CubEd
Manufacturing Guide

Recommended Supplies

Soldering Iron and Brass Insert Attachment (See resource list)
Set of Metric Hex Screwdrivers
Small Rubber Mallet
Hot Glue Gun
Super Glue

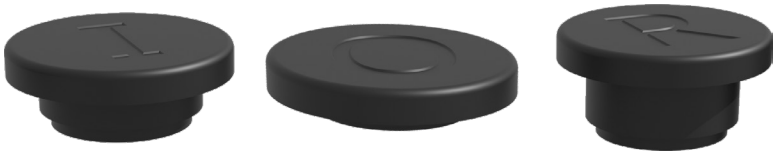
Tool Manufacturing

1. The tools are printed on a Voron 2.4R2 with a StealthBurner Extruder, using these print settings in PrusaSlicer and glue from a BambuLab glue stick to hold the parts in place.
   Use Prusament PLA as the source material for the printer.
   The print settings should be set to "0.2mm 0.4nozzle V2 - Revo"
   For any printer questions the documentation can all be found here.
2. Remove the tools and clean the glue off the surface by running them under water and rubbing the surface.
3. Dry the tools with a paper towel or any other method.
4. Insert the 4mm × 2mm Magnets into the tools via a press fit using any sort of pliers or adjustable wrench for leverage.

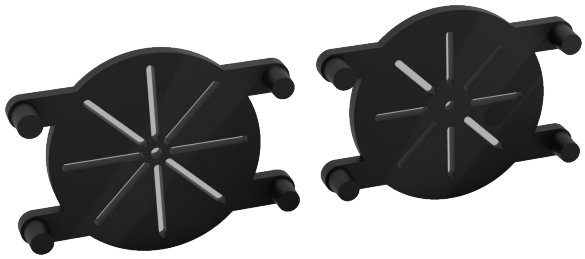
Note: The glue also comes off easily if bathed in a warm water solution containing dish soap with some passive movement.

Baseplate, Top and Bottom Magnet Tools

Note: Confirming that the magnets of the Top Magnet Tool are are oriented to connect to those of the Bottom Magnet Tool to ensure the cubes assembled using these tools fit together correctly on top of each other. The Baseplate Magnet Tool should also be able to clamp onto the Bottom Magnet Tool.

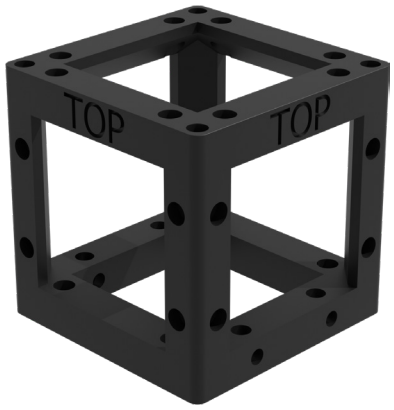


Inner, Outer and Removal SM1 Ring Presses



V1 and V2 Light Targets

Cube Manufacturing

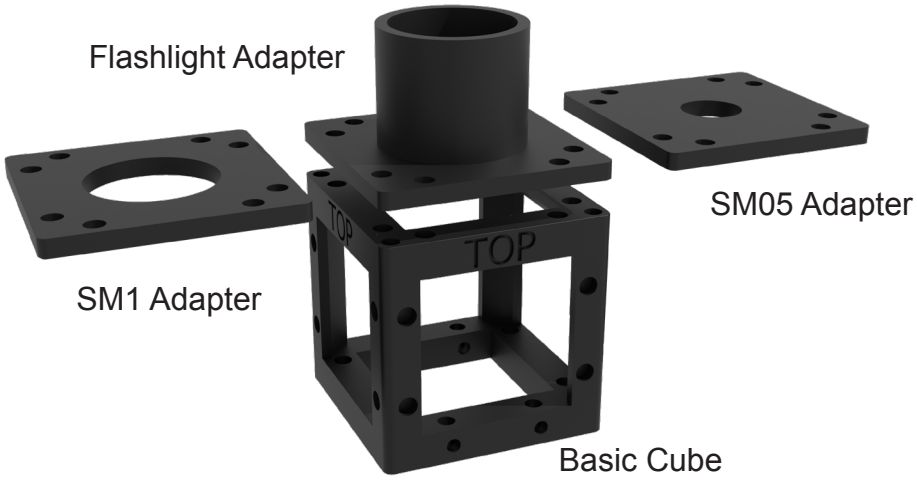


The cubes are printed on a Voron 2.4R2 with a StealthBurner Extruder, using these print settings in PrusaSlicer and glue from a BambuLab glue stick to hold the parts in place.
Use Prusament PLA as the source material for the printer.
The print settings should be set to "0.2mm 0.4nozzle V2 - Revo"
For any printer questions the documentation can all be found here.
Remove the cubes and clean the glue off the surface by running them under water and rubbing the surface.
Dry the cubes with a paper towel or any other method.
Insert the 4 mm × 2 mm Magnets into the cubes via a press fit using the top and bottom magnet tools.

