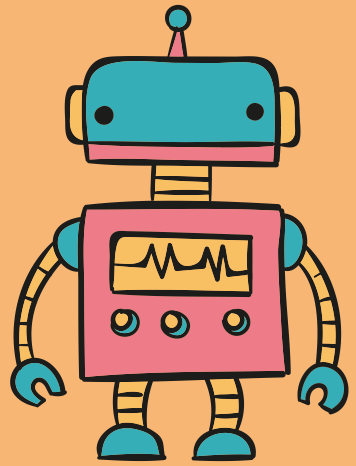
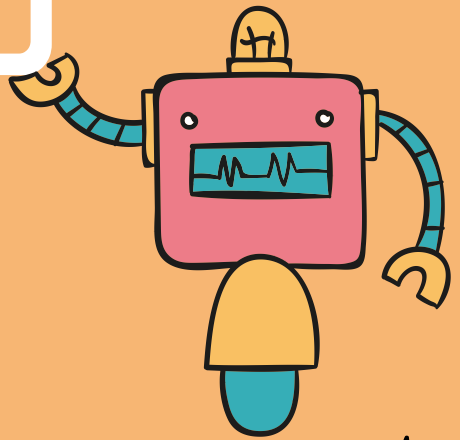
1024 Ninjas

Reverse Engineered 3D Printer



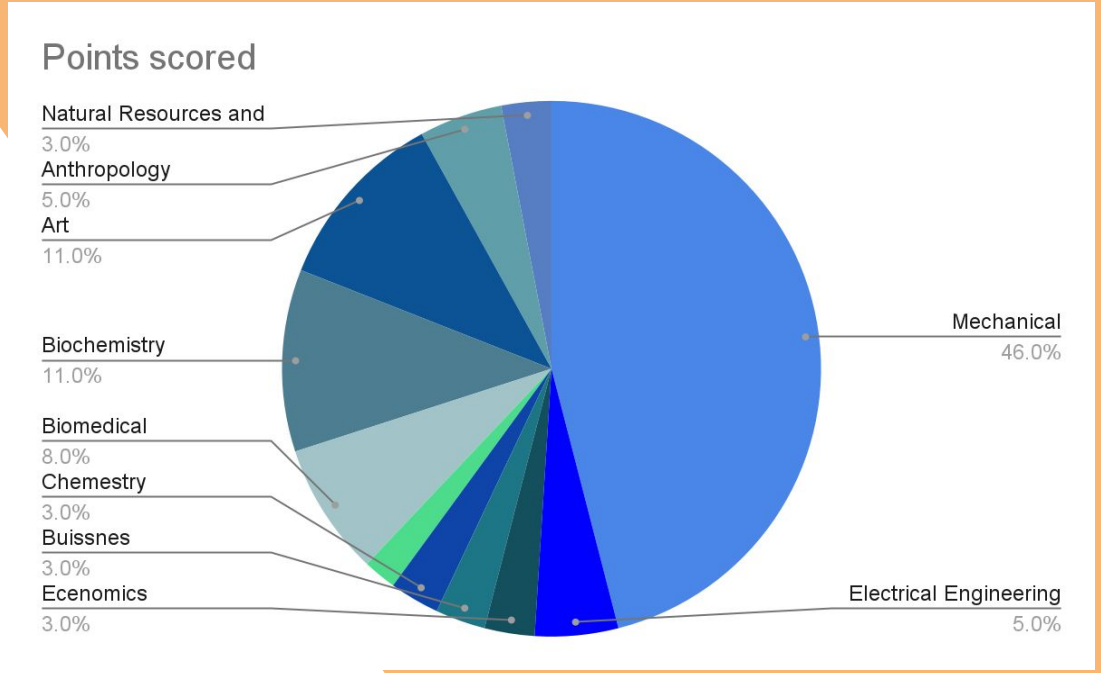


By: Liam Welty from Indianapolis, Indiana

WHY CHOSE A 3D PRINTER?

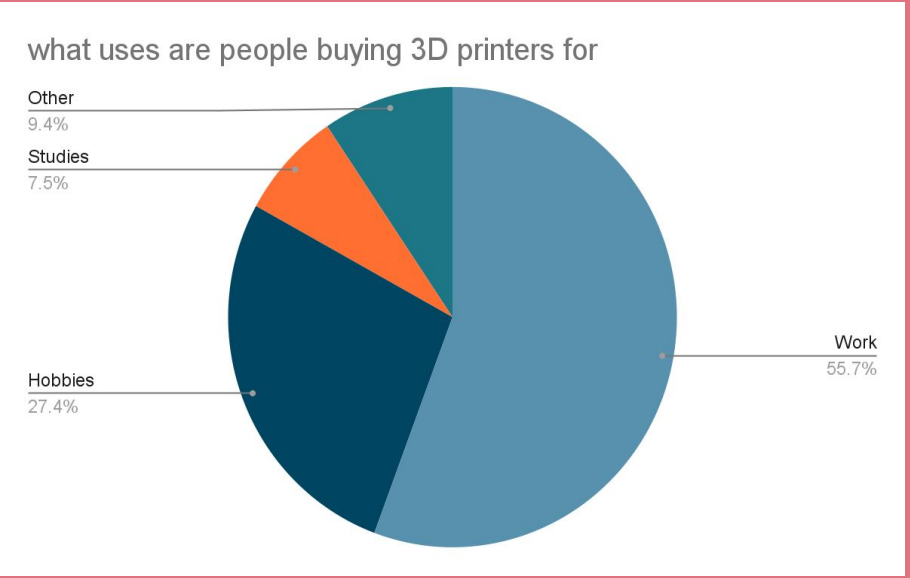
We chose to deconstruct a 3D printer for our reverse engineering challenge. We believe that 3D printers are the future of many different industries which is why we chose them. For example, 3D printers are being used in the construction industry, the manufacturing of medical equipment, the automotive industry, and many more. Their versatility was what made us so interested in them and how they work. They are so versatile, that they have been used to print houses out of concrete, but then they are still used to make little trinkets and pieces of medical devices. Although not an item that most people use in their day-to-day lives, it has been used to help improve so many people's lives without them even knowing it.

JOBS THAT USE 3D PRINTERS



This chart was made to show the percentages of different industries and how common/often it is that they use 3D printers. The industry with the highest percentage was Mechanical Engineering with 46%. The next largest is Biochemistry and art at 11%. Lastly. Biomedical engineering had 8%.

WHY ARE PEOPLE BUYING 3D PRINTERS?

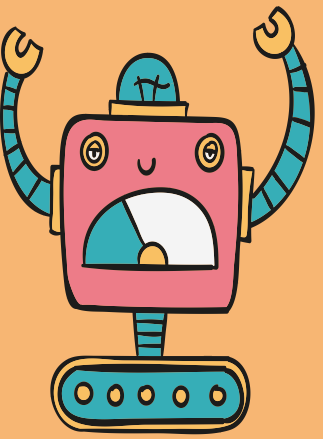


This graph shows that the majority (55.7%) of the people who are buying 3D printers are using them to help as a part of their job. About a quarter (27.4%) of the other people who bought 3D printers are using them for hobbies. 7.5% of people are buying them to help with their studies.

What are some innovations made using 3D printers

- People are working on 3d printing living organs for organ transplants. This is done by instead of using a plastic-based filament they use collagen. Collagen is the protein that holds cells in your body together so it is a great option due to its stability. So far they have been able to 3D print kidneys and they are developing a way to 3D print hearts. This could make the problem of the lack of organs for transplant a thing of the past.
- In Israel, 4 universities have partnered together to work on 3D printing coral reefs. They do that by scanning coral reefs then those scans are put into a database and they can then use that data to create ceramic structures. With these structures not only does it give a place for fish and other animals to live in the ocean but it also gives the corals a place to attach onto and grow which will hopefully restore the reefs.

SAFETY DURING DECONSTRUCTION



1. Luckily we do not have to worry about electrical shock from any of the components because there is no battery and the machine will be unplugged before we begin deconstruction.
2. One thing we do have to make sure to be careful about is making sure not to get cut from sharp edges on the base and insides of the printer.
3. We also will need to keep in mind of the weight of this machine because this machine is so heavy that it could hurt you if you got your finger or other body part stuck underneath it.

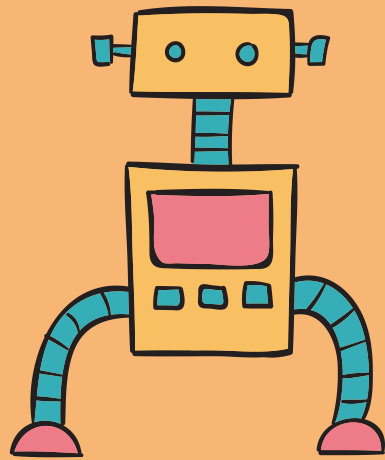
OUR 3D PRINTER BEFORE DECONSTRUCTION

THIS IS THE STRATASYS MOJO 3D PRINTER

THE DIMENSIONS OF THE STRATASYS MOJO 3D PRINTER ARE 25X 28X 21 IN. IT WEIGHS 27KG.

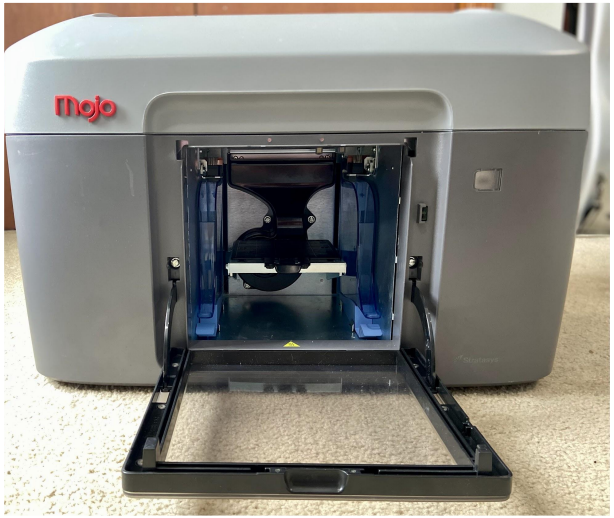
THE AVERAGE PRICE OF A STRATASYS MOJO 3D PRINTER IS $5,999.

