Blackbox CE Mechanical Assembly:

07-B. FDM Tool Adjustment

Change Log

Version	Notes
1	Initial Release

FDM Tool Alignment & Adjustment

We will now be making some adjustments to the FDM tool. One of the consequences of using the tool cooler's contact with the X plate as a point of constraint is that our printed parts and other hardware tolerances must be accounted for.

An overview of the steps performed in the next few pages:

Position the complete FDM tool against the X plate.

Adjust the angle of the tool so that the distance marked in Red is equal on both sides using a printed tool.

Adjust the tool cooler block so that it is flush with the X plate (marked in Blue) while maintaining the equal distance marked in Red.

Tighten the (2) tool cooler fasteners marked in green.

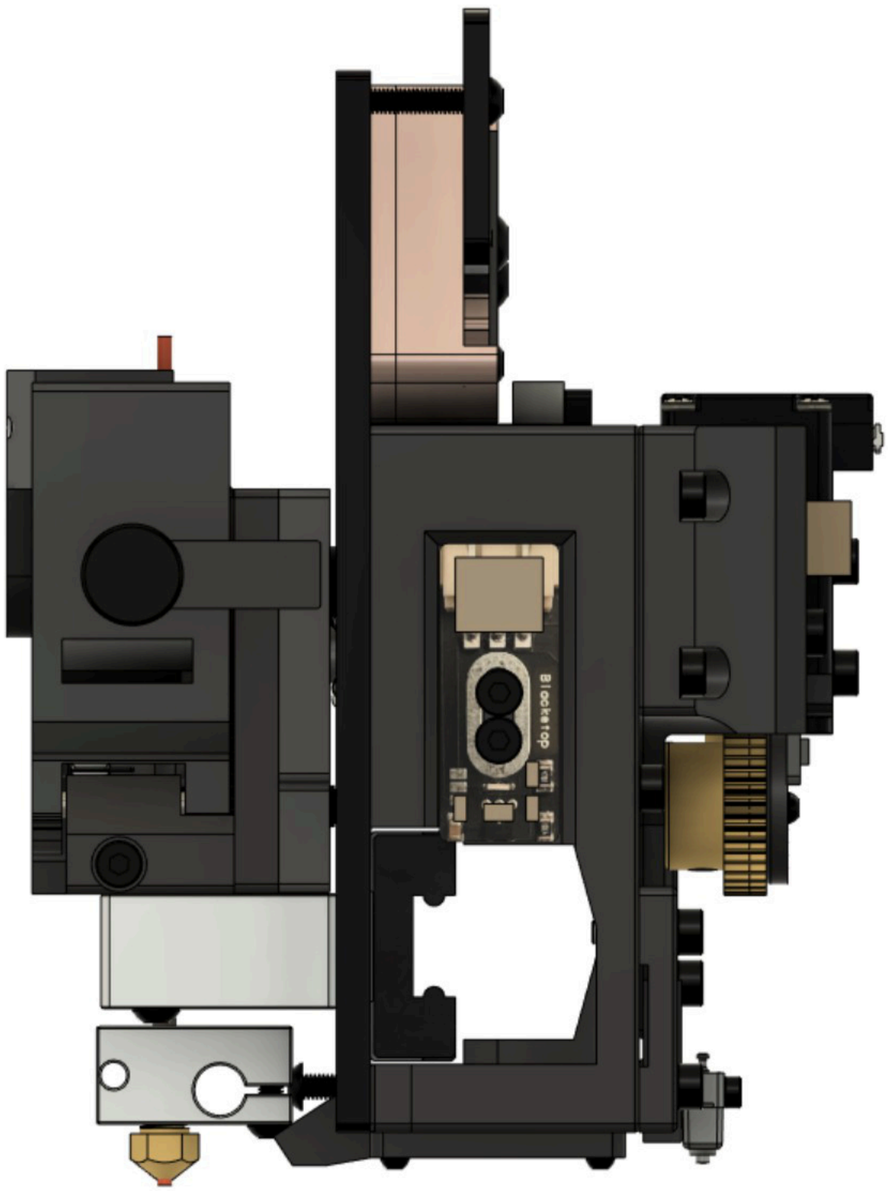
These adjustments are extremely important! If after tightening all fasteners any of the above conditions are not repeatable, address this now!

Position the tool against the X-Plate:

There are 3 total contact points between the tool and the X plate.

1. Kinematic Coupling Left (3 point)
2. Kinematic Coupling Right (2 point)
3. Cold Side of hot end to X-Plate (1 point)

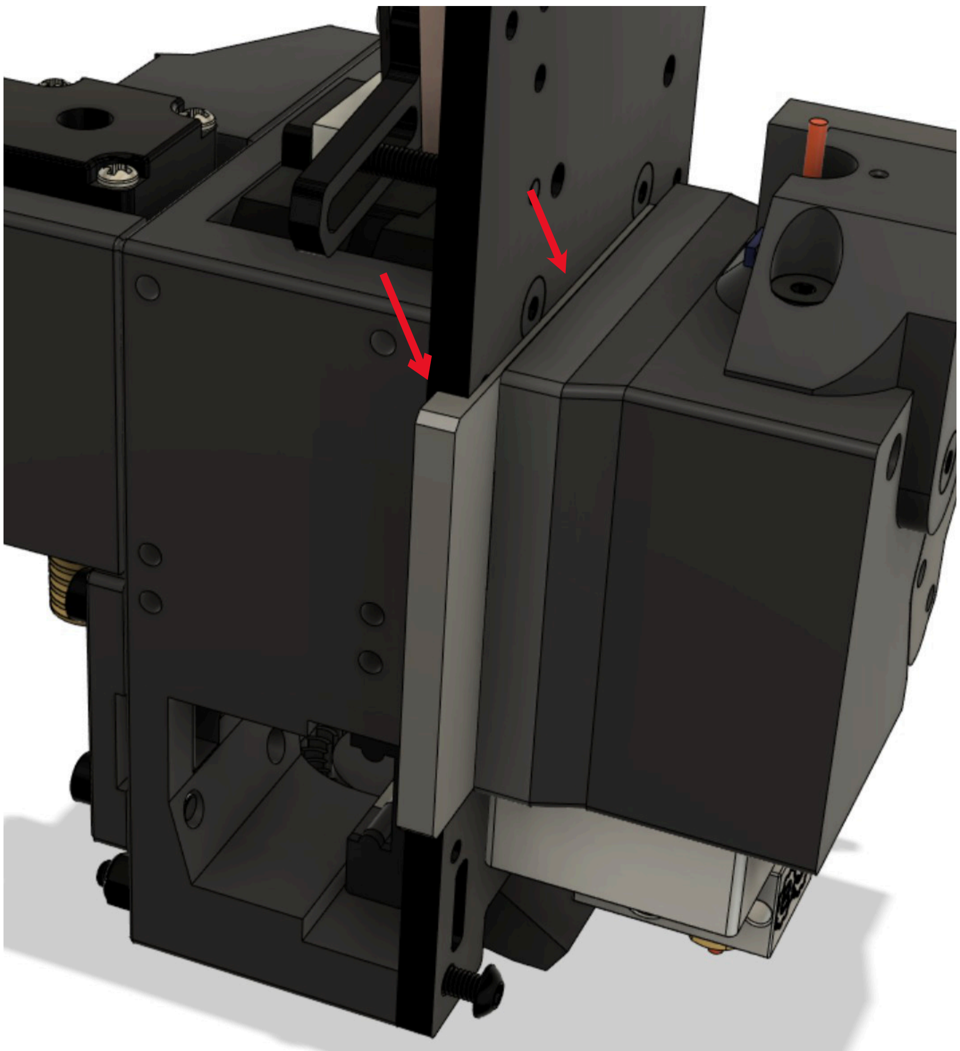
Ensuring that your tool lock is in the vertical position, place and hold the FDM tool onto the X-Plate using the two steel balls and pockets as a guide. This should require no effort, and the tool should not stay in place without holding it. See next page.