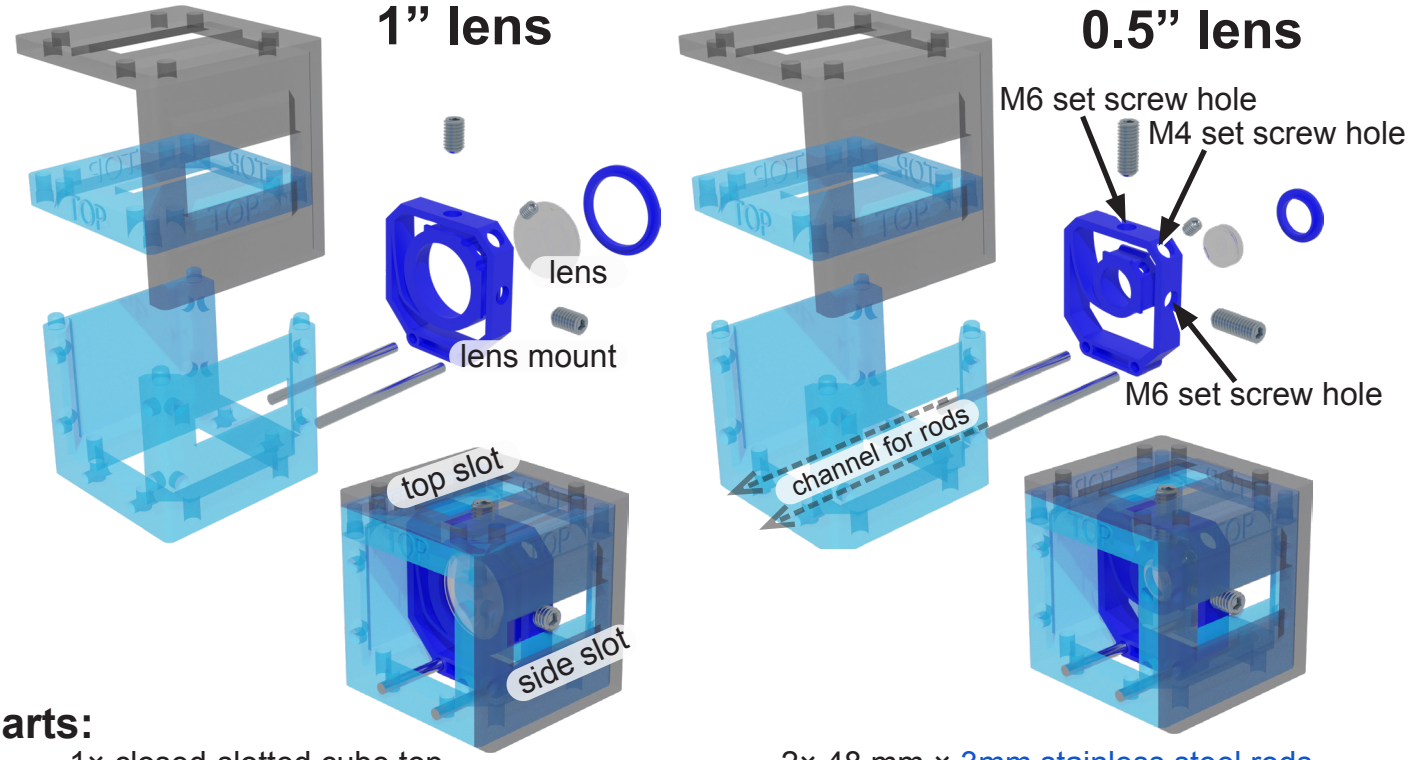
Note: The top piece will use the Top Magnet Tool, and the bottom piece will use the Bottom Magnet Tool.

Inserts and Other Parts

All other parts and inserts are printed using a BambuLab X1-C, using just the default print settings, with slight adjustments here and there to enable support for overhanging surfaces.
Print using official BambuLab Glue Sticks and a Smooth Plate.
Everything but the lens and laser mounts should be printed in Prusament PLA, the lens and laser mounts are printed in PLA-CF.



Lens Assembly



Parts:

- 1× closed-slotted cube top
- 1× closed-slotted cube bottom
- 1× lens mount (for given lens)
- 1× corresponding cover and open outer cover *(if you are not using an SM1 or SM05 mount)*
- 2× 48 mm × 3mm stainless steel rods
- 2× M6 set screws (10 mm for 1” lens; 16 mm for 0.5” lens)
- 1× M4 set screw

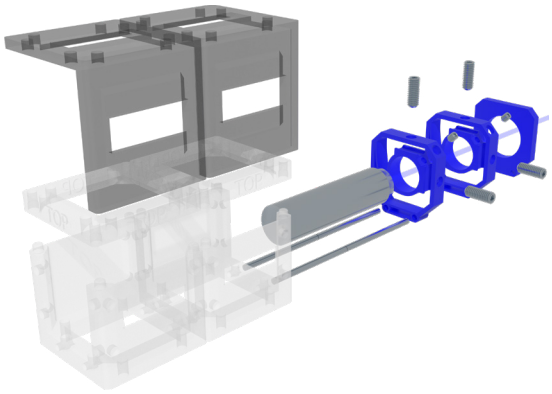
1. Insert the 2× M6 set screws into the two holes on the side and top of the lens mount.
2. *If you are not using an SM1 or SM05 mount:*
   (1) Insert the lens with its direction facing forward towards the smaller diameter of the lens mount.
   (2) Insert the M4 set screw into the small hole on the top right of the lens mount.
   (3) Tighten the screw only until the lens does not move anymore. Do NOT overtighten!

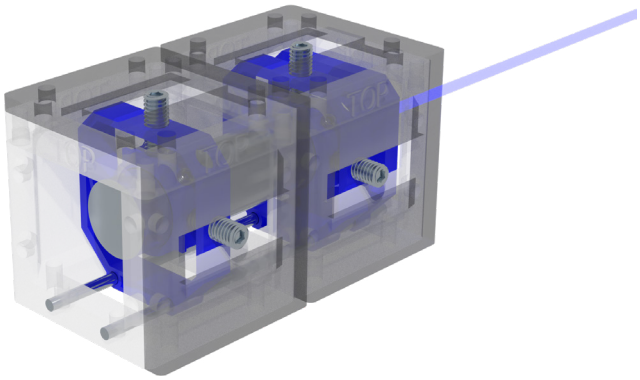
   If you are using an SM1 or SM05 mount:
3. Press fit the lens into the corresponding mount.
4. Insert the lens assembly into the cube such that the side set screw pokes out of the side slot of the cube.
5. Using a rubber mallet, tap fit each of the 2 mm × 3 mm rods into place through the bottom of the cube.

   The lens should be able to to slide back and forth along the rails.
6. Fasten the top piece of the cube such that the top set screw protrudes from the slot on top.
7. Adjustments to the lens position can be made by adjusting the M6 set screws.
8. Hot glue 2mm thick black foam to the inner edges of the larger openings.
9. Attach the outer cover with magnets

Note: Make sure that your foam meets exactly in the middle, otherwise it may inhibit sliding and adjusting the set screws.

Laser Assembly





Parts:

1× closed slotted cube bottom
1× base cube top
1× laser mount
1× laser mount adapter (for USB lasers)
1× laser switch (for USB lasers) with
corresponding 1× ND filter mount
2× 98 mm × 3 mm Stainless Steel Rods

1. Insert the 2× M6 set screws into the laser mounts into the 2 holes on the side and top.
2. Insert the laser mounts into the cubes, with the set screw on the side poking out of the slot on the cube, and tap fit the 2× 3mm rods into place with a rubber mallet.
3. Insert the laser so that it is within both laser mounts, and if necessary, include the laser switch for the USB lasers.