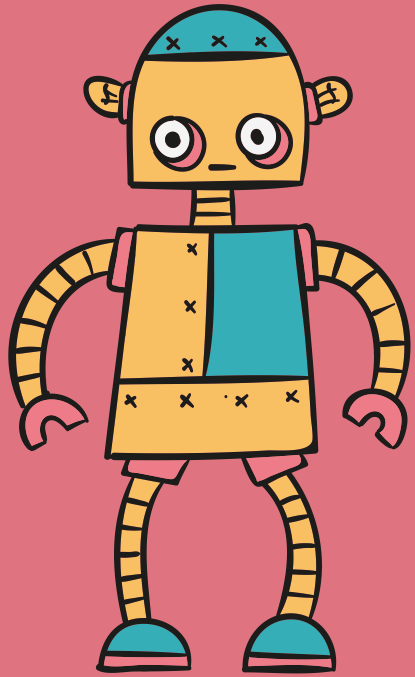
LID OF 3D PRINTER



- THIS LID IS MOVED VIA A HINGE

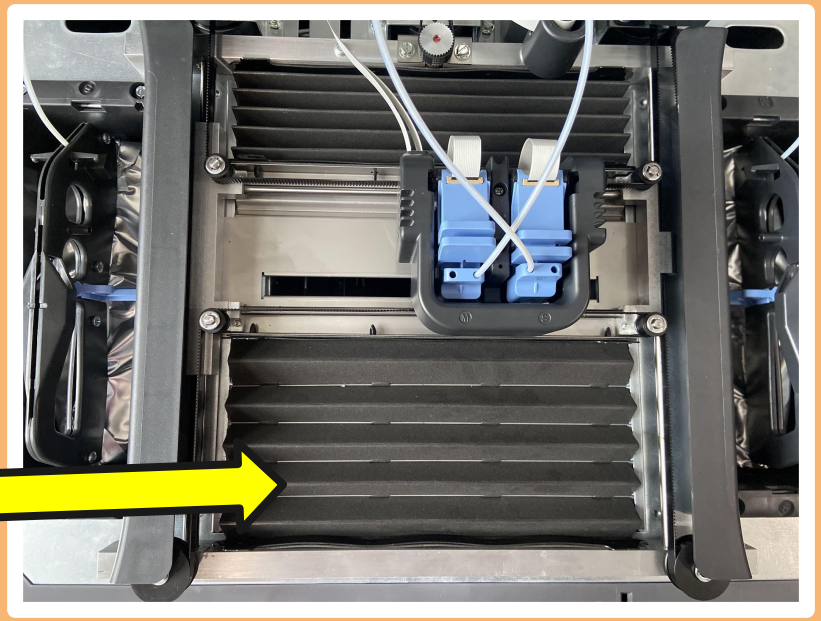
FRONT DOOR





- This front door is moved via a hinge

PERFORATED FABRIC

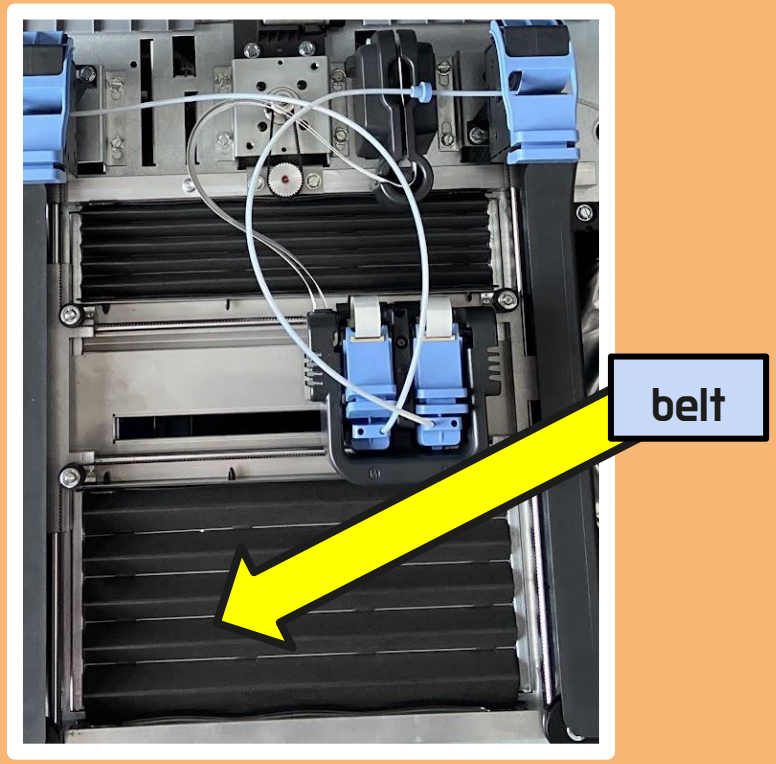


Perforated fabric

Thai fabric is used to keep the toxic fumes that the filament creates contained.

- This fabric is not moved by a mechanism but follows when the nozzle moved

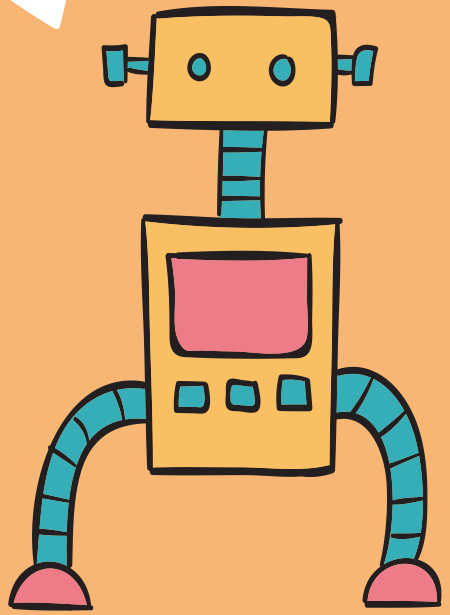
BELT

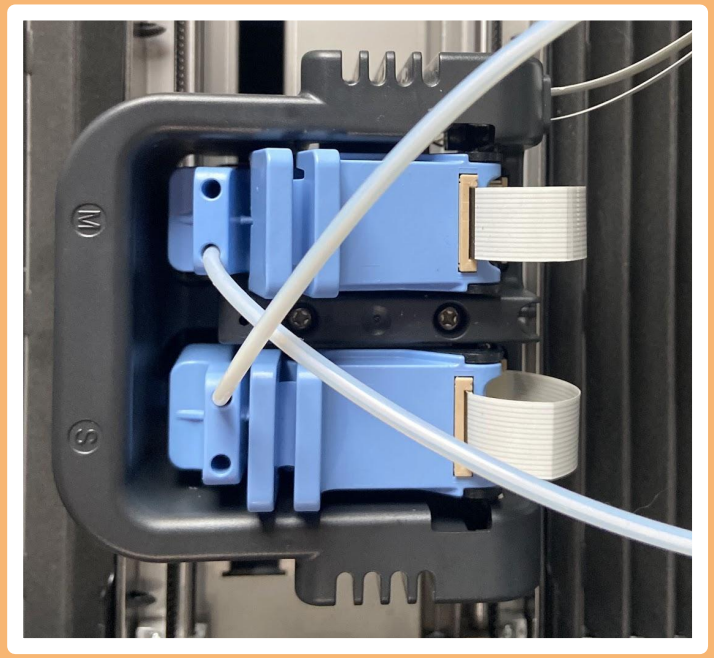


The belt is what moves the nozzle around the whole top of the printing surface.

- The belt is a pulley system powered by a motor with a sprocket that the belt is attached to

NOZZLE

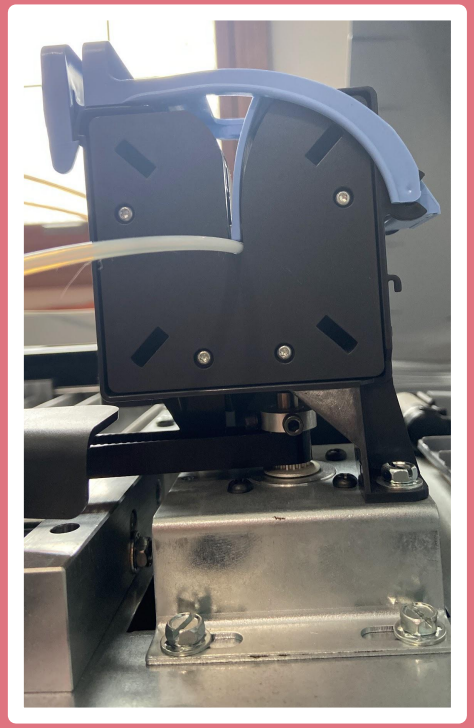




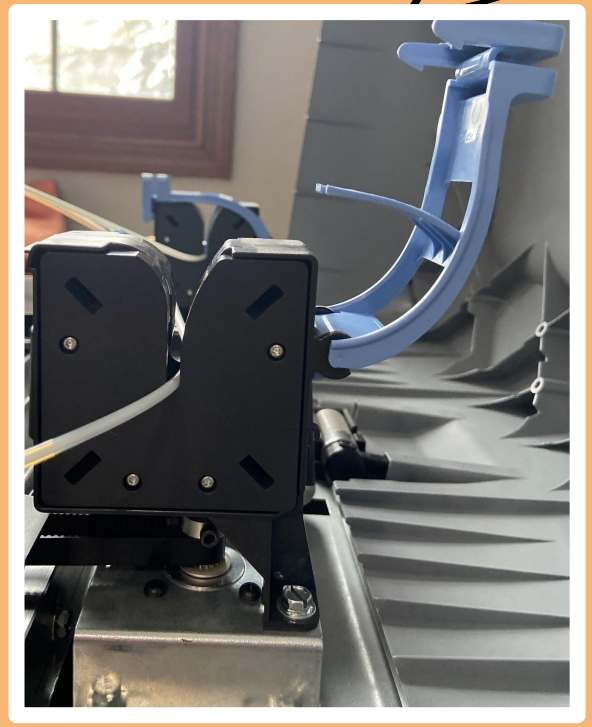
The nozzle is what creates each layer of your project to make the final product.

