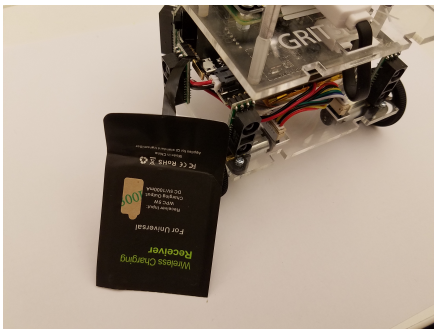
point. You may now insert the LB-Link wireless USB adapter into one of the slots next to the micro USB noodle cable.

3.6.4 Attaching the Wireless Charger

To finish the robot, the Qi wireless charger needs to be secured. Insert the acrylic back plate (the one without etching) of the charger into the slots in the top and bottom acylic plate of the chassis. It should slide in freely. Next, put the charging coil over this plate and fold the excess between the IR sensor and charging plate. It is best to route the connecting cable over the top of the PCB. Do not, cover the IR sensor with the excess of the charging pad. Finally snap the front plate into the same four slots of the bottom and top of the chassis. Make sure the etching is facing out so the Robotarium logo is not reflected! If done correctly, the back of the robot



(a) The micro USB cable connecting the Rapsberry Pi (through the Zero4U) and Teensy.



(b) The Digiyes Qi charging reciever plugged in properly.

Figure 34: The GRITSBot X with electronics properly attached.

should look like Figure 35.

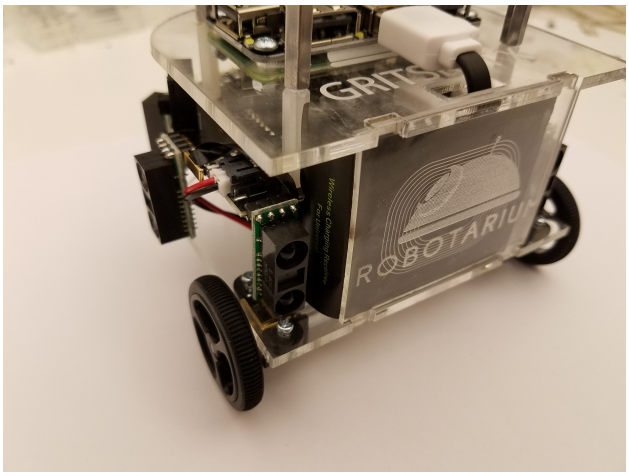


Figure 35: The charging plate of the GRITSBot X properly attached.

3.6.5 CELEBRATE!

Congratulations! The GRITSBot X is completely assembled. You may move onto the next guide to get the software up and running and then begin programming your robot to do super cool tasks!

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