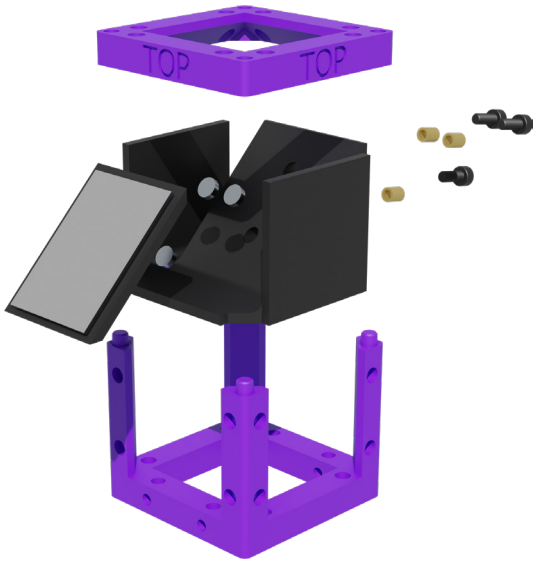
   The laser is held in place using 2× M4 set screws on the laser mounting points.

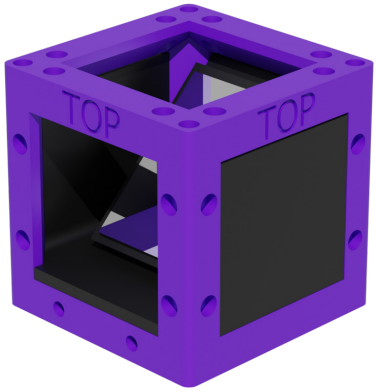
   Note: Take care not to over tighten the set screws.
4. Fasten the top pieces of the cubes into the correct spot corresponding to the set screws. When doing so, maintain the ability to slide the laser back and forth.
5. Attach the outer cover with magnets, and hot glue 2mm thick black foam to the inner edges of the larger openings.

   Note: Make sure that your foam meets exactly in the middle, otherwise it may inhibit sliding and adjusting the set screws.

Mirror Assembly

Vertical



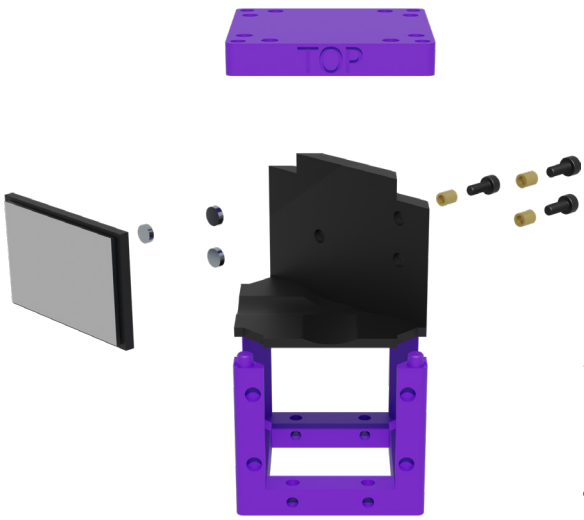


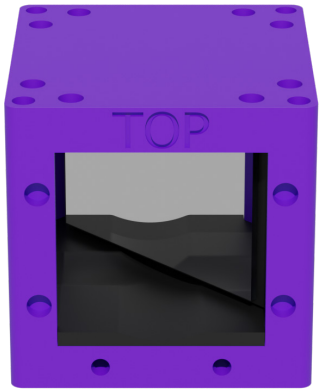
Parts:

1× base cube top (purple)
1× base cube bottom (purple)
1× vertical mirror base
1× vertical mirror plate
3× M3 knurled inserts
3× ferrous M3 screws
3× 5 mm magnets
1× 30mm × 40mm optical mirror
1× optical adhesive for bonding glass to plastic

1. Heat-press the 3× M3 knurled inserts into the corresponding holes in the base piece using a soldering iron attachment.
2. Press-fit the 3× magnets into the plate using optical adhesive.
3. Glue the optical mirror surface to the opposite side.
4. Screw the 3× screws into the inserts.
5. Attach the plate to the ends of the screws using the magnets.
6. Slide the assembly into the bottom cube piece.

Horizontal





Parts:

1× closed base cube top (purple)
1× base cube bottom (purple)
1× horizontal mirror base
1× horizontal mirror plate
3× M3 knurled inserts
3× ferrous M3 screws
3× 5 mm magnets
1× 30 mm × 47.5 mm optical mirror

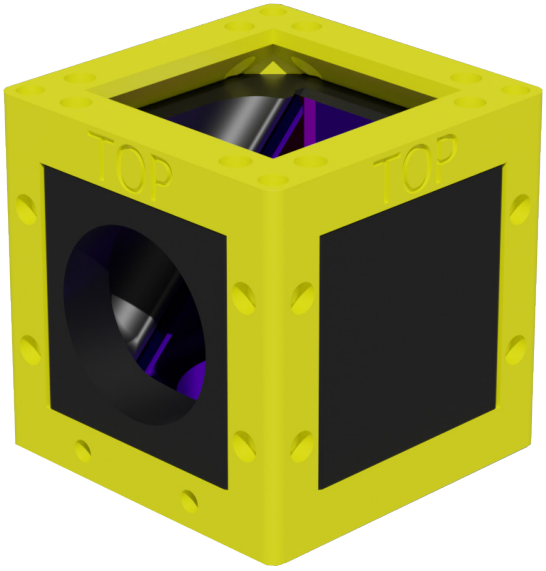
1. Heat-press the 3× M3 knurled inserts into the corresponding holes in the base piece using a soldering iron attachment.
2. Press-fit the 3× magnets into the plate
3. Glue a 30mm × 47.5mm optical mirror surface to the opposite side.
4. Screw the 3× screws into the inserts.
5. Attach the plate to the ends of the screws using the magnets.
6. Slide the assembly into the bottom cube piece.
7. Attach the top cube piece.