- The nozzle is attached to the belt so when the belt moves the nozzle move with it. It heats up from an electrical current running and the electricity transfers to heat

FILAMENT THREADER

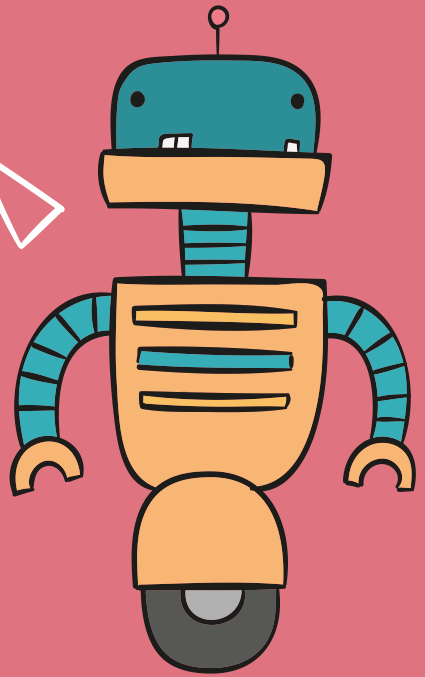


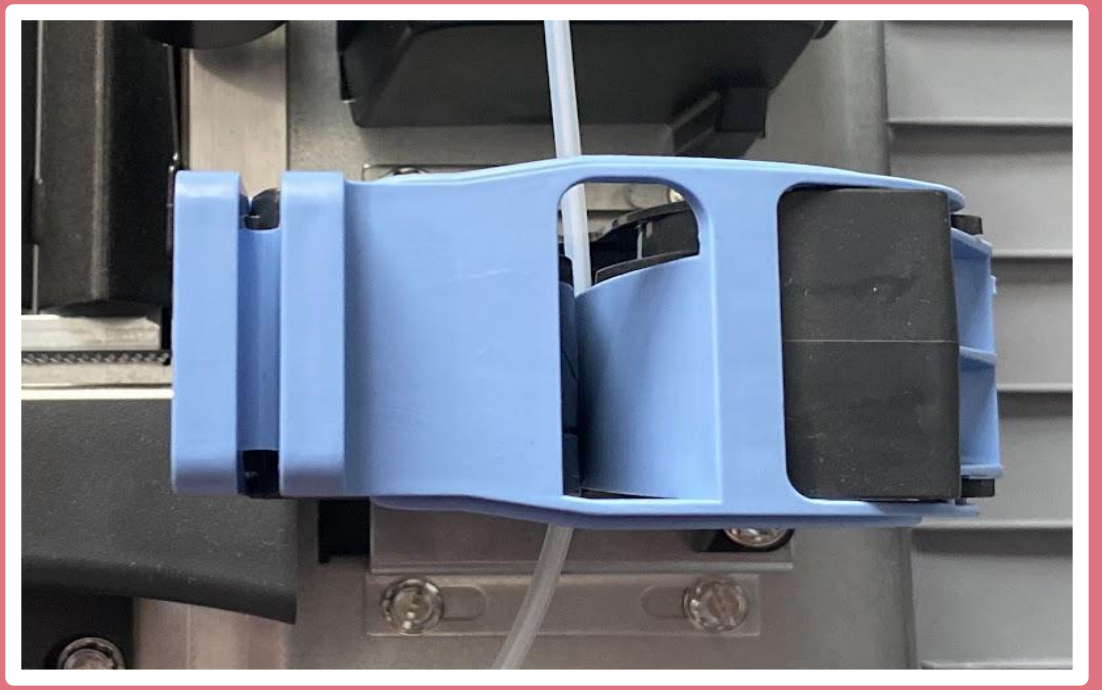
The filament threader helps to organize the filament going into the nozzle. It also acts as a cover for the motor that moves the belt.



- The filament threader like the door opens via a hinge.

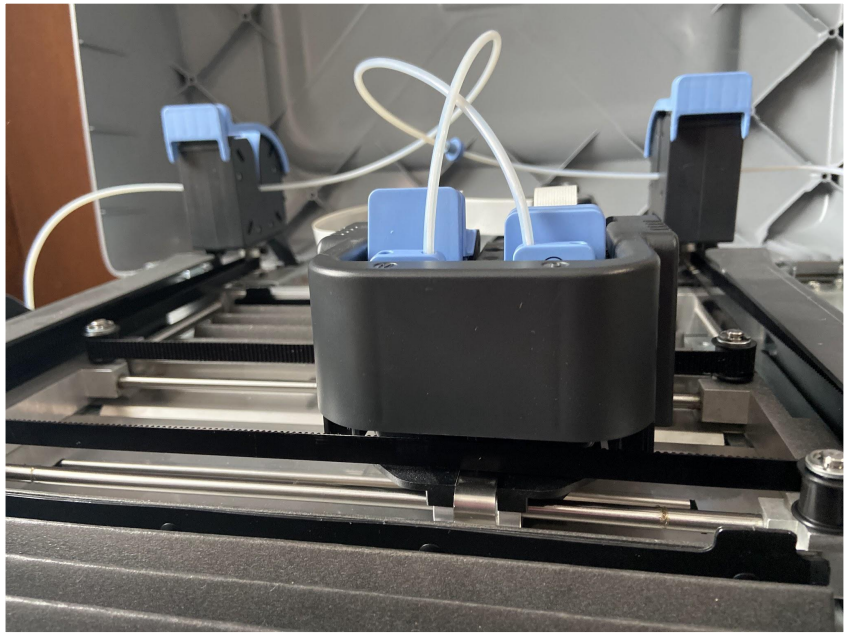
BELT MOTOR

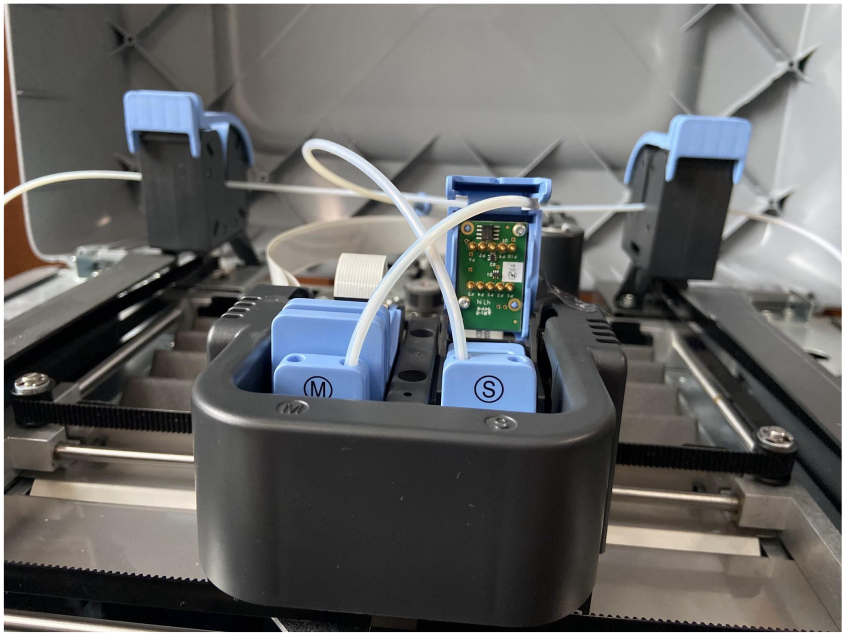




- The belt motor powers the belt to spin using a 1 to 1 gear ratio.

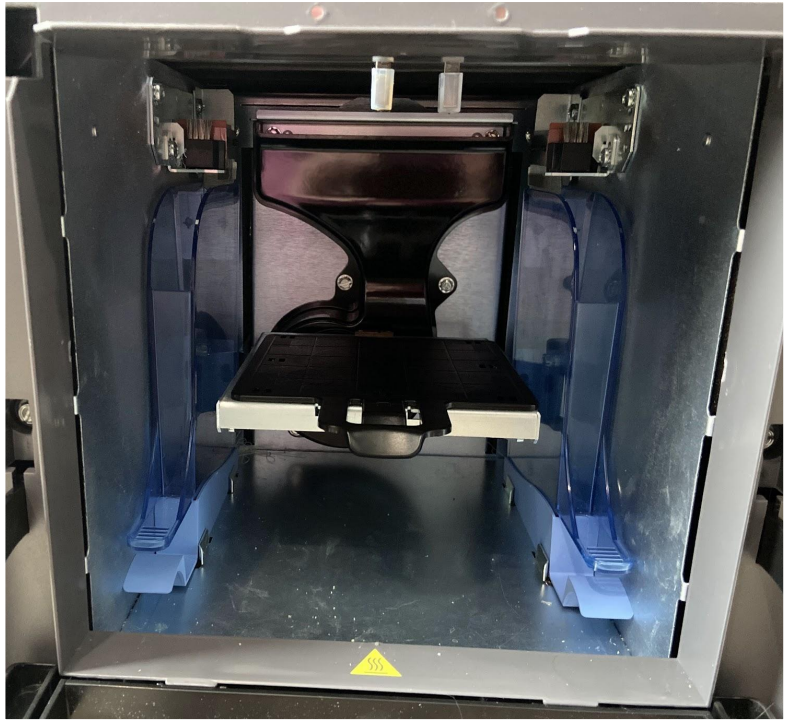
HEAT ADJUSTMENT





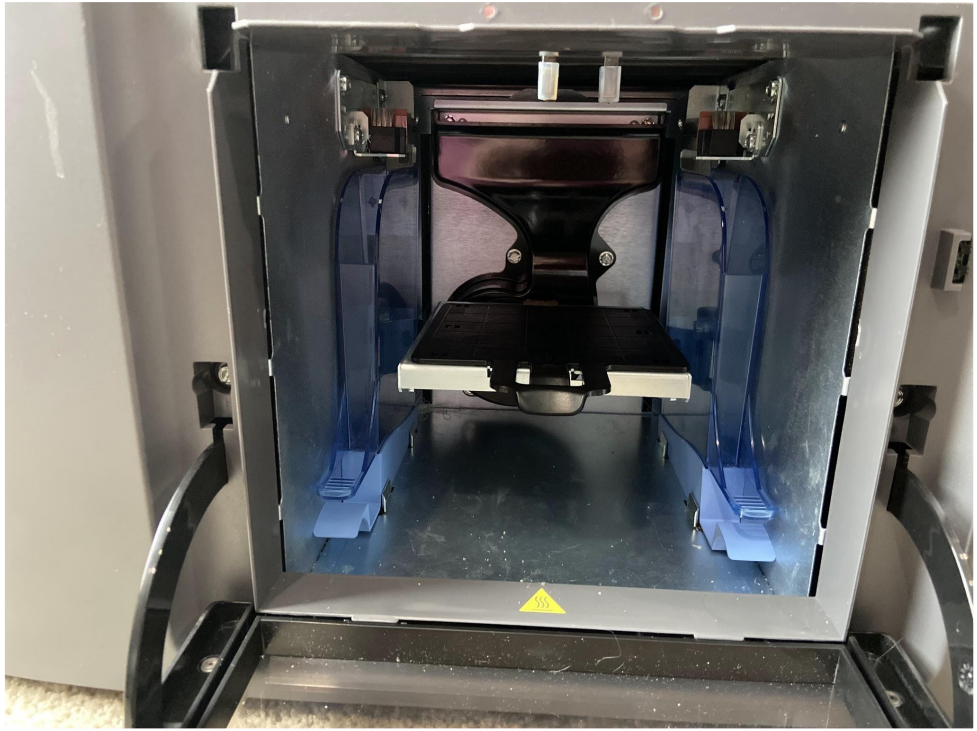
- The heat adjuster allows you to adjust the heat for different types of filament on each nozzle .