Install printed tool and tension:

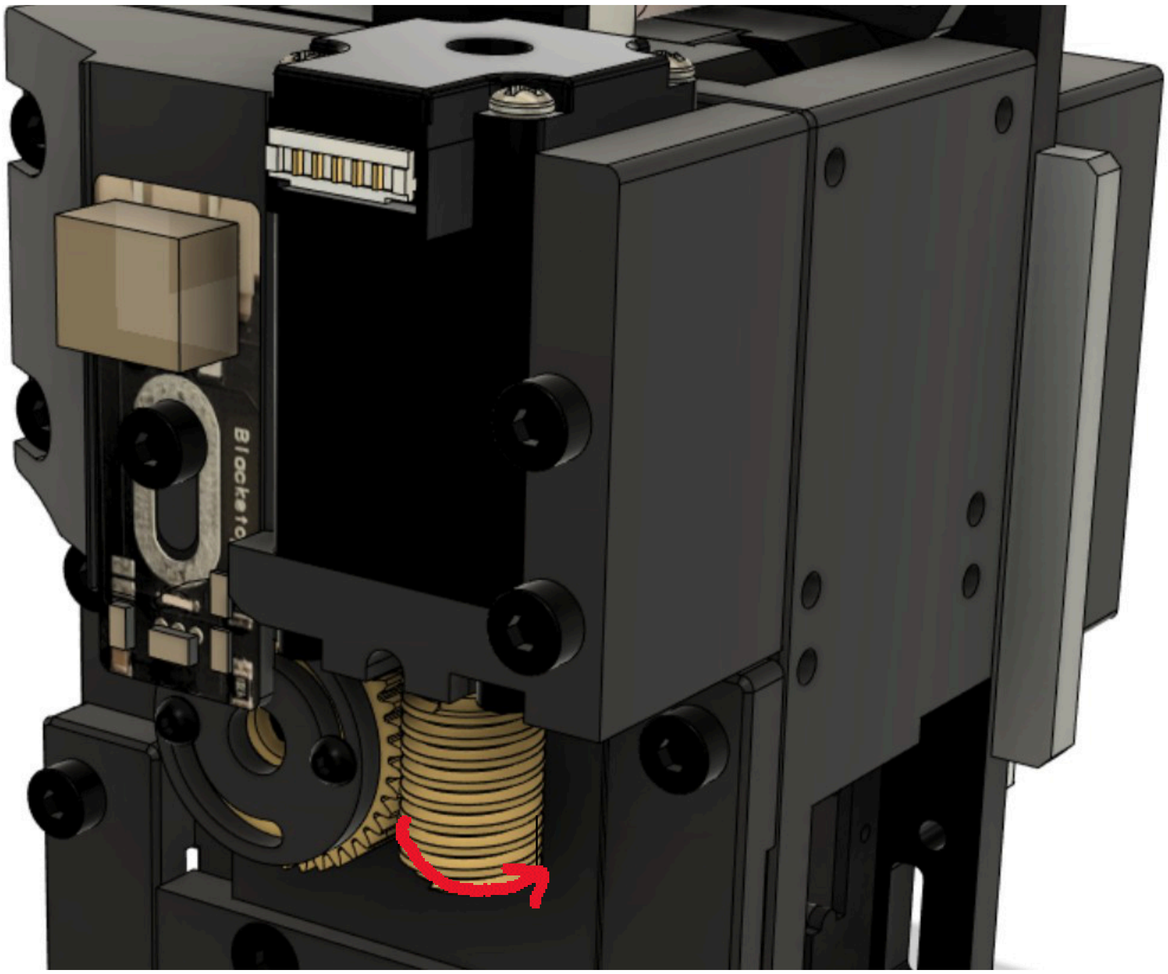
Locate Print_AssemblyTool_KinematicSpacer and insert in the below shown location. Note that the position of the tool is flush with the top of the tool while the flange is flush with the X-Plate.

Continue supporting the tool through the next page.



Tensioning:

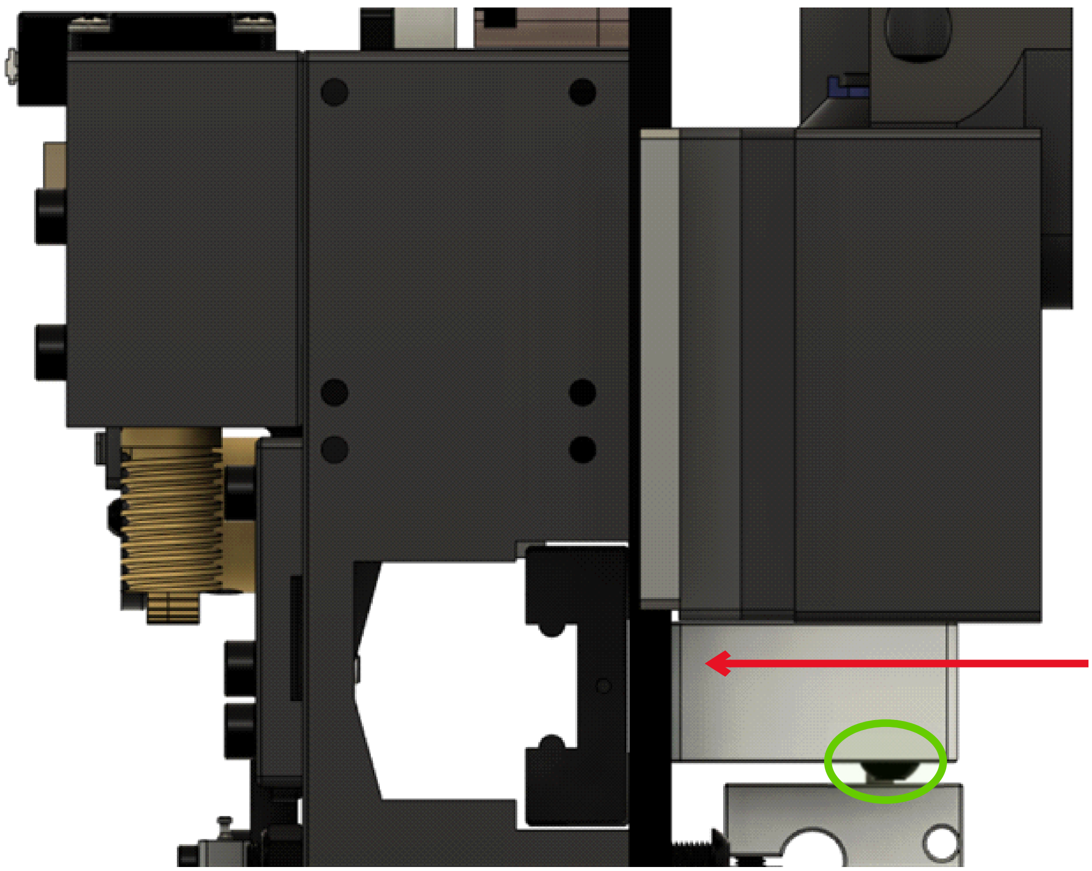
Rotate the tool lock drive (worm) gear attached to the Nema 8 motor in the counter-clockwise direction until you can feel the tool-lock begin to draw in the tool assembly. Continue rotating until a light tension force is achieved. When this happens, the tool will support itself against the printed tool and kinematics without any gaps or excessive play when referencing the Tool Plate to the X-Plate. The next page will adjust the Tool Cooler Block's position.



Adjustment:

Apply light force to the tool cooler block in the direction of the X-Plate. The cooler block should reach the X-Plate without the tool body lifting or moving out of place against the printed tool. Additional tension can be added to the tool lock if this occurs.

While maintaining force against the tool cooler block, fully tighten the (2) M3x18 BHHS shown in Green.

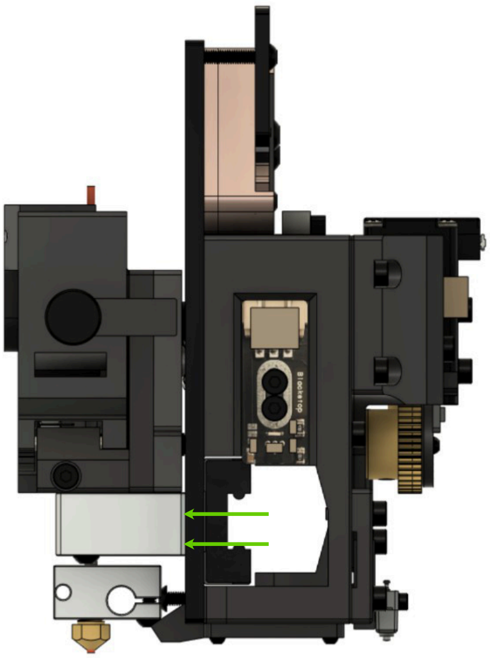


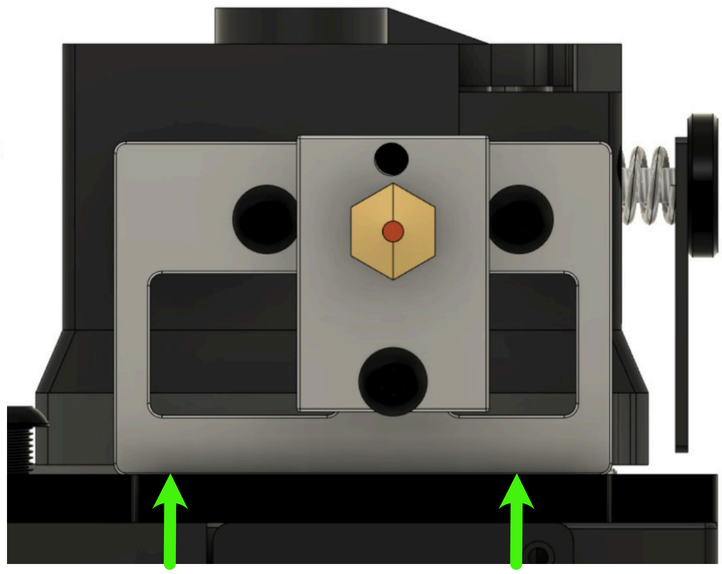
Check and Repeat:

Slightly loosen the tool lock's tension on the tool body. Remove the printed tool. Re-tension the tool body with the tool lock (without the tool in place) until a moderate tension force is achieved.