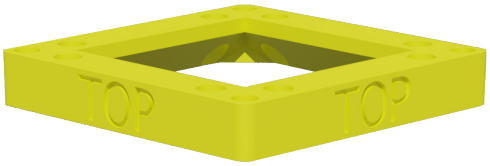
Dichroic Assembly

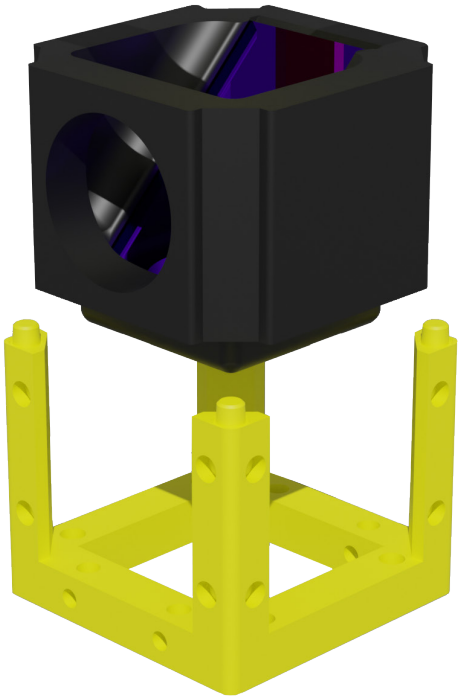
Parts:

1× base cube top (yellow)
1× base cube bottom (yellow)
1× dichroic mount
1× dichroic mirror*
1× emission filter*
1× e×citation filter*
1× SM1 inner, outer and removal tools

*appropriate to the wavelength of the laser





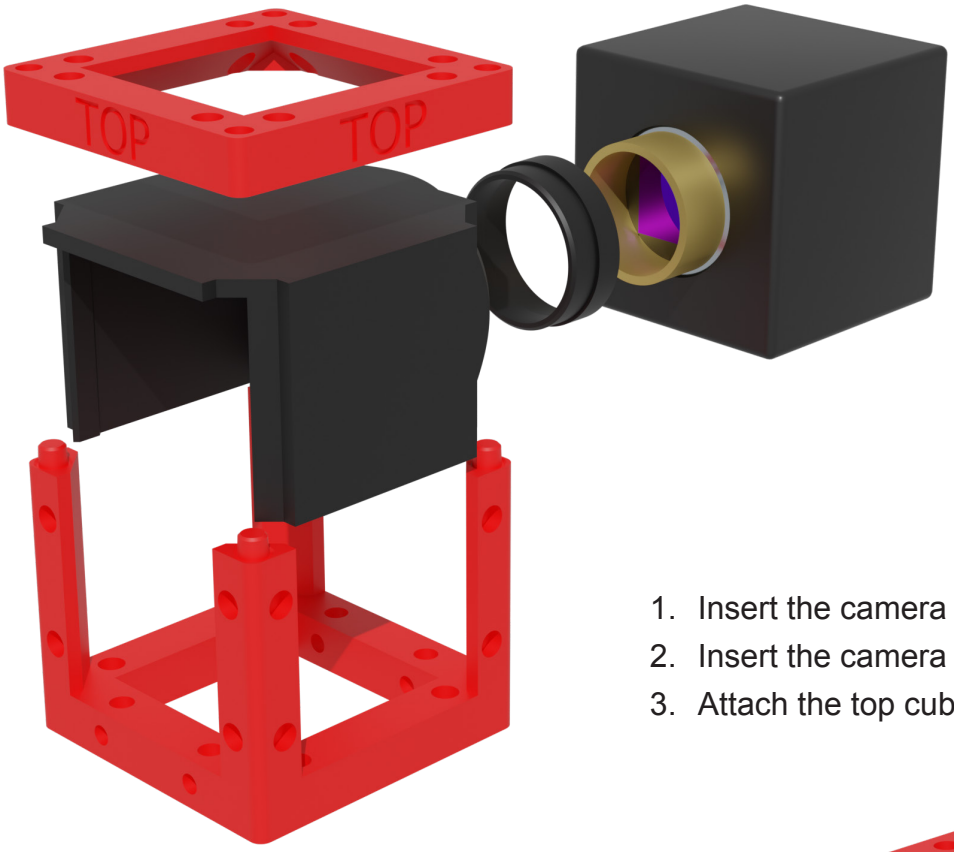


1. Insert a standard SM1 clip using the SM1 inner press tool.
2. Pace an appropriate 1” filter into the same circular hole, ensuring the arrow is pointing in the direction that the beam path is originates.
3. Secure the filter into place with another standard SM1 clip using the SM1 outer press tool.
4. Repeat the process for the other filter location.
5. Slot the 25.5 mm × 36 mm × 1 mm dichroic mirror into the corresponding slot.
6. Attach the top cube piece.

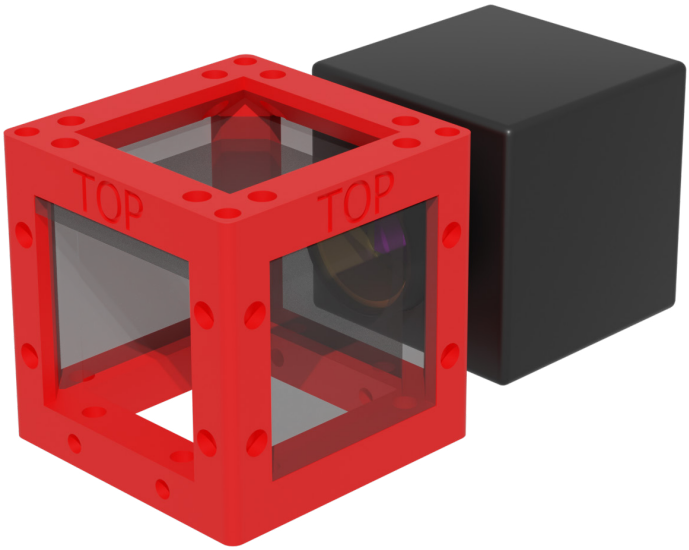
Camera Assembly

Parts:

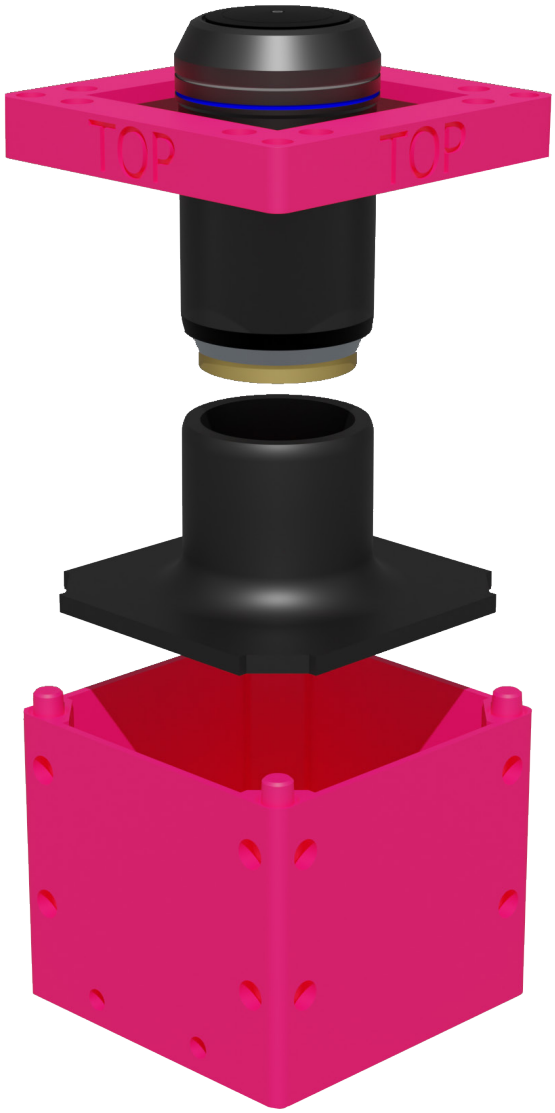
- 1× base cube top (red)
- 1× base cube bottom (red)
- 1× camera adapter
- 1× camera mount
- 1× camera



1. Insert the camera mount into the bottom cube piece.
2. Insert the camera adapter into the camera mount.
3. Attach the top cube piece.



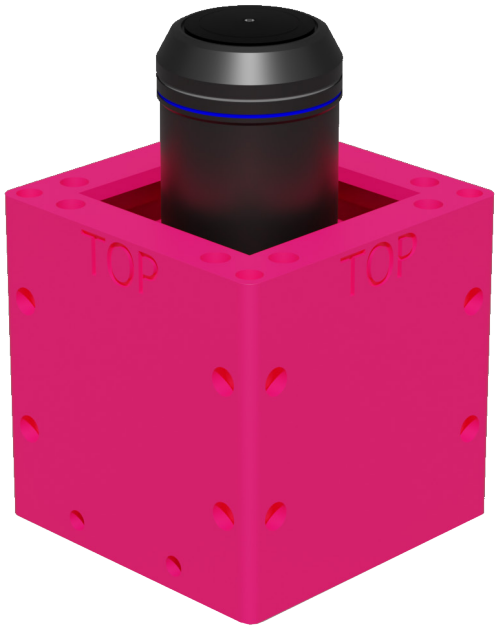
Objective Assembly



Parts:

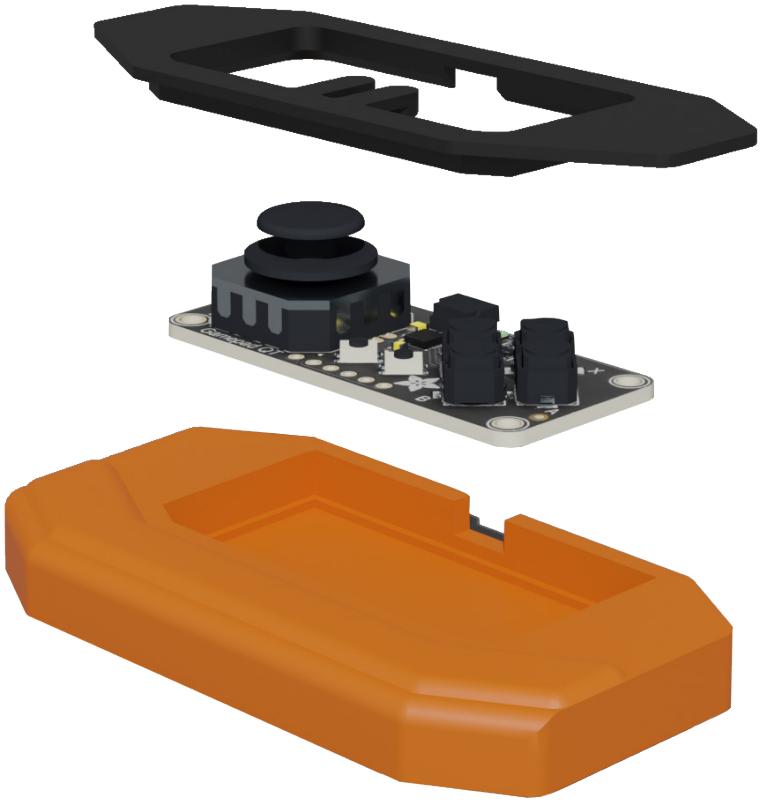
1× base cube top (pink)
1× closed vertical base cube bottom (pink)
1× objective mount
1× objective

1. Insert the objective mount into the closed vertical bottom base cube piece.
2. Insert the objective into the objective mount.
3. Attach the top cube piece.



xyz-Stage Assembly

Controller Assembly



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> Use Prusament PLA as the source material for the printer. The print settings should be set to "0.2mm 0.4nozzle V2 - Revo" For any printer questions the documentation can all be found here.

Remove the tools and clean the glue off the surface by running them under water and rubbing the surface.
Dry the tools with a paper towel or any other method.
Insert the 4 mm × 2 mm magnets into the tools via a press fit using any sort of pliers or adjustable wrench for leverage.

Note: Take care when using the hot glue. Dripping may occur. Do not let any glue get onto the buttons, joystick, or lower joystick assembly.

Parts

1× gamepad top
1× gamepad bottom
1× Adafruit Gamepad
1× QT/QWIIC Cable
4× 4 mm × 2 mm magnets

1. Press-fit the magnets into the gamepad base using the bottom magnet tool.
2. Insert the gamepad into the bottom piece, with the connector at the back facing the opening.
3. Place a dab of hot glue on the very edge of the corners of the gamepad and press the top piece into place.
4. Pull the top piece off of the joystick, put a tiny amount of hot glue in the hole on the top piece, and press fit it back onto the joystick.
5. Insert the QT/QWIIC cable into its port, and place a few more dabs of hot glue to hold it in place.