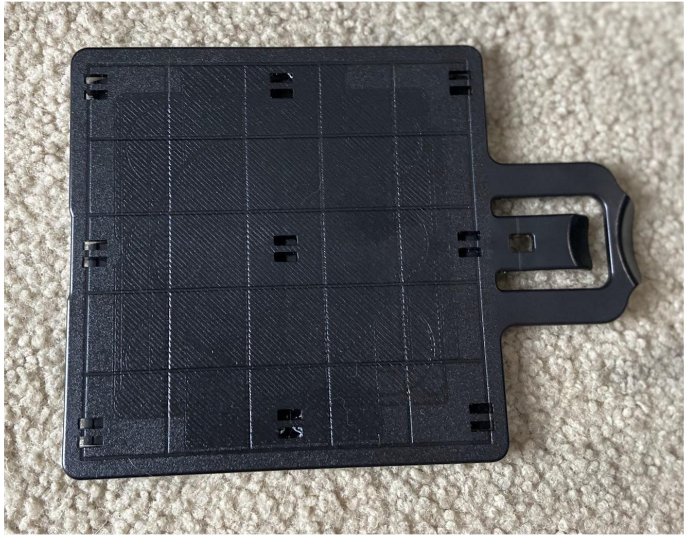
PURGE BUCKET



- The purge bucket is connected to the inside via a latching mechanism. Its role is to collect the scraps from the 3D printing process

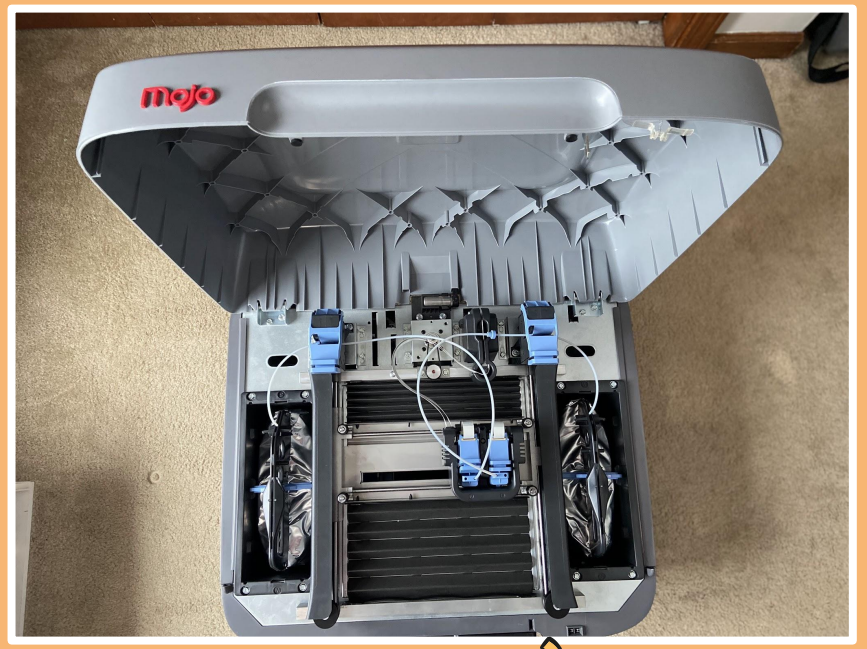
TRAY +

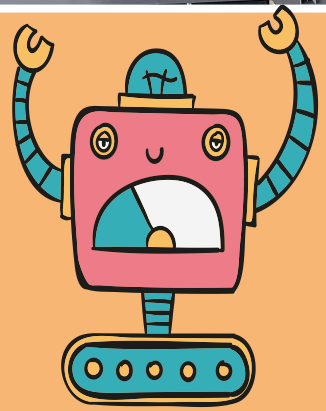




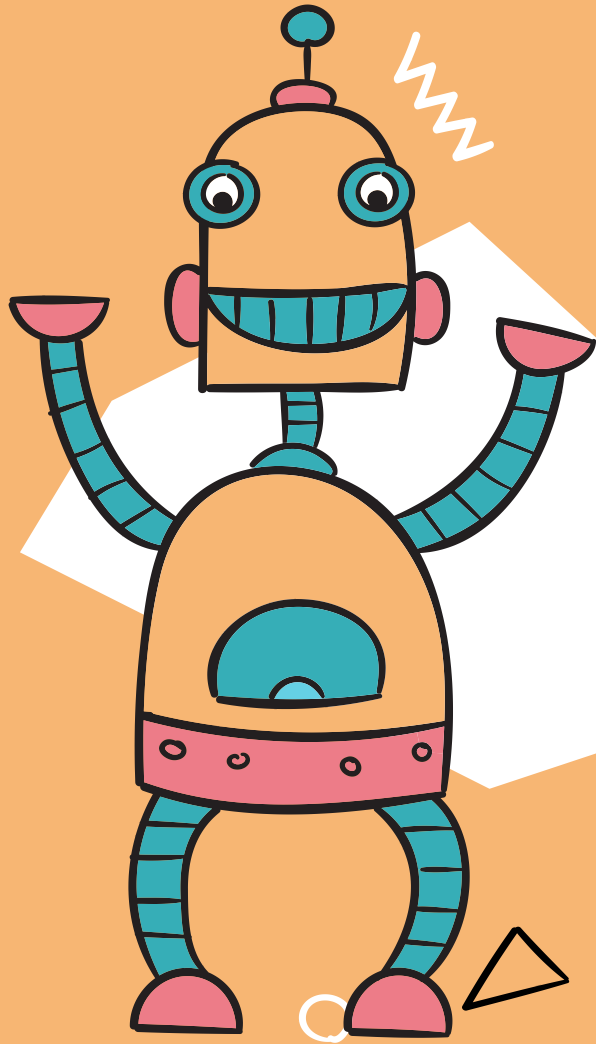
- The tray is connected by a latching mechanism too. It is what your project prints on.

Top View





FRONT VIEW

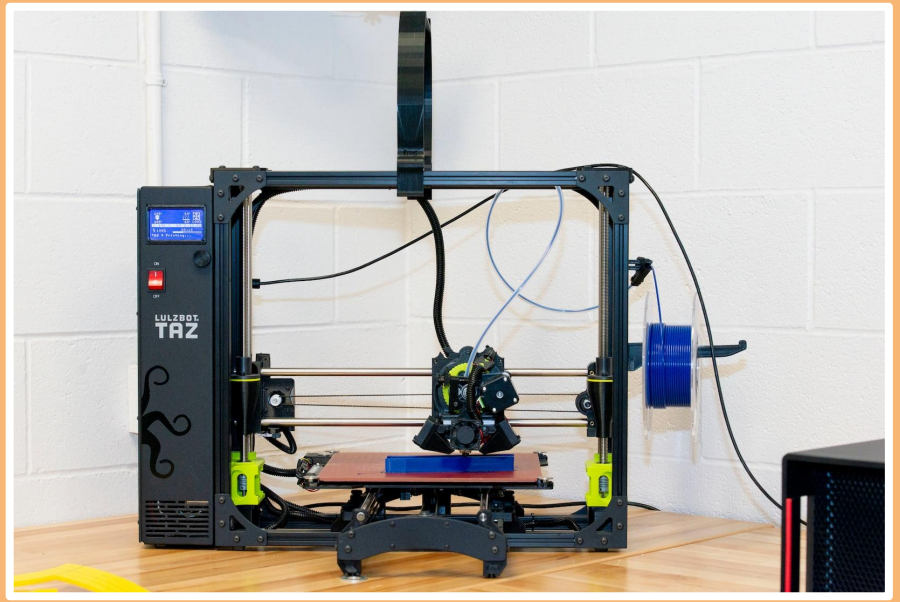


RIGHT VIEW

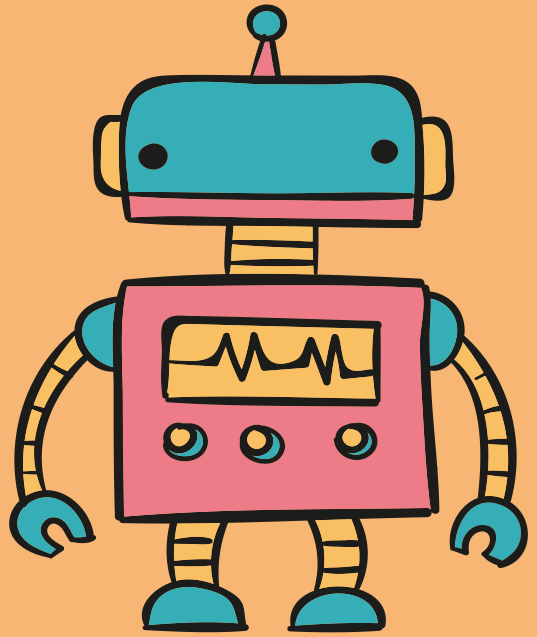
HOW DOES A 3D PRINTER WORK?

A 3D printer goal is to create a physical 3D model of what you're trying to make.

- Upload your online model onto the printer
- The filament heats up
- The filament is then fed into the nozzle
- The printer finally creates your project layer by layer from the bottom up