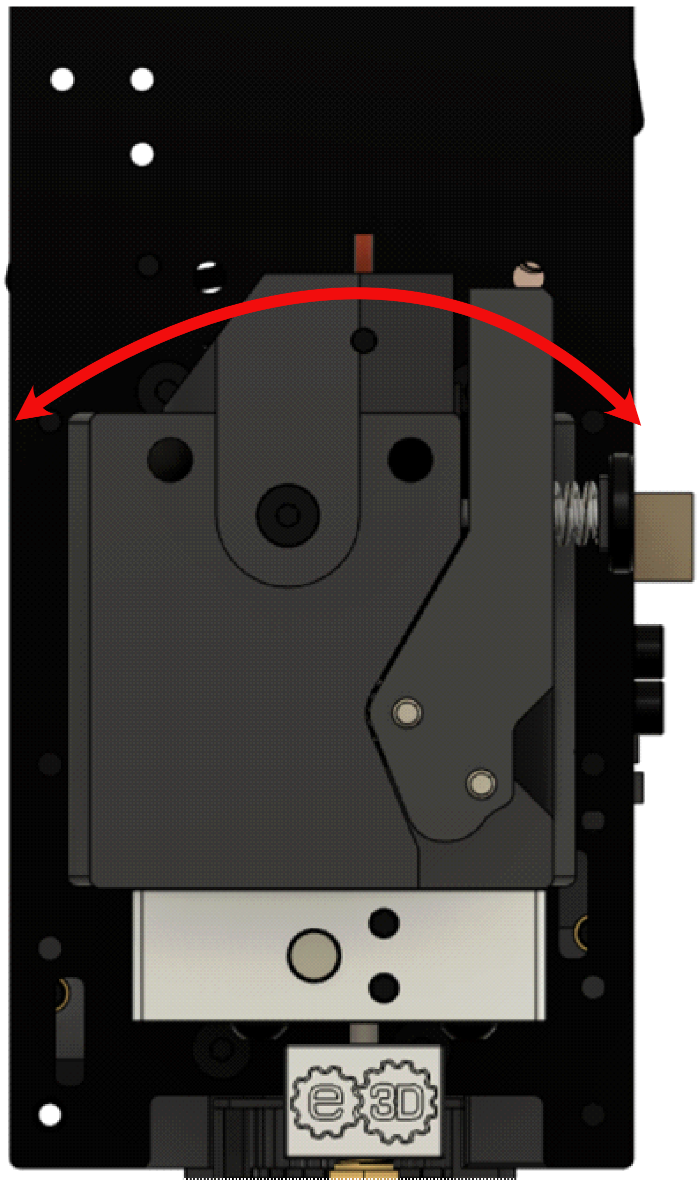
Check that all the following are true:

1. The Tool Cooler Block is resting squarely against the X-Plate in both directions. Use a flashlight ahead of your chosen viewing angle to confirm that no light shines through this interface. This interface is what will cool your hot end during printing!





2. Grab hold of the Tool body while mounted and ensure that there is no clearance/play in any direction when the below shown motion is applied. Note that with high hand force you may be able to over-power the tool lock tension and thus the balls will move from their sockets. With light force however no free play should be present in this system.

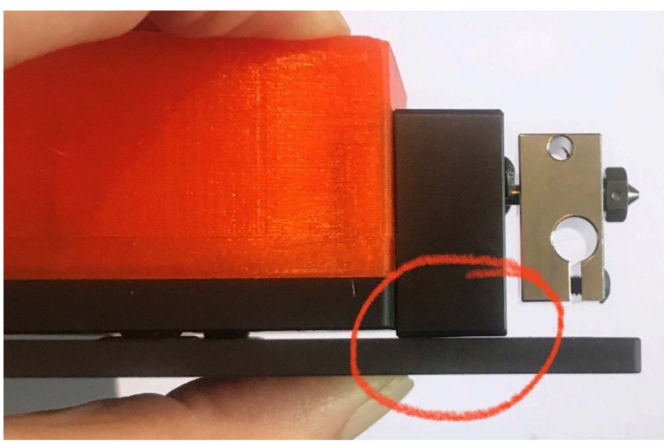


If you were able to confirm the above – Congratulations! This is a testament to your assembly discipline up to this point! Move onto the next step.

If you were not able to confirm the above:

Both above checks rely on overlapping variables, so a failure of one test will usually result in failure of both tests. Here are some things to consider (working your way from the top down):

1. Before proceeding – Try Again. Be sure you understand what we're aiming for and why. This will help you address issues. Your printed tool should measure ~ 0.6mm thick at all locations. Make sure the tool has no high spots from retraction or and over extruded top layer.
2. Try without the printed tool – The printed tool has a geometry that expects a high level of printed part accuracy to be useful. The process can be done without it by using your eyes to maintain the distance shown in red on the first photo of this step. If the final checks pass, it doesn't matter how you get there.
3. Printed part precision – The printed parts used in this guide are some of the most important when it comes to being geometrically accurate. If you have not produced a passing Blackbox Readiness Test Print there is a higher chance that the printed parts are causing deviations that cannot be adjusted for. See below.
4. The total thickness of the assembled tool is one of the most important factors in achieving a flush tool cooler. If you find that your kinematics operate properly but your tool cooler is at an angle (when looking from the front or rear of the machine) you likely need some small adjustment that can be carried out without reprinting. See Below.



In this example a gap exists toward the bottom side of cooler block. This is a result of an overall too-short print height in the Z direction when printing FDM_Tool_Part_03 and FDM_Tool_Part_02. While shims can be added to address this (simple paper gaskets can work) it is usually best to instead consider a reprint of Part_02 after determining the reason for the short Z. Note that a single layer can make a difference here in some materials!

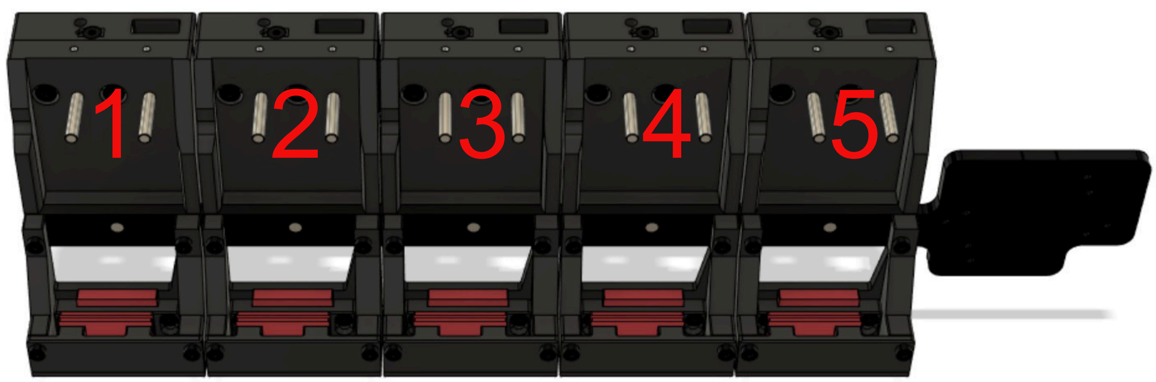
If however your gap is opposite this, your printed parts are too tall. Removing the Tool Plate and lightly face sanding Part 02 and/or Part 03 in incremental guess-and-check amounts will solve this.

Step 4 – FDM Tool Dock Adjustment

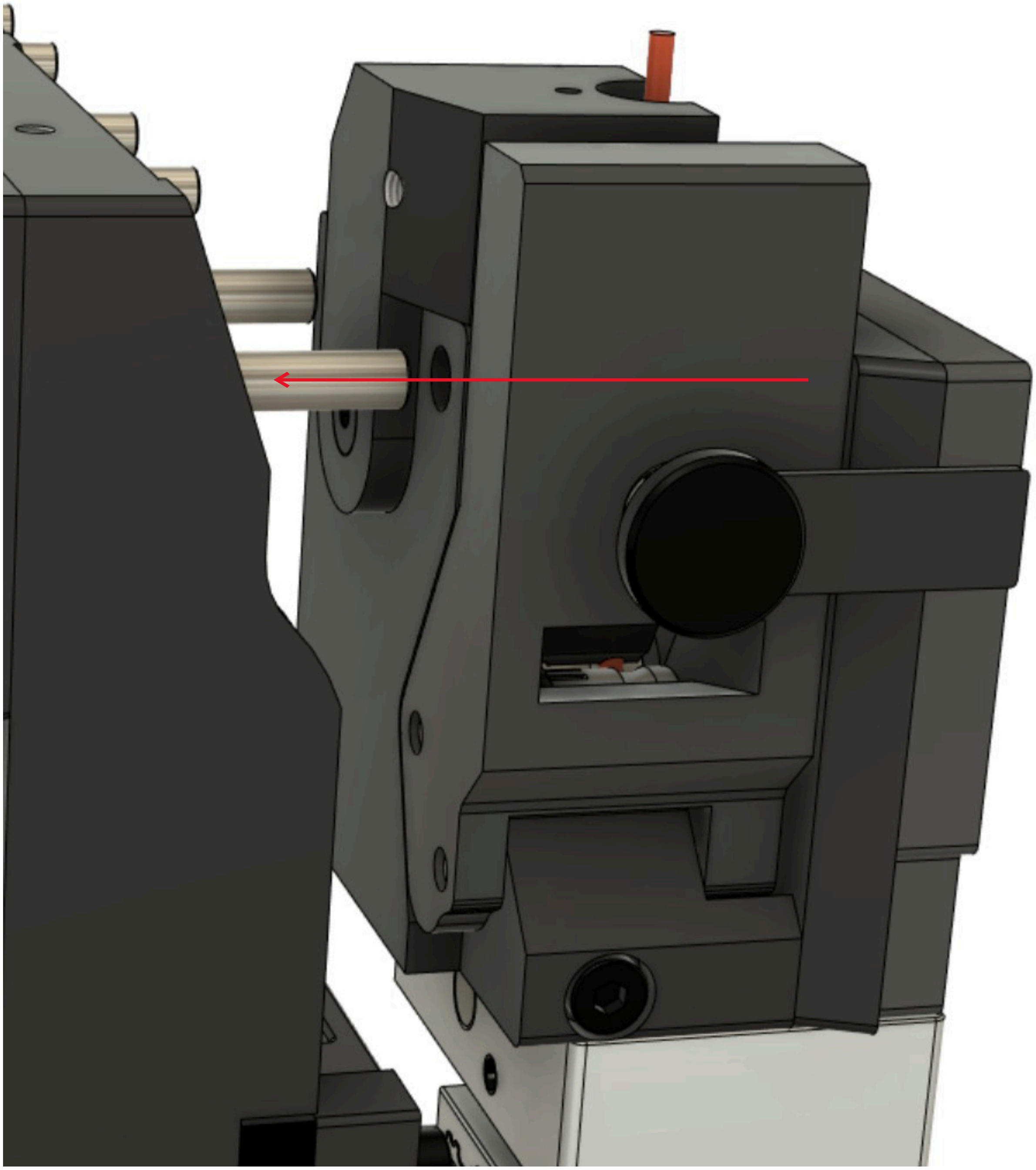
Going forward from here we will now be “marrying” a particular tool to a particular dock. This is because the adjustments made in the step may not be relevant for all tools.