Stage Assembly

Parts

1× each of the xyz-stage 3D printed parts (3 total)
1× rod motor lengths tool
4× 2 mm stainless steel rods
3× 8 mm M3 nuts
36× 4mm × 2mm magnets
3× DC motors with screws
3× DC motors with extended backs
2× sideways encoders
1× normal encoder
8× low profile M3 Ssrews
1× Motor 2040 controller board
4× JST-SH cables
1× Adafruit LED Sequin

Code Source

CubEd.grunwald-lab-umass.io/additional_files/circuit_python/

Preparation

Rods

1. Safely cut the stainless-steel rods using the rod motor lengths tool to mark the cuts along the bottom edge of the tool.
   6× 44 mm rods (y-xis)
   6× 38 mm rods (x-axis)
   6× 50 mm rods (z-axis)
2. Cut the M3 screw rods from the flat surface of the gearbox assembly using the rod motor lengths tool to mark the cuts along the bottom edge of the tool.
   1× 37.5 mm (x-axis)
   1× 35 mm (y-axis)
   1× 27.5 mm (z-axis)

Notes: The motor parts are very small. Take care not to strip the screws or damage the gears.
Keep track which gear is which as well as the motor from which they came.

Motors

For each set of motors:

3. Unscrew the gearboxes from the motor.
4. With a wire stripper or similar tool, clamp onto and remove the gears from the shaft of each motor.
5. Press fit the M3 gear on the motor with the extended back shaft. Screw the gearbox back.
6. Solder the specified encoder type on the designated axis motor.

motor	encoder kit
x-axis	normal
y-axis	sideways
z-axis	sideways

Note: Make sure that the polarities on the motor and circuit board are aligned.

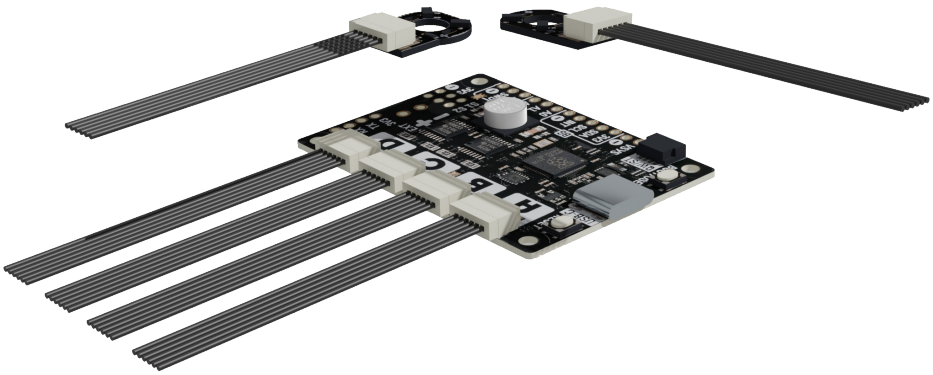
For each set of motors:

7. Press fit the encoder wheel onto the shaft with the dots facing away from the motor.

   Ensure there is less than a 2 mm gap between the encoder wheel and the Hall effect sensors on the board.

Motor 2040 Controller Board

1. While holding the Boot/User button, plug the Motor 2040 board into a computer running WIndows. A device should show up in File Explorer.
2. Drop the UF2 file1 into the device and keep it plugged in, this will install circuit python onto the board.
3. After installation is complete, a device called “Circuit Python” will be available. The code library2 should be copy-pasted into the device’s “lib” folder.
4. It will have a file named code.py, open this file with Notepad++, and copy paste the stage code3 over any currently existing code, and save the file.
5. The device will reconnect, and you should see the motor lights indicating they are trying to move, this will happen with or without motors connected.



1 adafruit-circuitpython-pimoroni_motor2040-en_US-9.0.5.uf2

2 CubEd.grunwald-lab-umass.io/additional_files/circuit_python/lib.zip

3 additional_files/circuit_python/XYZ Stage Code.py

Adafruit Sequin LED

1. Take the Adafruit LED and one of the JST-SH cables, plug the JST-SH cable into the Motor 2040, on the cable, cut off the other end as far as you can, and then cut the four wires to the right on the motor 2040 end, leaving the two wires on the left.
2. Solder the right wire, or the one on the inside, to the negative terminal on the LED, and the left wire, or the one on the outside, to the positive terminal on the LED.

Note: These are the motor power connections, they will be used to power the LED.

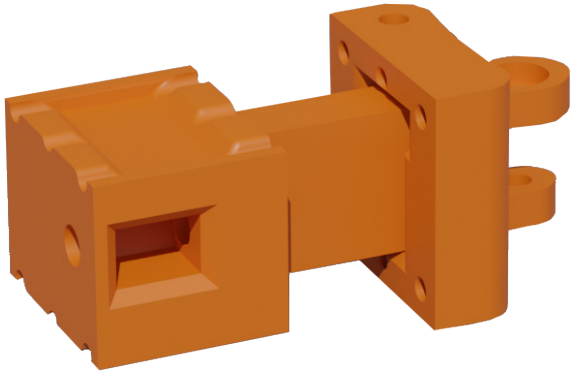
Note: Make sure the led side is facing towards the wires, so that the empty spot with the resistor is facing away from the wires.fitting the gear on and then screwing the gearbox back on.

Assembly

1. Press-fit the M3 nuts into the side slot on the X Stage Body, Y Stage Body, and Z Stage Part, and secure them in place with a light layer of hot glue on top of them.
2. Press-fit four magnets into the Z Stage Body on the back using the Top Magnet Tool.
3. Press-fit eight magnets into the top of the Z Stage Body using the Top Magnet Tool, and the other twenty-four magnets to the bottom using the Bottom Magnet Tool

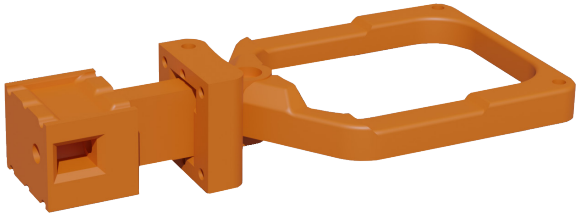
x-axis

1. Slot the x body through the y part.



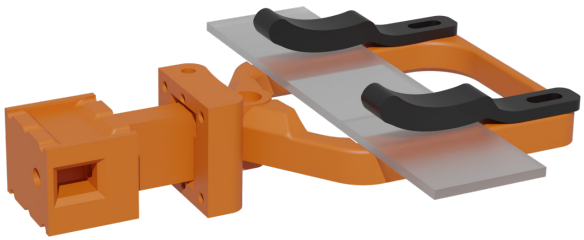
Note: The two flat sides should be facing towards each other as shown.