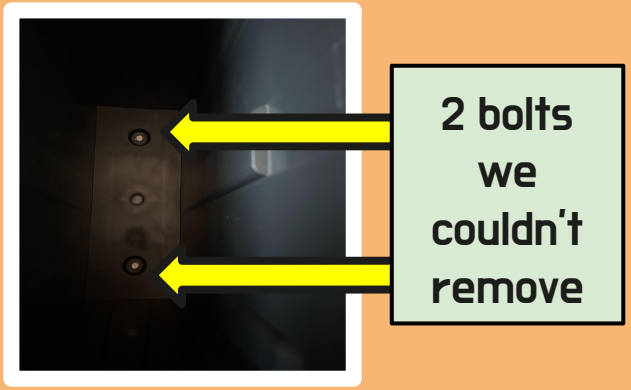


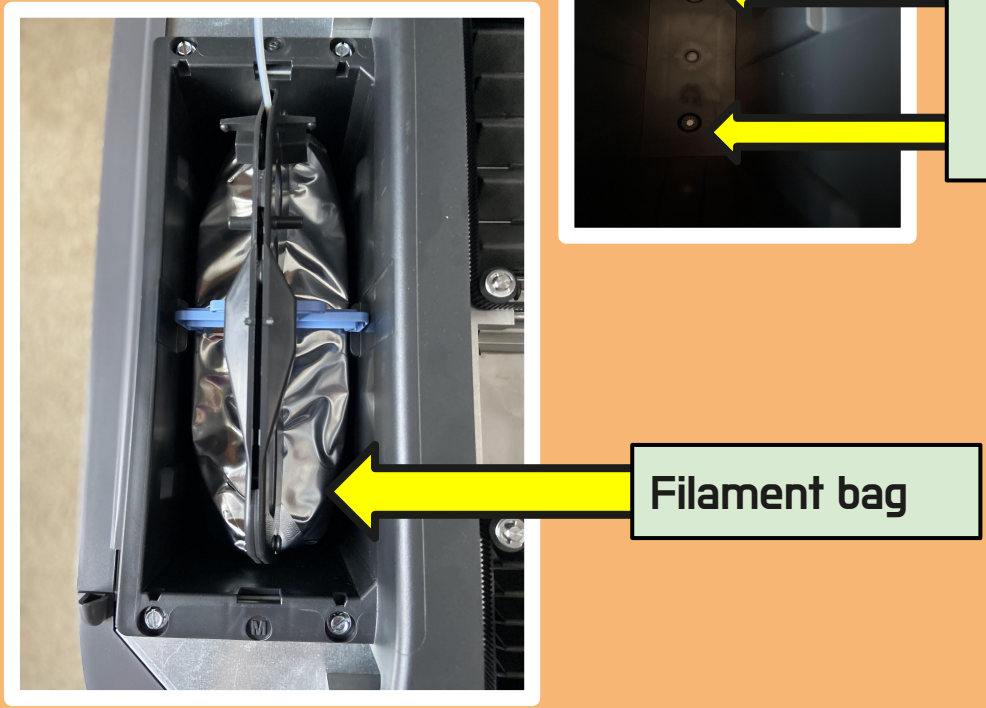
THE PLAN FOR DECONSTRUCTING



1. Taking off filament bags and filament bag holding boxes.
2. Removing the belt and nozzle.
3. Removing metal plate that is on the top of the printer.
4. Taking off the rails and belt motor area.
5. Disconnect lid, back plate, and side panels.
6. Remove and organize electronics.

Step one : taking out filament holder





We first need to start by taking the filament bag out.

The next thing that we do is remove the 4 screws on the 4 corners of the plastic piece. That's when we found that there are two bolts at the bottom of it connecting to the bottom of the printer. So we tried using a wrench to get them but it was to big because there is a dip that the bolt is inside. We then tried using pliers because they are smaller to get them out but it also didn't work and we don't think that they are able to come out so we decided to go onto the next step.

STEP 2 : TAKE OUT BELT AND NOZZLE

Two screws were removed from the middle of the nozzle cover to remove the shell around it. That exposed the components of the nozzle

2 screws were removed from the back of the nozzle area.

The belt was then disconnected from the nozzle area by untwisting the two connection points.

The perforated fabric was then removed by taking out 10 small plastic pins on each sides that connected the fabric to the metal frame.

The nozzles were removed from the frame they sit on. The filament was still connected to the nozzle. In result the filament was cut with wire cutters.

STEP 2 : CONTINUED

The filament bags were then removed by taking them out of its holding bin.

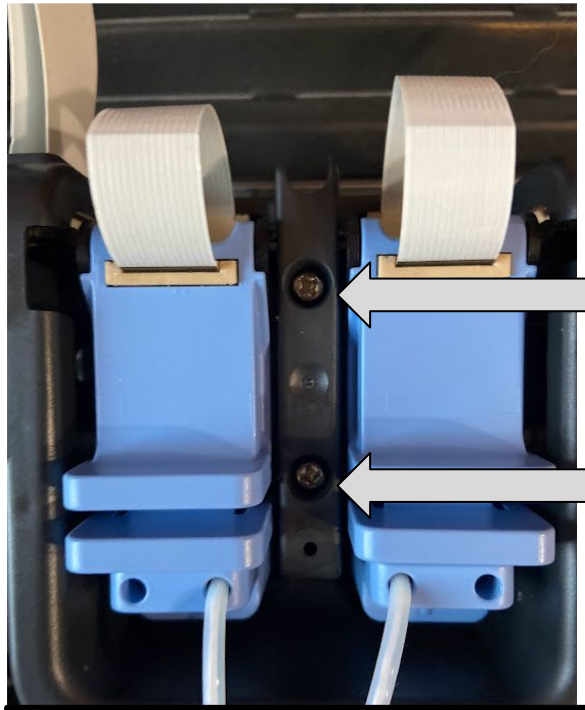
The last electric parts of the nozzle were then removed lifting up on a latch.

There was an attempt made to disconnect the metal frame that went over the top. In the end it could not be removed because the bucket that held the filament overlapped it making it impossible to remove.

The base that held the motor was then removed by unscrewing 4 screws. The cover over the motor was then disconnected by removing 2 screws that held it on.

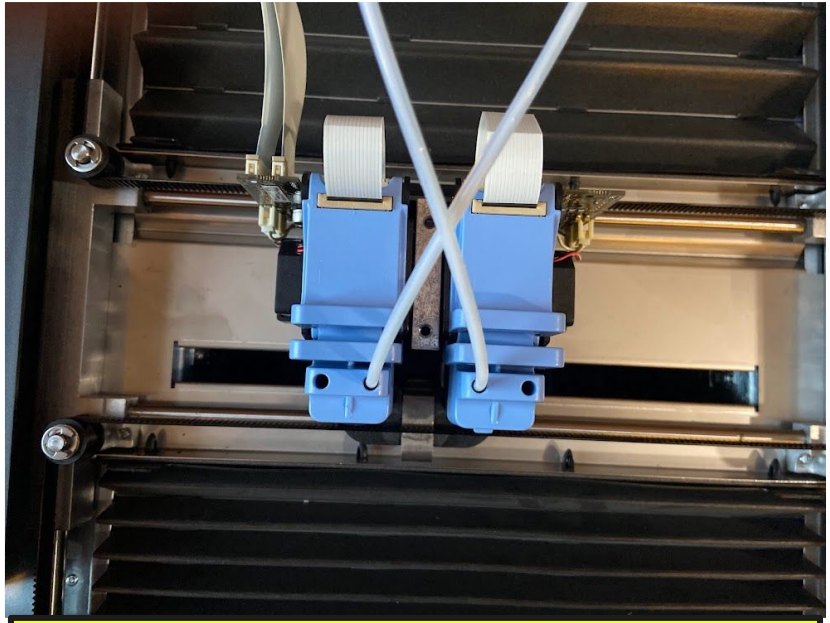
The same process is then repeated on the opposite side.