A brief note on tool numbers:

When working in firmware tools have a zero-based index. This means that the first tool is referred to as “T0.” For the purpose of this guide (and general naming convention) we will use the name “Tool 1” when referring to the first tool, despite its true identifier in firmware being T0.

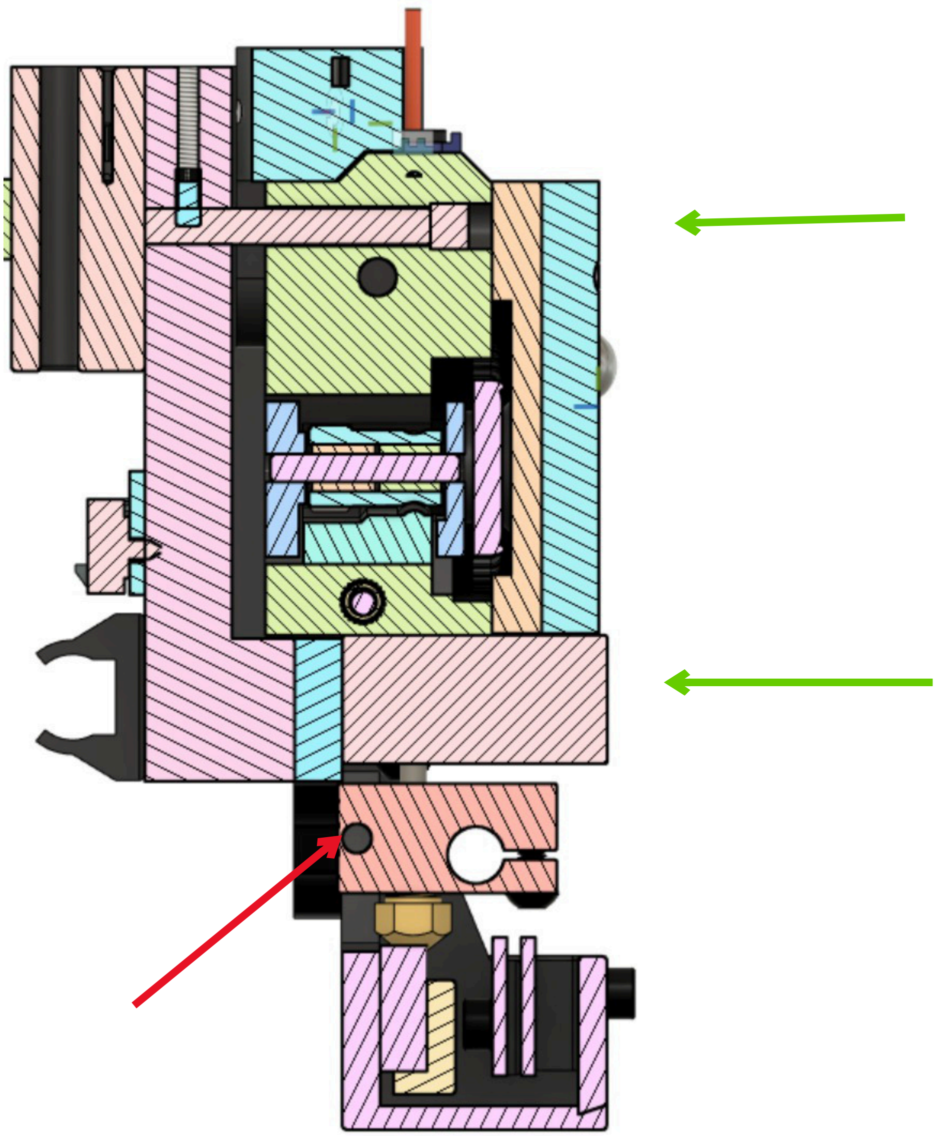


Begin by placing an assembled and adjusted tool onto a tool dock via engaging the 4mm shafts.



Attempt to seat your tool securely to the inward most possible position. This should take very little effort. Compare your tool's docked position to the following check list:

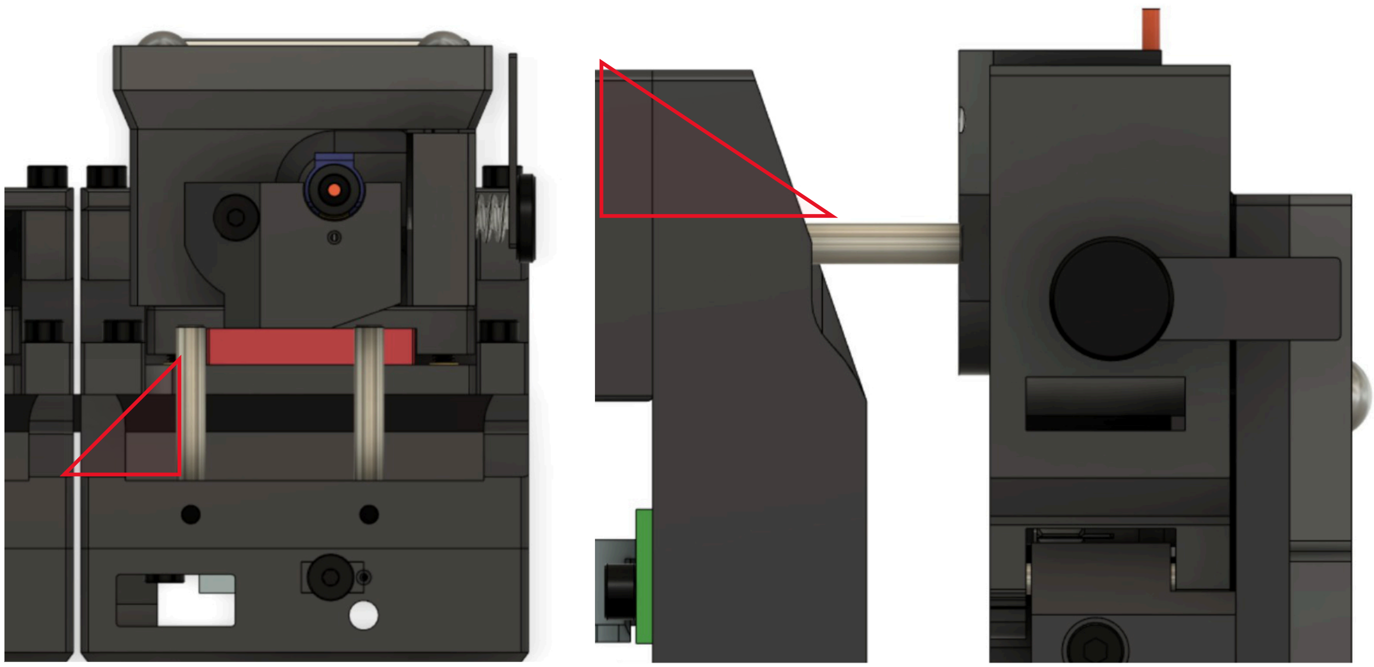
1. When approached squarely the tool should slide smoothly on the 4mm shafts. It's worth noting that our hands are not as precise as the motion system we just built. You may have to change your point of reference and/or angle of approach to achieve smooth motion.
2. As the tool approaches the inner most part of the dock a natural pulling force should begin to pull the two components together via the 3 magnetic contact points.
3. With the tool in its final docked position the tool cooler block should evenly contact the idle tool cooler bar, just as did the X-plate during the previous step's adjustments. See this location in Red below.
4. With the tool in its final docked position there should not be any resulting movement in the tool itself when light alternating pressure is applied to and of the locations shown in Green below.



If any of the above checklist items fail, see the corresponding tips below for troubleshooting guidance.

Test Point 1 failure:

1. Ensure that the 4mm shafts protruding from the tool dock are visually perpendicular to the face of the dock itself when viewed from both the side and the top of the machine.