2. Slot the x stage part into the square receptacle on the x stage body.

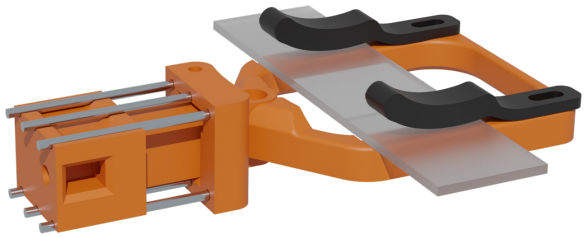


Note: *The larger radius on the x body fits into the slot on the top of the x part*

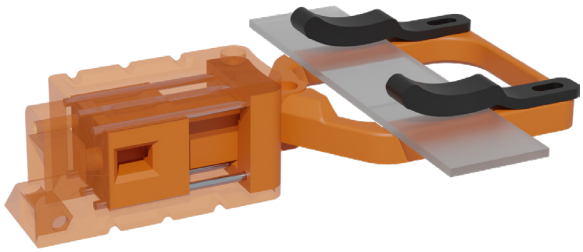
3. Secure the two S Stage Parts together with one of the low profile M3 screws, Do NOT overtighten!
4. Grab 2x X Stage Clamps and screw them into the X Part where the two holes are, they will hold your sample plate in place, Do NOT overtighten!



5. Insert 6x X axis rods into the Y Stage Part and slide the X Stage Body through them so that the two holes on either part line up.

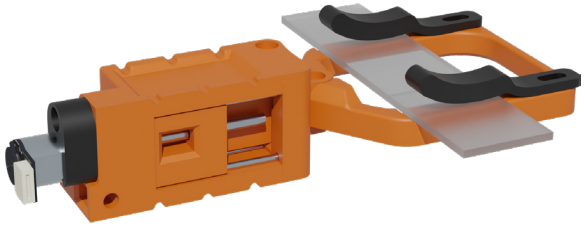


6. Press-fit the Y Stage Body onto the rails and secure it into place with two low profile M3 screws.



x motor

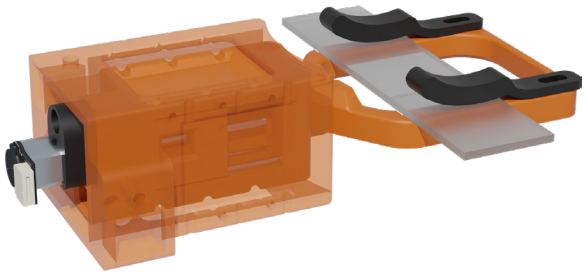
1. Temporarily hook up the X Axis Motor to the D Port on the Motor 2040 using a JST-SH cable and plug the Gamepad's cable into the QW/ST Port.
2. Plug in the Motor 2040 into USB power and it will spin the motor in the direction required to screw it into place.
3. Make sure to align the motor so that the encoder port points away from the main X/Y Bodies like below, and let it screw itself all the way in.
4. Grab the X Motor Clamp and attach it to the motor, making sure to line up the holes and inset for the screw head.
5. Secure the motor in place with another low profile M3 screw and disconnect the JST-SH cable from the motor and disconnect the Motor 2040 from USB power.



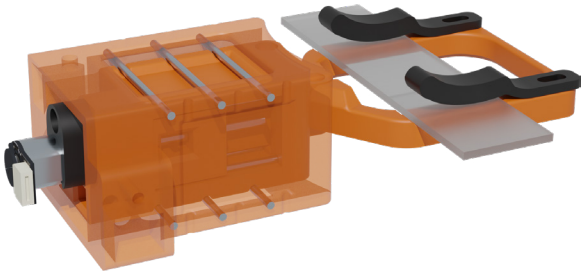
Note: Make sure you are plugging in the cables correctly or you will damage the pins.

y-axis

1. Grab the Z Stage Part and insert the assembly so that the M3 nut on the assembly and the corresponding motor mount line up.

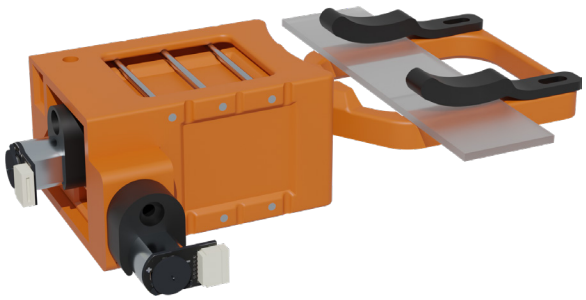


2. Insert the 6x Y axis rods into the side of the Z Part, making sure that they pass through the Y Body correctly and are flush with the other side of the Z Part.



y motor

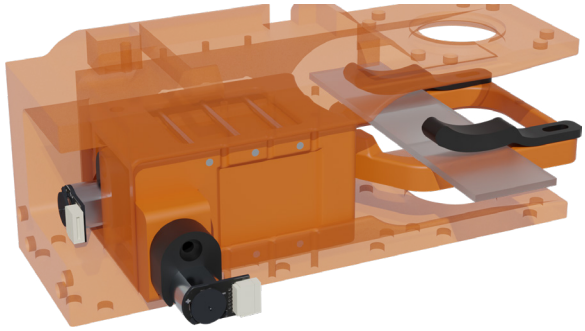
1. Temporarily hook up the Y Axis Motor to the D Port on the Motor 2040 using a JST-SH cable.
2. Plug in the Motor 2040 into USB power and it will spin the motor in the direction required to screw it into place.
3. Make sure to align the motor so that the encoder port points towards the X Axis Sample Clamps like below, and let it screw itself all the way in.
4. Grab the Y Motor Clamp and attach it to the motor, making sure to line up the holes and inset for the screw head.
5. Secure the motor in place with another low profile M3 screw and disconnect the JST-SH cable from the motor and disconnect the Motor 2040 from USB power.