EXPOSING CONTENTS OF NOZZLE



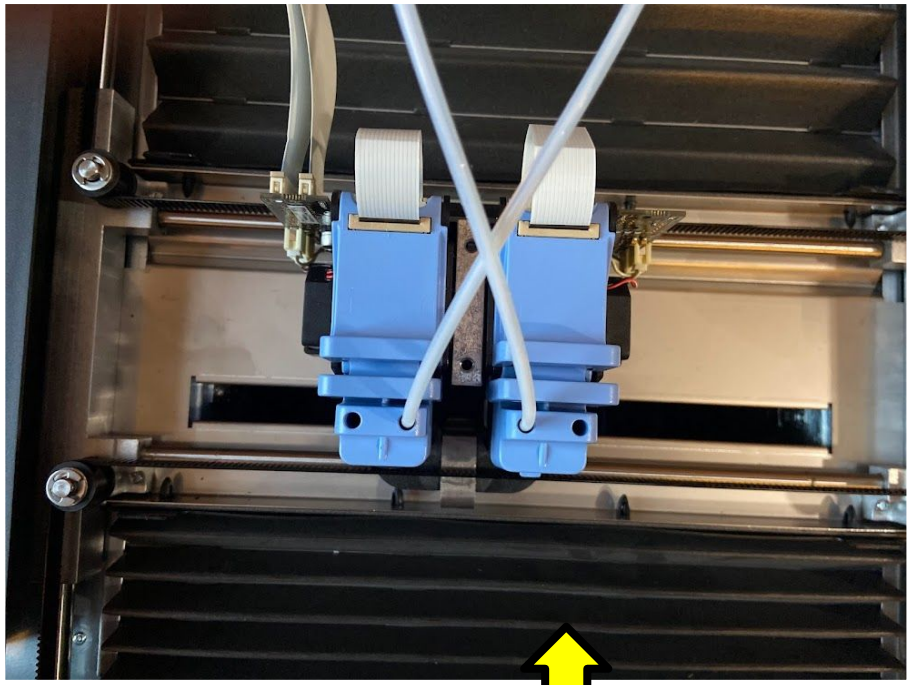
Screws removed

Before we removed screws

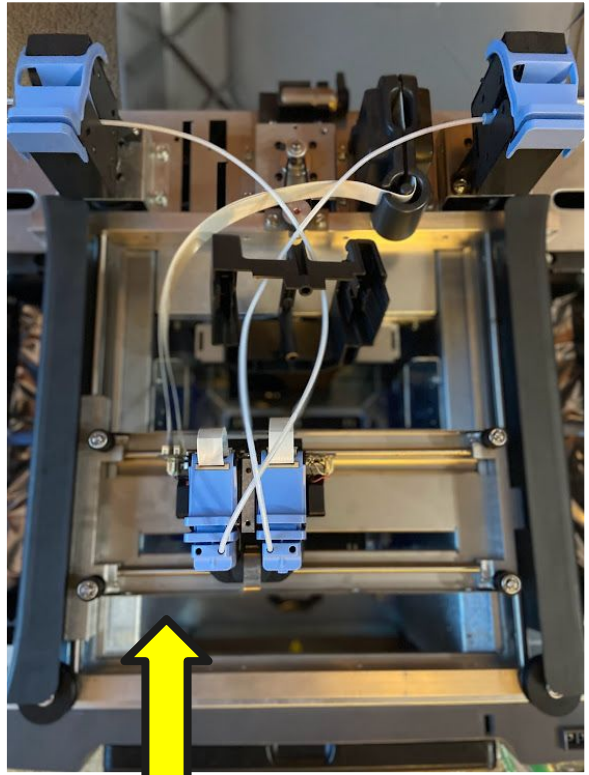


After removing screws and shell

TAKING OUT PERFORATED FABRIC

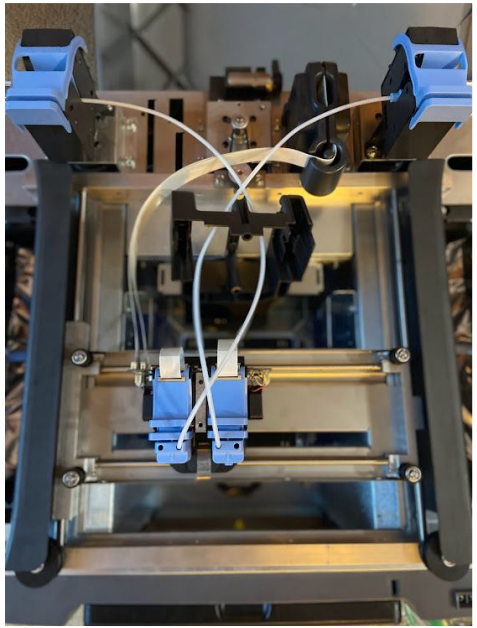


Perforated fabric

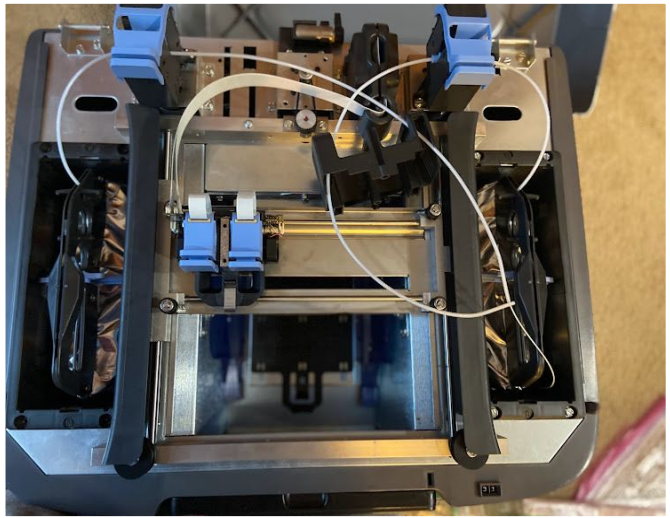


Without fabric

TAKING OUT NOZZLES



3D printer with nozzle

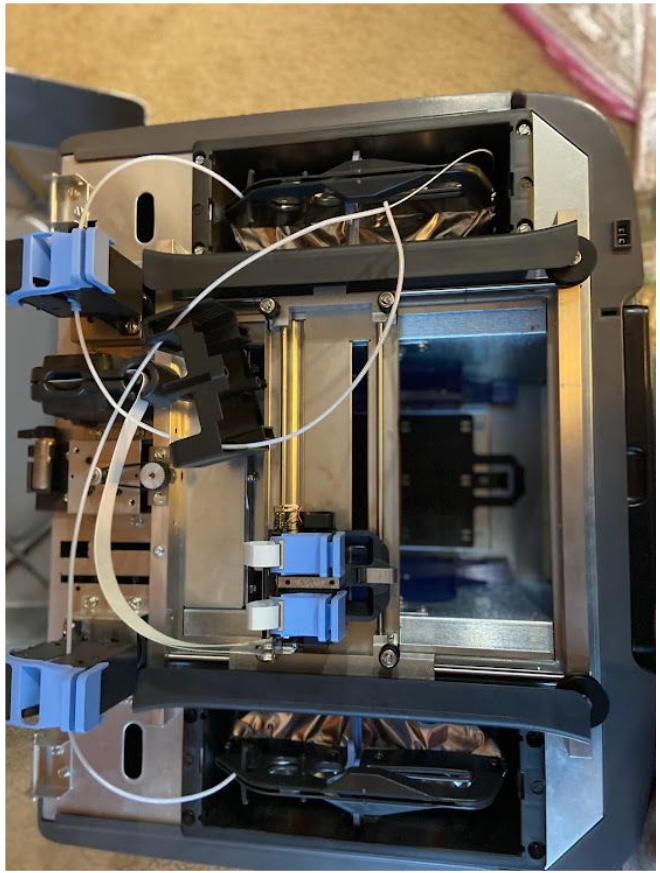


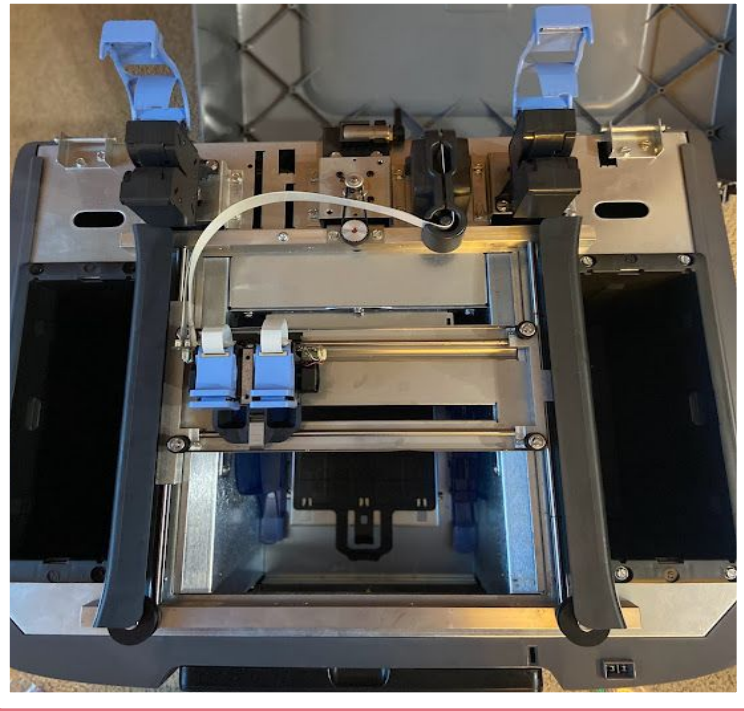
3D printer without nozzle

Nozzles out of 3D printer

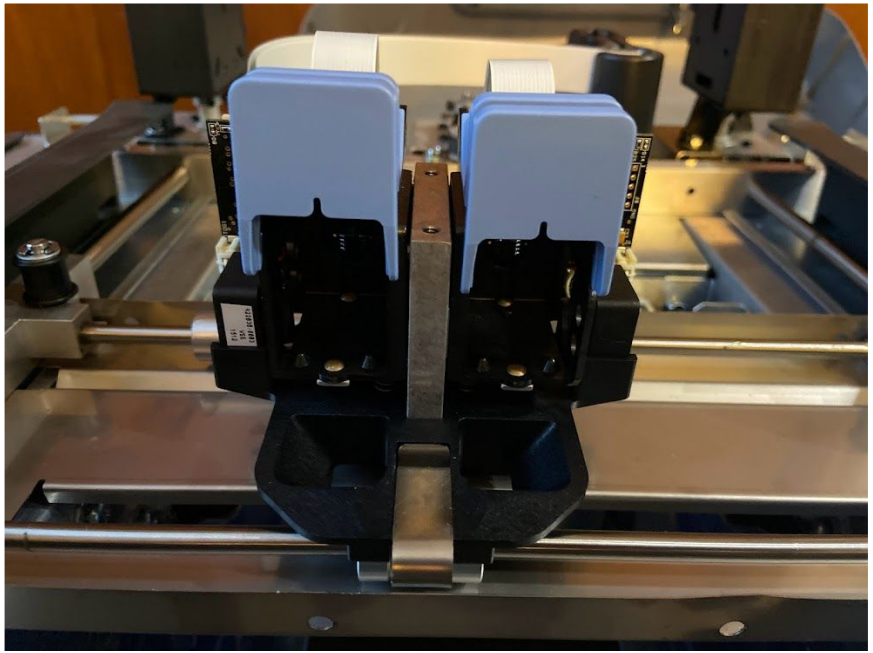
Why are there 2 nozzles on the 3D printer? There are two nozzles because the printer can print 2 different sizes or colors in one project.