2. Ensure that no contact is occurring elsewhere causing the binding. This can come from heater/thermistor wires out of place, a nozzle leak blocker set too high, ETC.

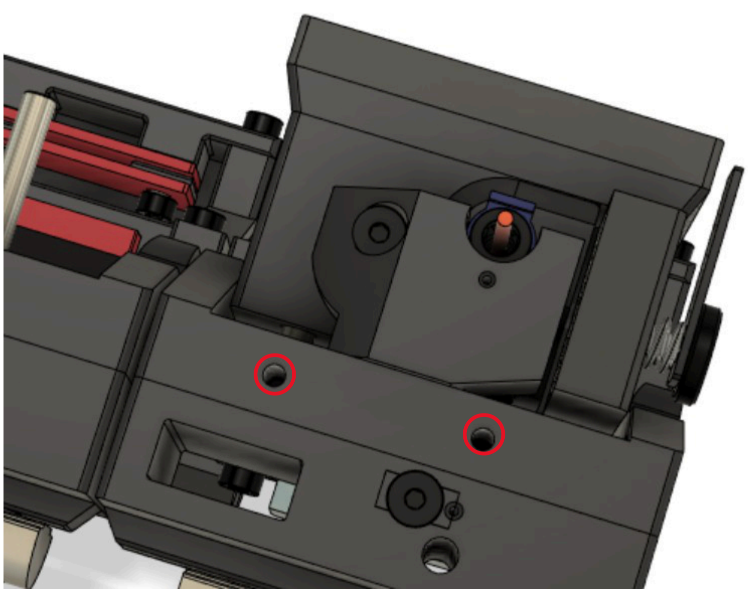
3. If all else is OK, use a 4mm or 4.5mm reamer to clean/expand the bores in the tool that accepts these shafts.

Test Point 2 failure:

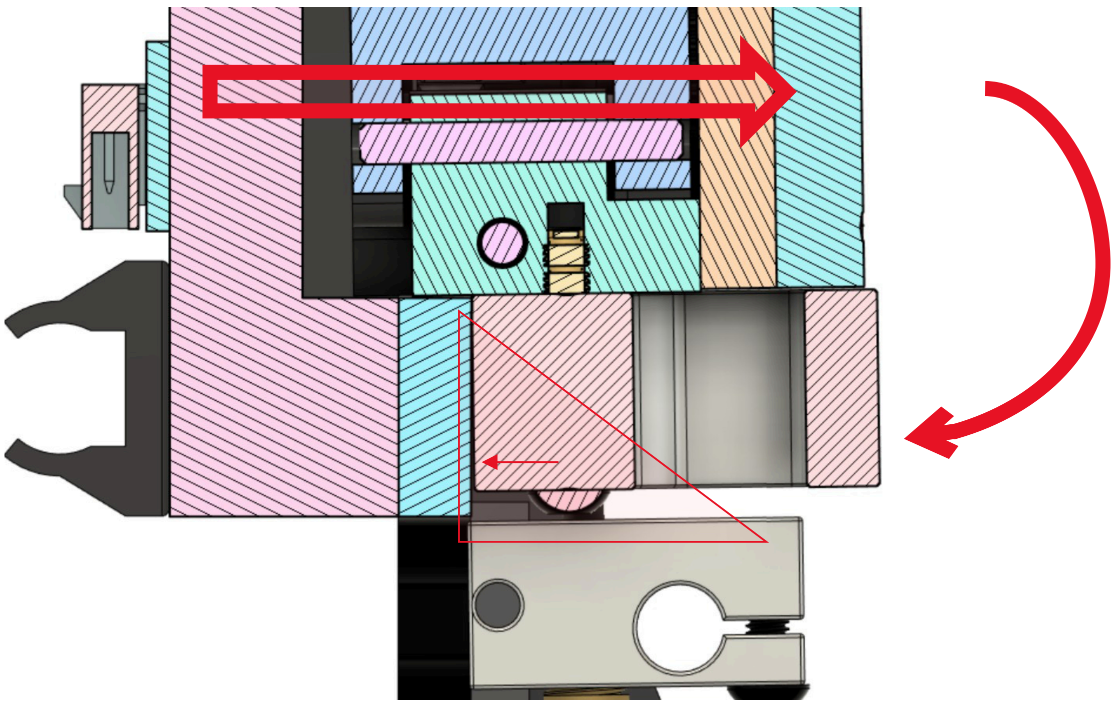
1. Test point one can be directly causing an issue in test point two!
2. The polarity between the lower 5x10 (dock side) and 5x4 (tool side) magnets may be reversed if the lower half of the tool has a resistance to seating. Due to the relatively high constraint offered by the 4mm posts this may not be obvious at first. If a polarity issue is confirmed the only serviceable magnet is the 5x10 type on the dock side. See the previous guide for information.
3. Ensure that no contact is occurring elsewhere causing the binding. This can come from heater/thermistor wires out of place, a nozzle leak blocker set too high, ETC.

Test Point 3 and/or 4 failures:

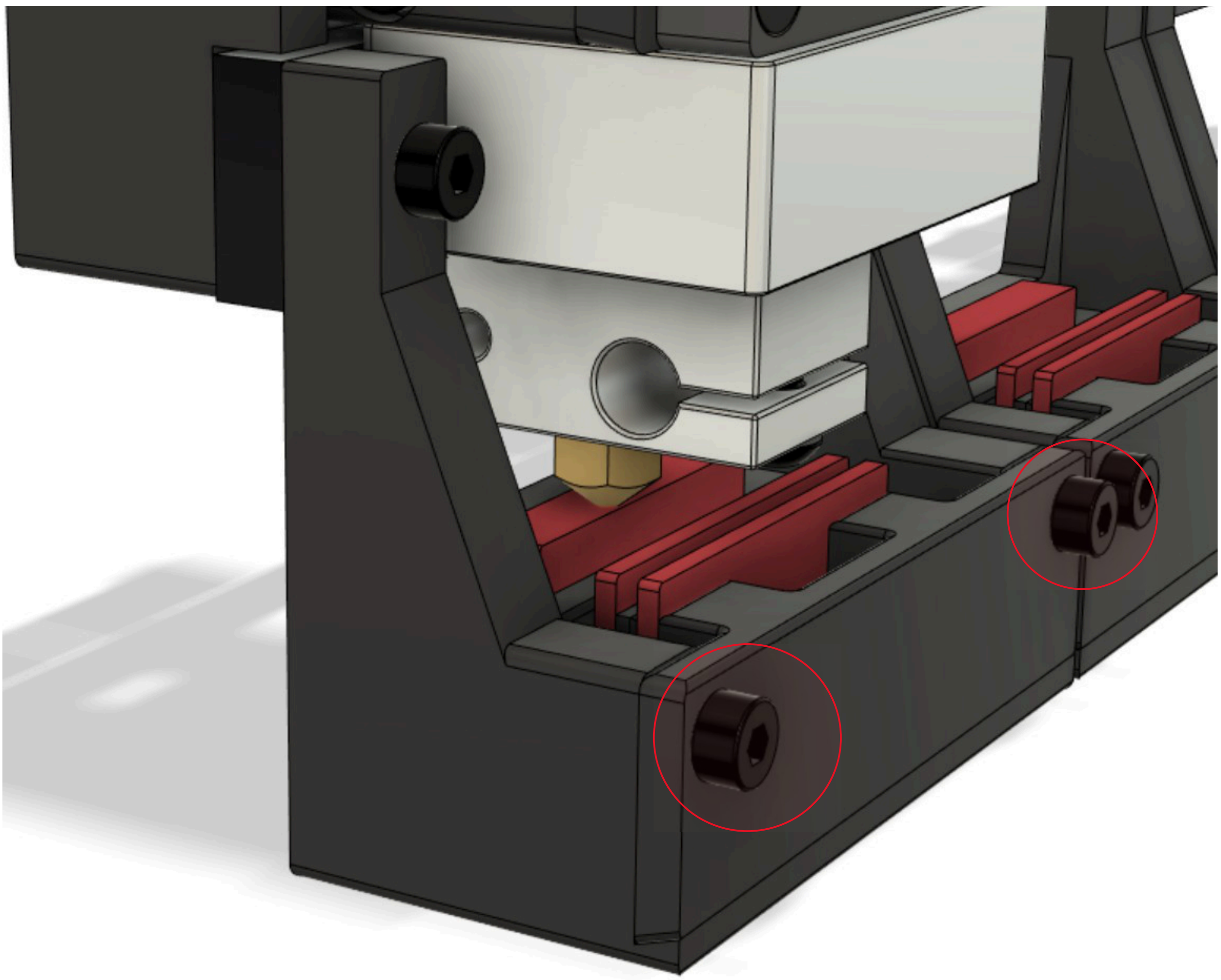
1. An adjustment exists for solving this issue in the form of adjusting the overall protruding length of each (or both) posts. Loosening the set screws shown in Red below will allow us to move the posts inward or outward to attain a proper 3-point plane for the tool when docked.
2. Use the below image to visualize the triangle of support that should be aimed for. The posts should ideally be of an identical length to each other resulting in perpendicularity to the X axis and frame. On some occasions printed part variations can force exceptions here.
3. The most important part of a properly docked tool is a flush point of contact between the Tool Cooler block and the Idle Tool Cooling Bar. Without proper contact here the cold block will accumulate heat and likely result in excessive drooling and/or clogs.