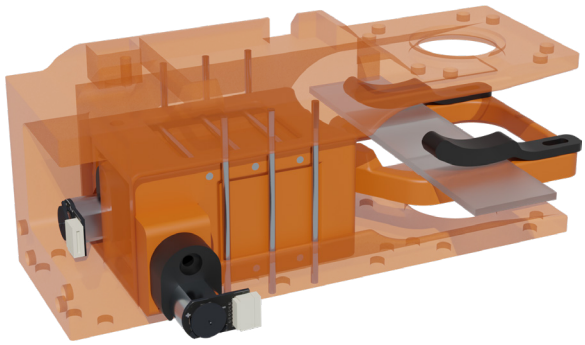
Note: Make sure you are plugging in the cables correctly or you will damage the pins.

z-axis

1. Grab the Z Stage Body and insert the assembly so that the M3 nut on the assembly and the corresponding motor mount line up.



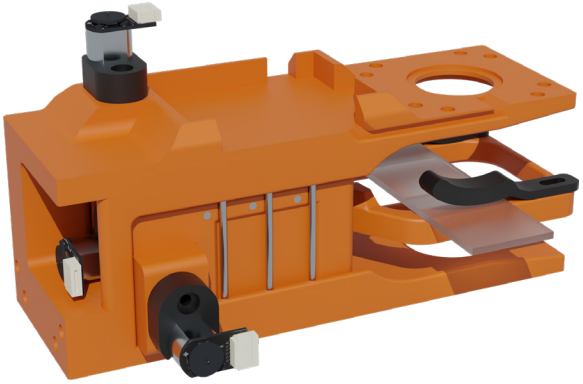
2. Insert the 6x Z axis rods into the bottom of the Z Body, making sure that they pass through the Z Part correctly and that they are fully inserted and not sticking out from the bottom.



Note: You may need to use some force from a mallet to tap them into place fully. Make sure to be gentle though as you can split your printed part with too much force, if necessary, use one of the magnet tools for the cubes to support the edge.

z motor

1. Temporarily hook up the Z Axis Motor to the D Spot on the Motor 2040 using a JST-SH cable.
2. Plug in the Motor 2040 into USB power and it will spin the motor in the direction required to screw it into place.
3. Make sure to align the motor so that the encoder port points towards the X Axis Sample Clamps, and let it screw itself all the way in.
4. Grab the Z Motor Clamp and attach it to the motor, making sure to line up the holes and inset for the screw head.
5. Secure the motor in place with another low profile M3 screw and disconnect the JST-SH cable from the motor and disconnect the Motor 2040 from USB power.



Note: Make sure you are plugging in the cables correctly or you will damage the pins.

Electronics Assembly

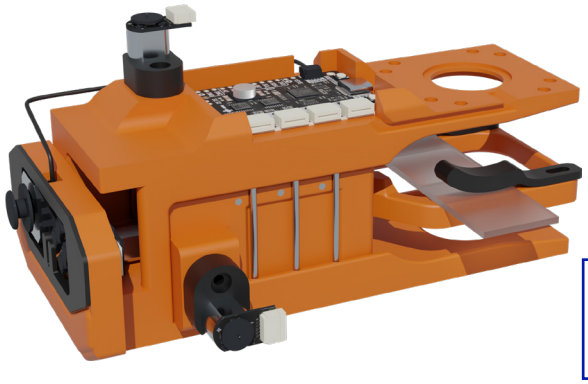
Motor 2024 Controller Board

1. Grab the Motor 2040 board and mount it to the top of the Z Axis Body using a dab of hot glue in each corner like below.

Note: The USB-C port and other corresponding ports will line up where you should place the board.

Adafruit Gamepad

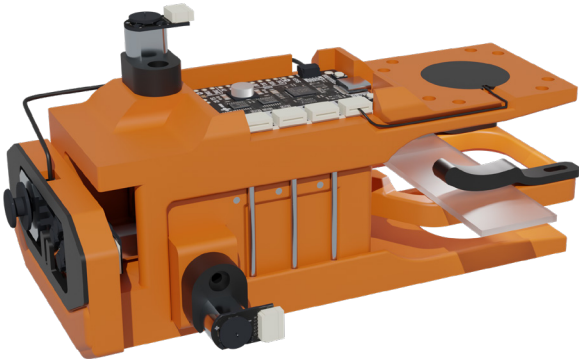
1. With the Gamepad plugged into the QW/ST port, add a few dabs of hot glue to keep it in place.



Note: The hot glue gun will melt the wire's insulation away, so be careful to only let the hot glue touch it.

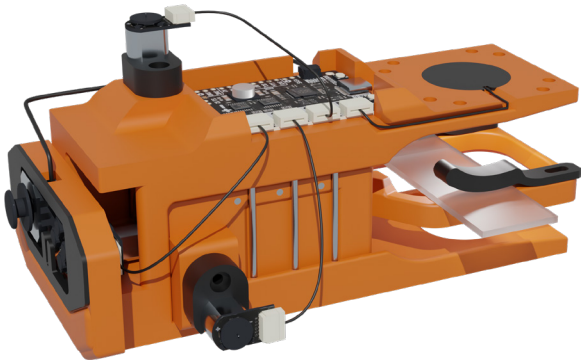
Adafruit Sequin LED

1. Prepare a JST-SH cable by first plugging it into the A Port on the Motor 2040.
2. Cut the other end of the cable off and then cut the four wires to the right off as well, the first two wires on the left will provide power to the LED.
3. Mount the LED to the Z Stage LED Mount using hot glue to hold it in place to the recess on the underside with the wires being hot glued there as well.
4. Mount the LED Mount to the stage making sure to line up the wires with the channel on the top.
5. Mount the wires into the recessed channel that runs to the motor 2040, leaving some slack on the Motor 2040 side.



Motors

1. Connect the X Axis Motor to the D Port on the Motor 2040 using a JST-SH Cable, and then put a dab of hot glue on both connections to secure them in place.
2. Connect the Y Axis Motor to the C Port on the Motor 2040 using a JST-SH Cable, and then put a dab of hot glue on both connections to secure them in place.
3. Connect the Z Axis Motor to the B Port on the Motor 2040 using a JST-SH Cable, and then put a dab of hot glue on both connections to secure them in place.



Note: The hot glue gun will melt the wire's insulation away, so be careful to only let the hot glue touch them and not the end of the hot glue gun.

4. As a finishing touch, attach the Electronics Cover to the stage above the Motor 2040 using a dollop of hot glue in each corner, and then press fitting it into the correct direction and orientation.