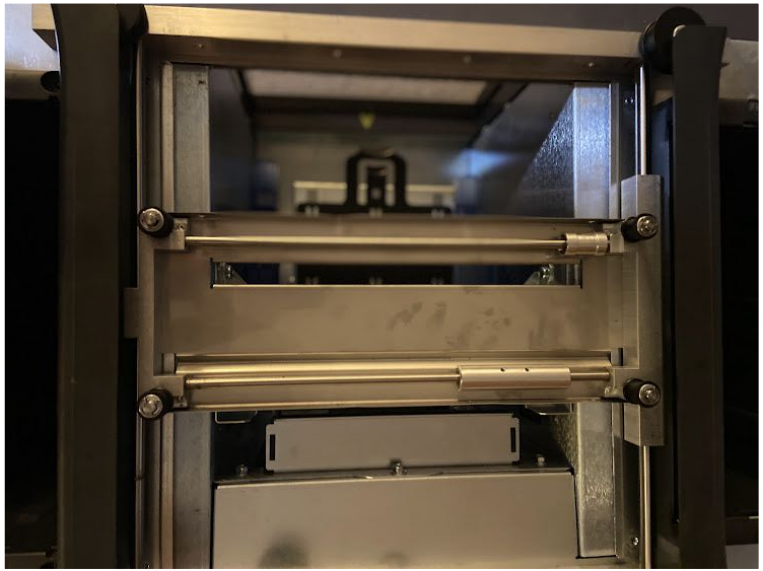
TAKING OUT FILAMENT BAGS



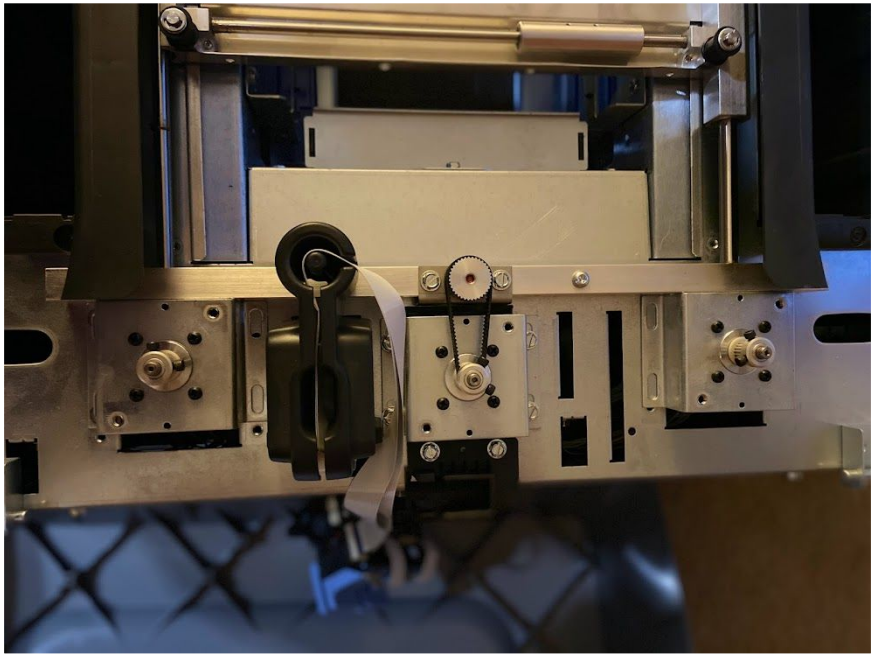


REMOVAL OF LAST NOZZLE PARTS



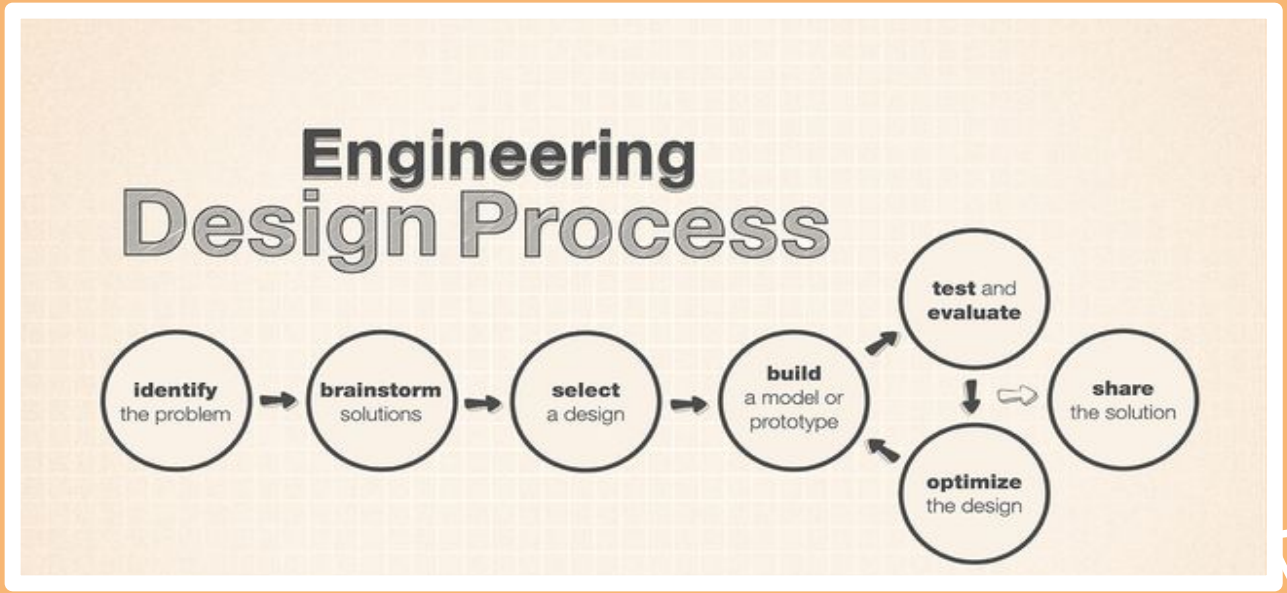


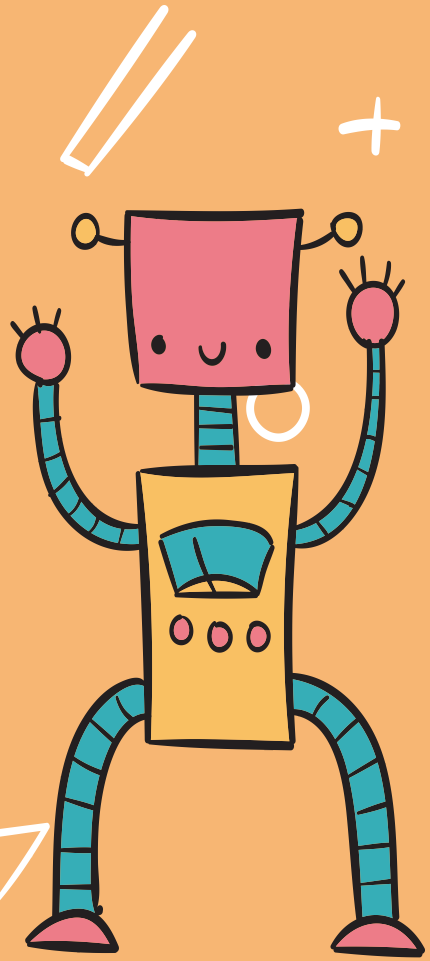
REMOVING BELT MOTORS



STEP 3 :

It was not possible to go through with this step. So like the Engineering design process we made an iteration from our plan and went on to the next step.





STEP 4 REMOVE LID AND SIDE PANELS

The lid broke off of the hinges from its weight so we do not have to take that off

The back panel was removed .That was done by removing the top 6 screws. 5 screws on the bottom. and 2 screws on both the right and left side. The 2 screws on the right and left side were then removed. While doing that it let the right side panel come off.We did the same thing on the left side and the same thing happened

The last thing that we needed to do is take out all electronics including the main board and the fan. The 7 screws that connected to main board to the frame were removed.

The motors that controlled the belt were still connected to the main board so the 4 screws were removed that held the motor onto the main structure. That let the motors fall through the holes that they were run through.

The fan on the right side was then removed by unscrewing the 6 screws that held it onto the metal structure.

STEP 3 : CONTINUED

Then there were a whole bunch of cables that went from the main board to the fan that were zip tied to the outside of the metal shell. So using scissors the zip ties were cut.

Another reason that the board was not coming out was that there was a motor that lifted the plate that your project printed onto. This is so that the nozzle doesn't have to move up or down.

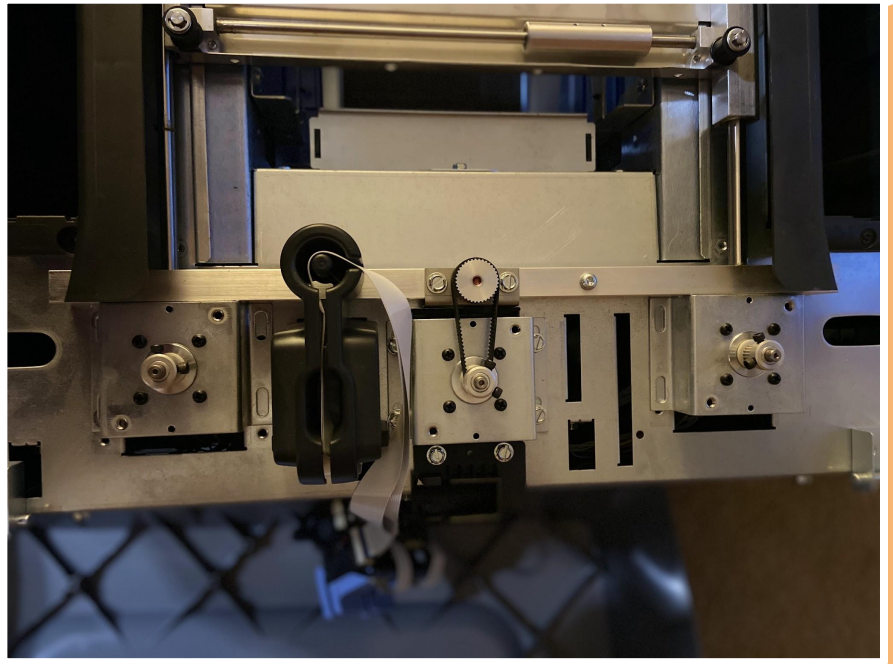
3 screws are removed on the tray so that the tray came out and there was better access to the back from the front.

3 screws where then removed on the fan. And it came off of the back of the metal board.

The wires connecting to the main board were attached by plug in so we unplugged the wires making us able to remove the main board from the inside of the machine.