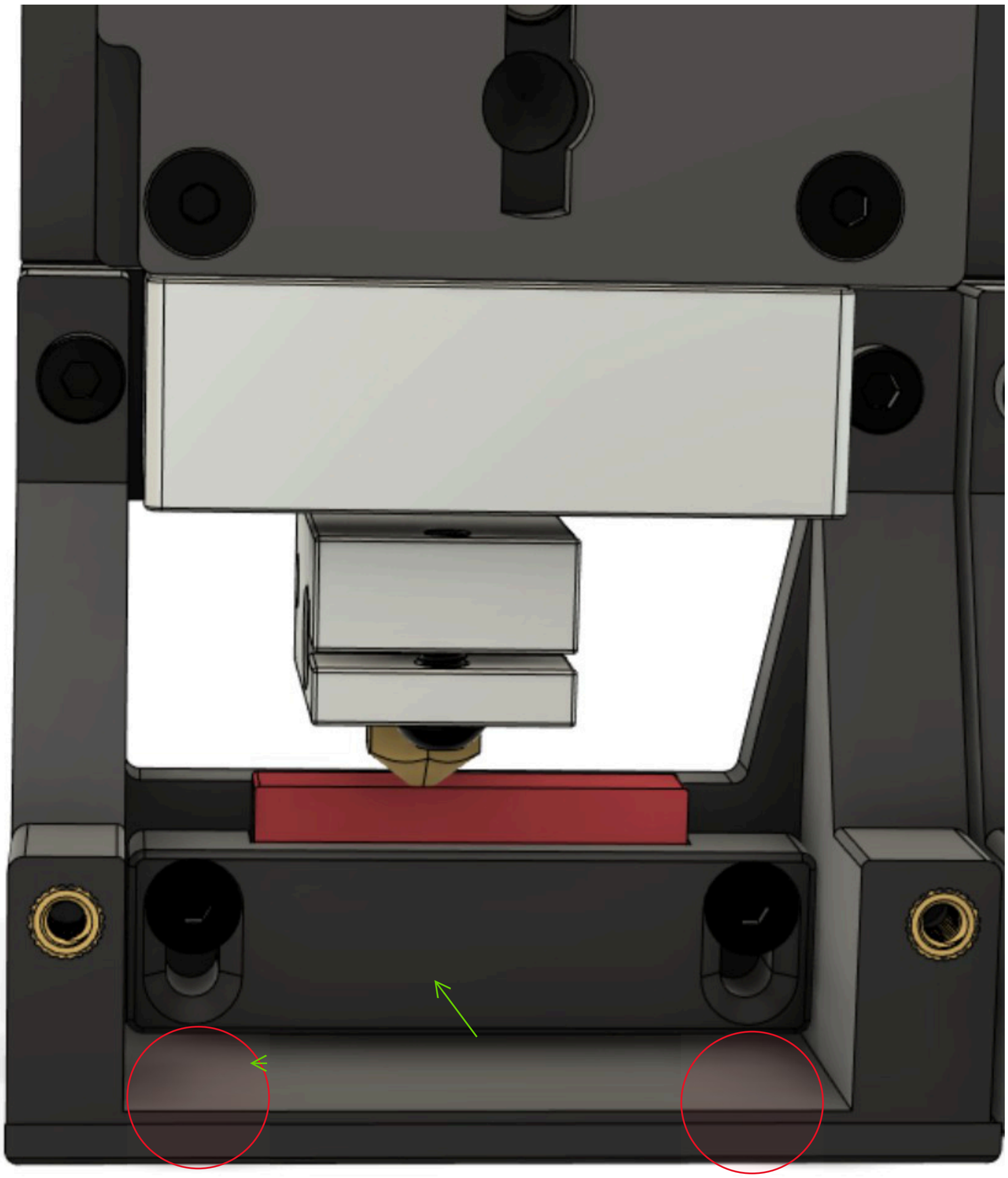
Example: This tool has contact only at the top of the cooling interface due to poor alignment. Moving the two upper posts outward by a uniform amount solves this.



Set the height of the leak blocker and nozzle wipers by first removing the fasteners and nozzle wiper assembly shown below:



Loosen the shown fasteners and adjust the height of the leak blocker. It is only recommended to raise the leak blocker until it just begins to contact the nozzle face. If too much height is added the tool will not dock properly. Retighten the fasteners to lock in place and confirm the tool can be installed and removed by hand with no excessive leak blocker contact.



Perform the same adjustment to the nozzle wipers before reattaching the nozzle wiper assembly to the tool dock.

Step 4 – FDM Tool Umbilical

There are very few wires/connections that connect directly to each tool. In totality they are:

1. Bowden Tubing (reverse) for filament feed path.
2. Thermistor wiring (2 circuits)
3. Heater wiring (2 circuits)
4. Spring steel wire for umbilical “hoop” support

During this guide we will be installing items 1 and 4.

CAUTION: Working with spring steel music wire can be dangerous! With inherently sharp edges and unpredictable movement it is important that you exercise safe handling practices.

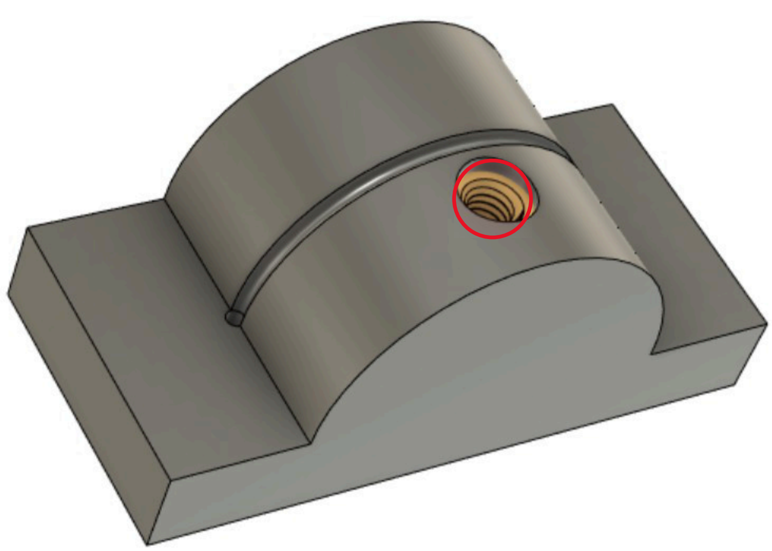
Begin by preparing a 1 meter length of Bowden tubing for the tool being installed. Only one end of the tubing needs to be cut with a clean and square face (the side that will interface with the tool)

Prepare also a 65cm length of spring wire.

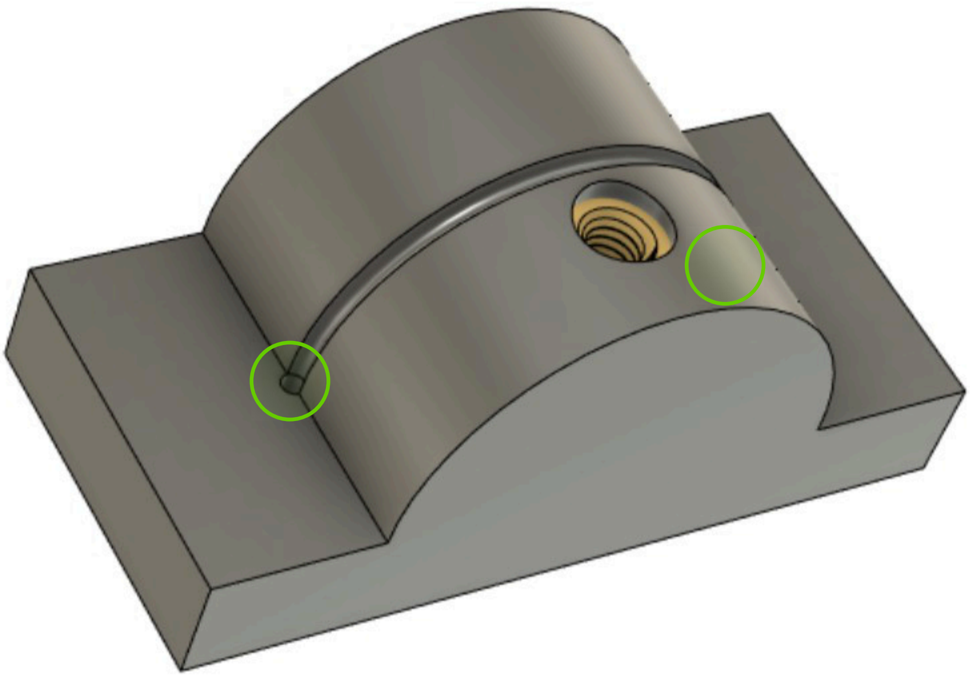
TIP: Spring wire is supplied most often in the form of a wire coil. Click here for a YouTube video that shows very nicely a process for straightening this music wire without expensive tools. We will need a straightened length of wire to begin this process:

Locate the mid-point of the 650mm spring wire length and mark the mid-point.

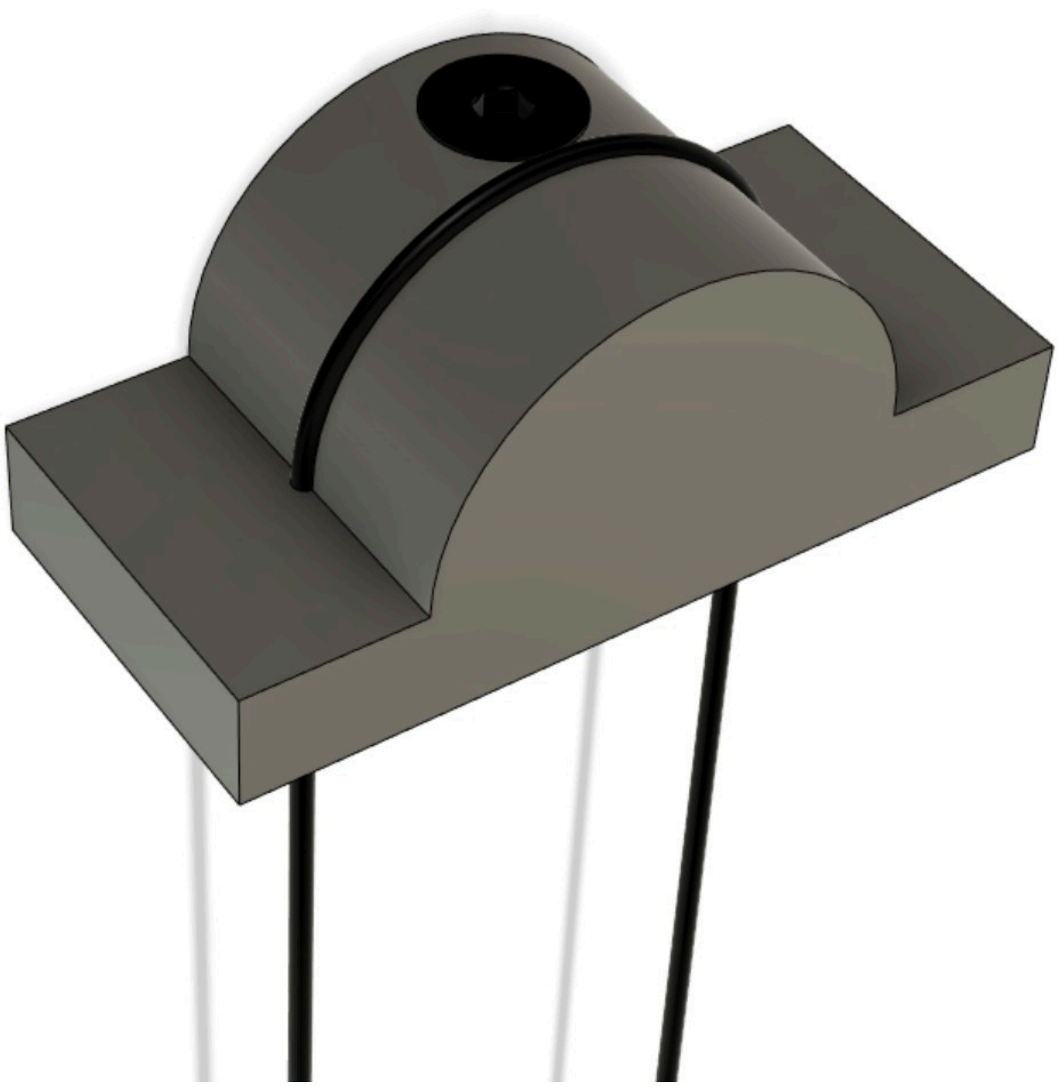
Locate Spring Wire Tool Printed Part A and install an M3 heat set insert into the shown location at a depth of 1mm beyond flush.



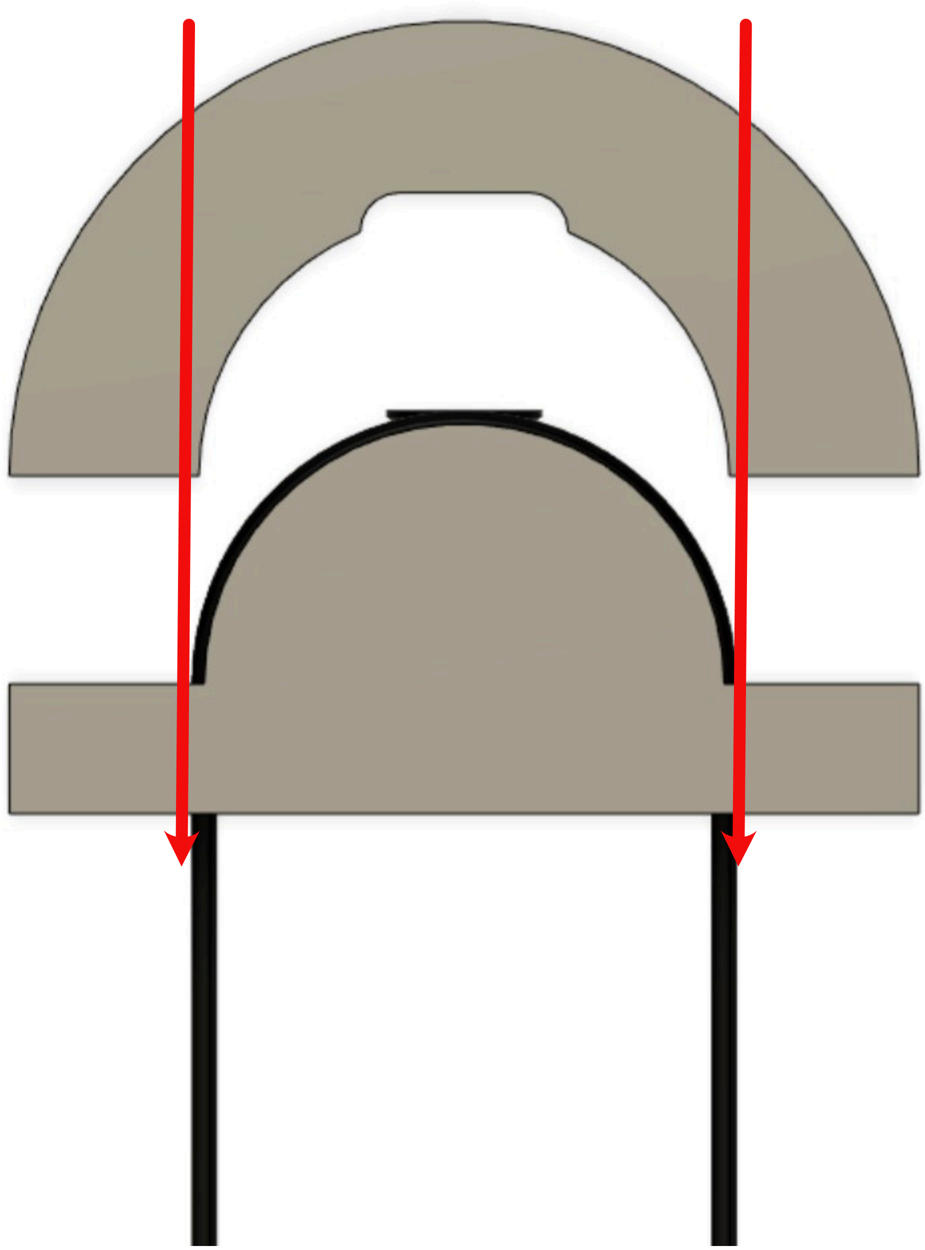
Feed both ends of the spring wire through the printed holes shown in green below.



Align the previously marked mid-point of the spring wire with the previously installed heat set insert and install an M3xN FHHS fastener (length is unimportant) to secure the wire to the printed tool. Pull any excess spring wire through the body of the printed tool.



Use Spring Wire Printed Tool Part B to force a radius into memory of the wire as shown below:

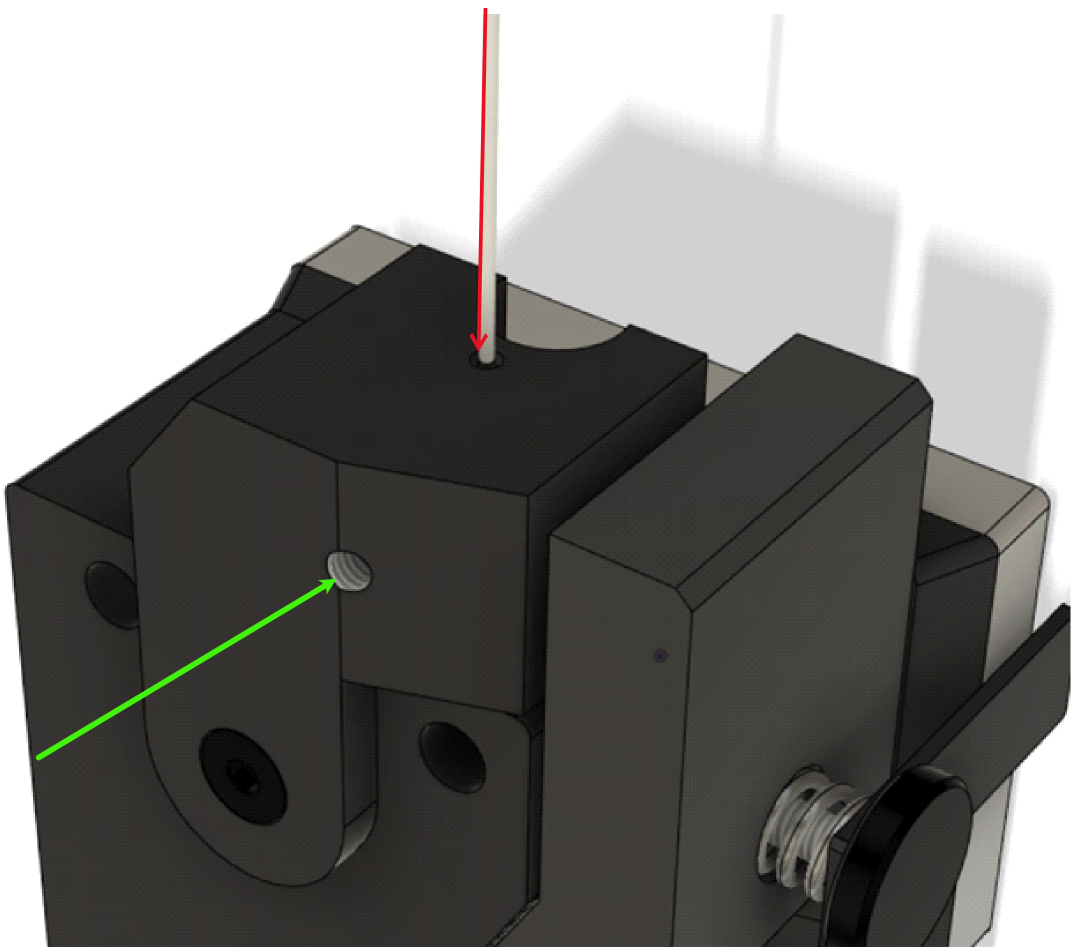


Release the tool and remove the spring wire from the printed die. The newly introduced radius will serve as the peak of a tool's umbilical cable. Don't worry if the wire legs are not parallel after this process. They don't have to be.

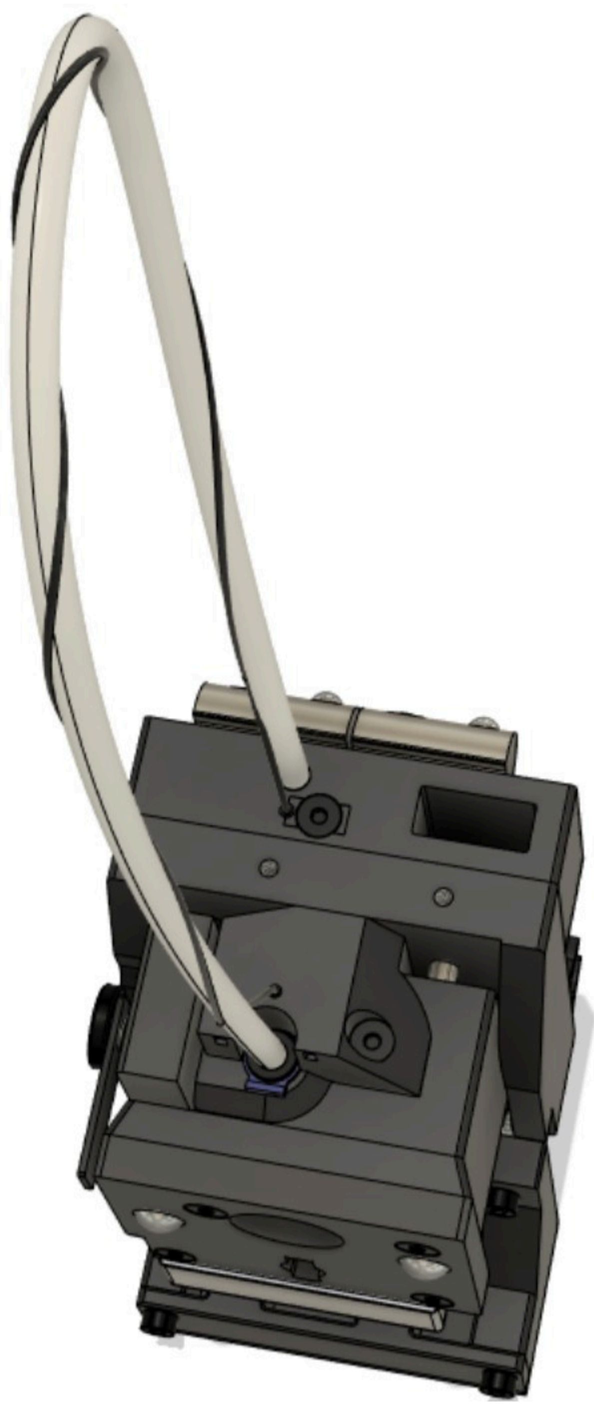
Insert the squarely cut end of the previously prepared Bowden tubing into the coupling on top of the FDM tool. Be sure to seat completely. Insert a small tie-wrap into the printed channel shown in green and secure – pulling the Bowden tube against the FDM Tool Part 04.

Feed the other end of the Bowden tube into the below shown pass-thru bore in the dock to which this tool has been adjusted to fit. The length on either side of the tool dock spacer is not yet important.

Insert one end of the previously prepared spring wire into the FDM tool bore shown in red. Secure in place using the previously installed set screw shown in green.

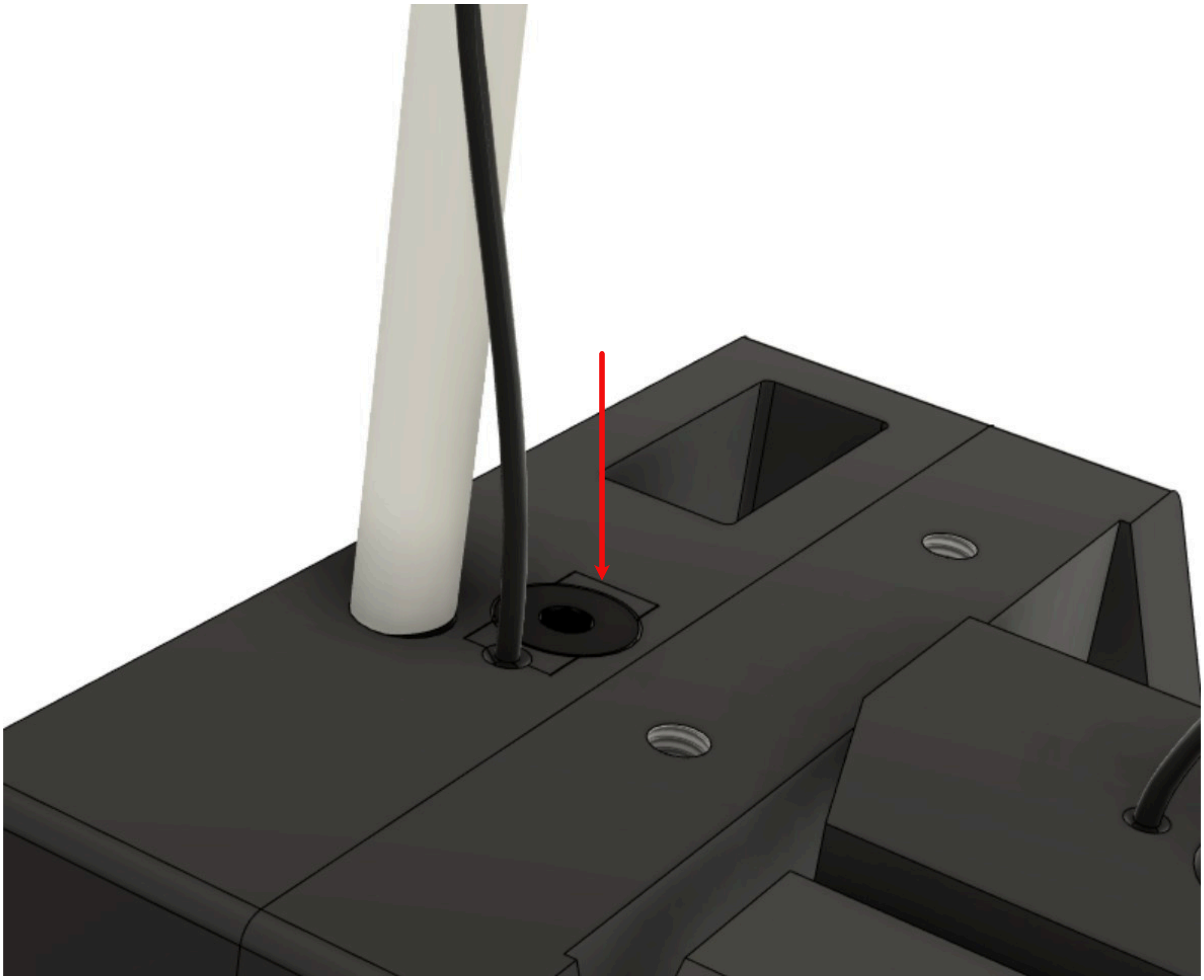


Wrap the spring wire around the Bowden tube 4-5 rotations as shown in the image below. Maneuver the Bowden tube when positioning the peak of the spring wire where we previously introduced a radius into the wire's memory.



Raise the FHHS fastener and wire retention printed part and insert the remaining loose end of the spring wire into the bore located on the top of the associated tool dock spacer.

Push down on the FHHS fastener (and thus the retention piece) while holding the spring wire in place. Tighten the FHHS. This will arrest the spring wire.



Here is an image for reference demonstrating the overall shape of umbilical hoops when a given tool is docked.