Lid removal

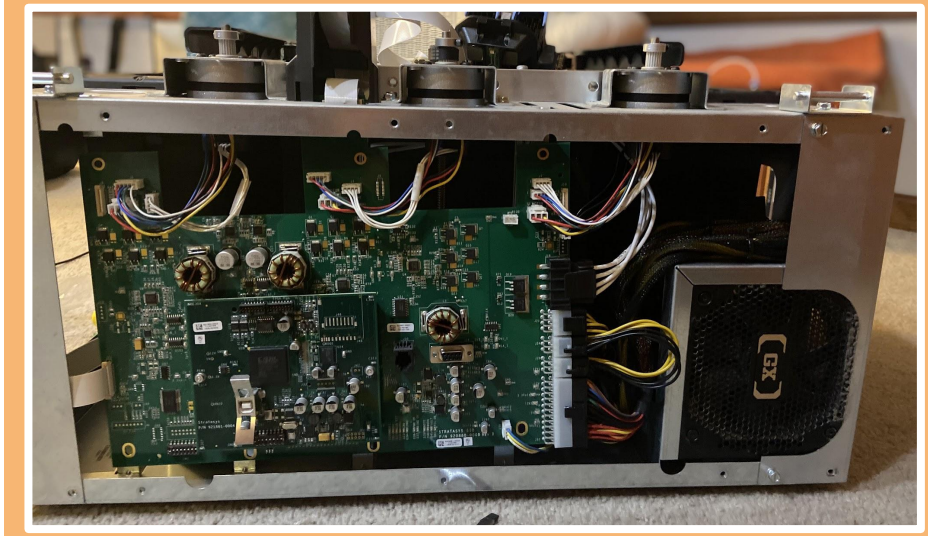
Before removing the lid



After removing

Back panel removal

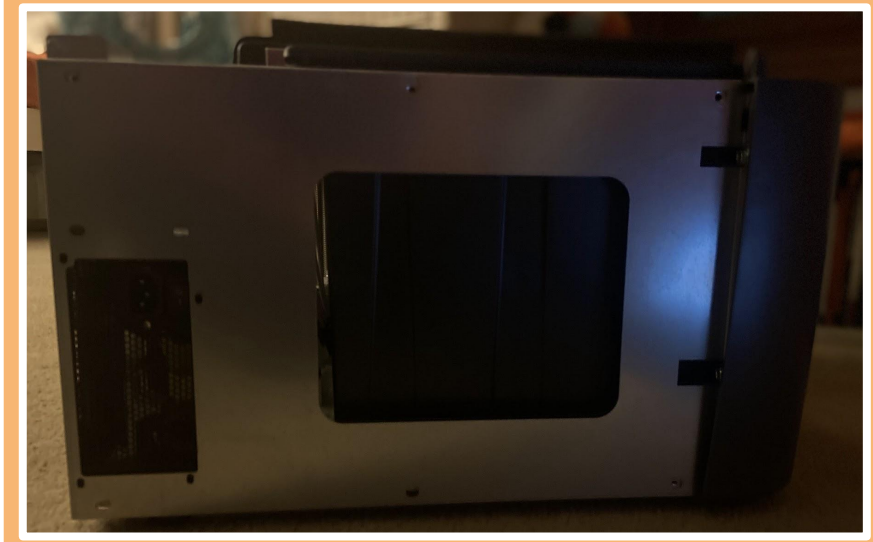
Before removing back panel



After removing back panel

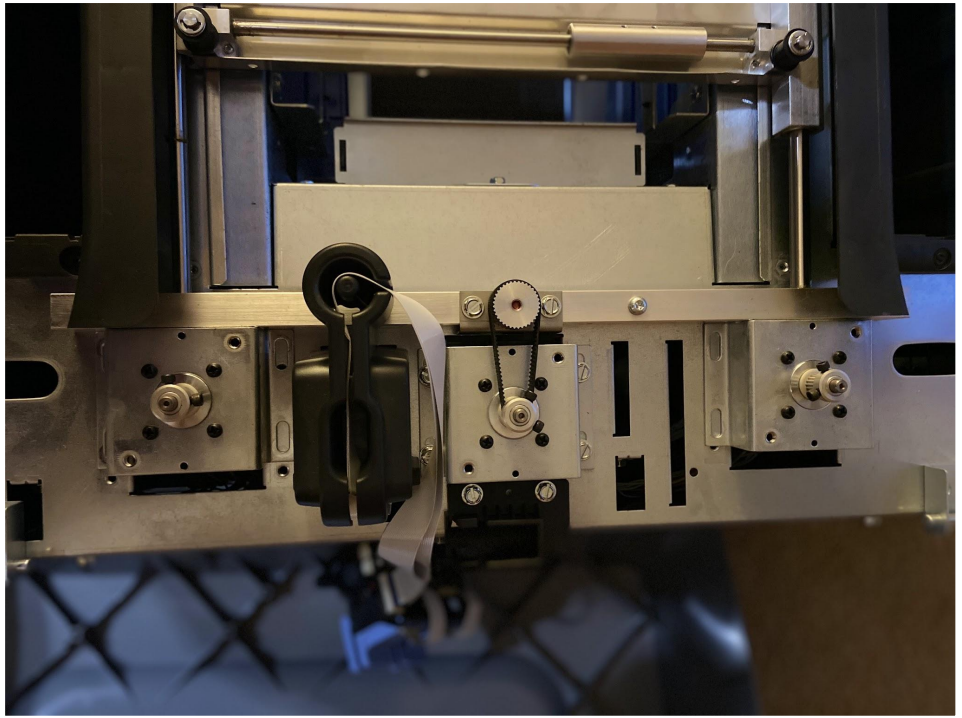
Removing side panels

Before removing side panel

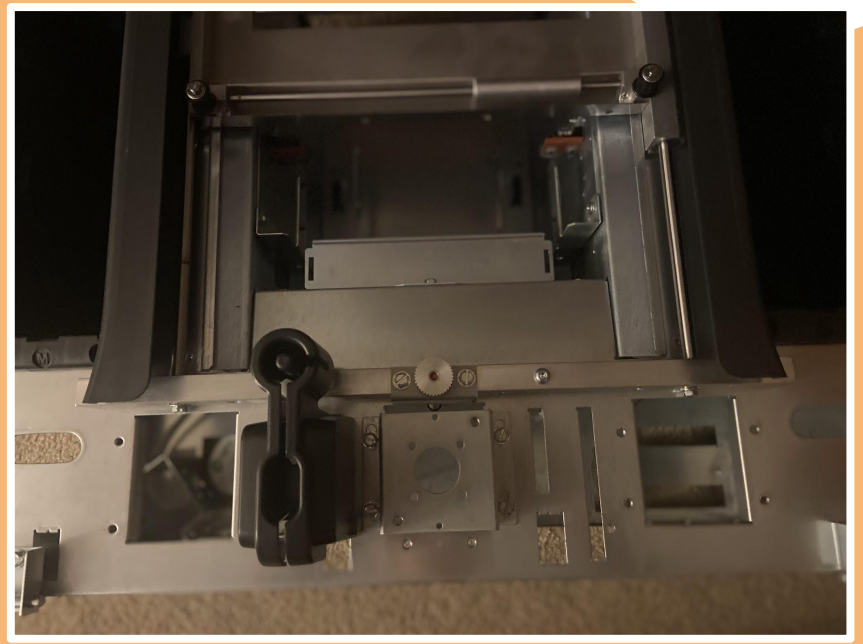


After removing side panel

Removing motors

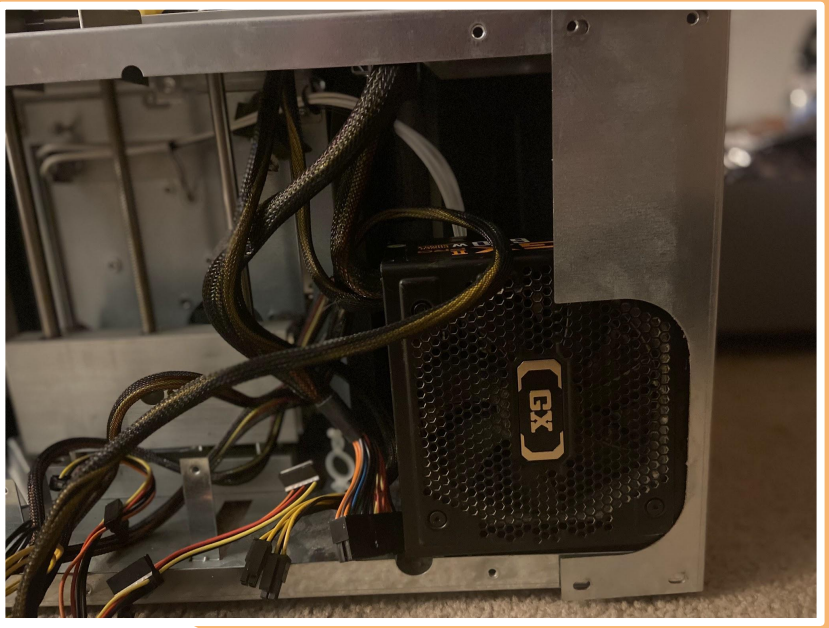


Before removing motors

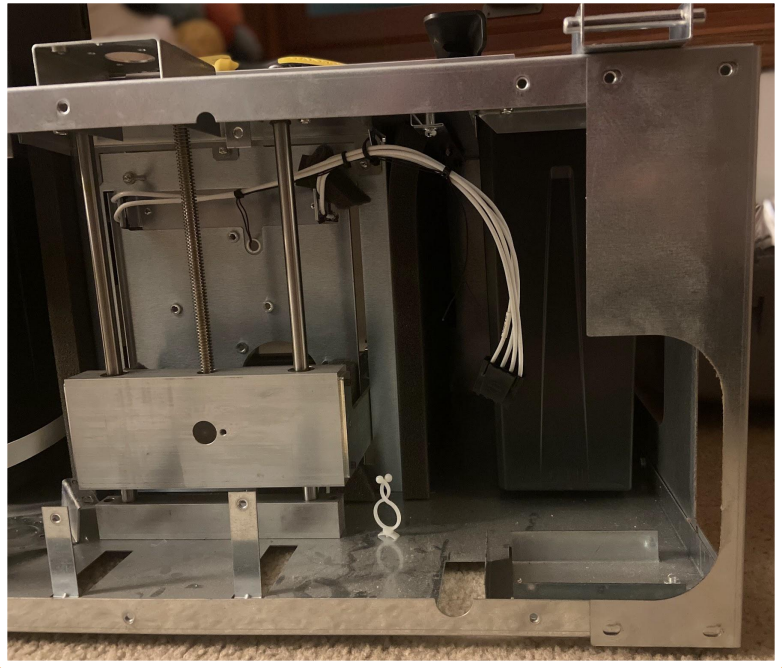


After removing motors

Disconnecting Outside Fan

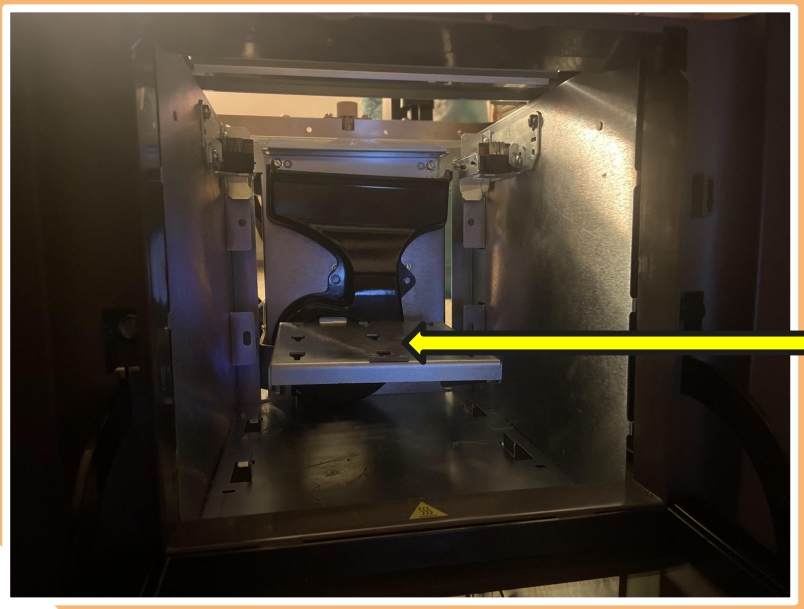


Before removing inside fan

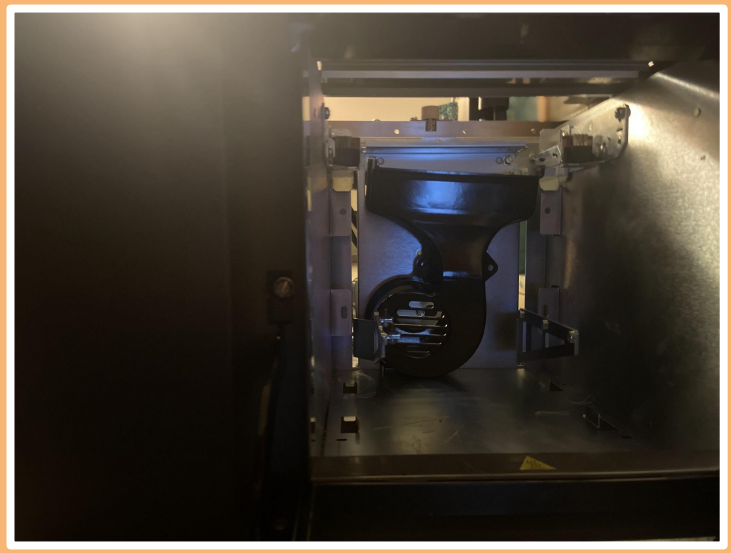


After removing inside fan

Removing the front tray



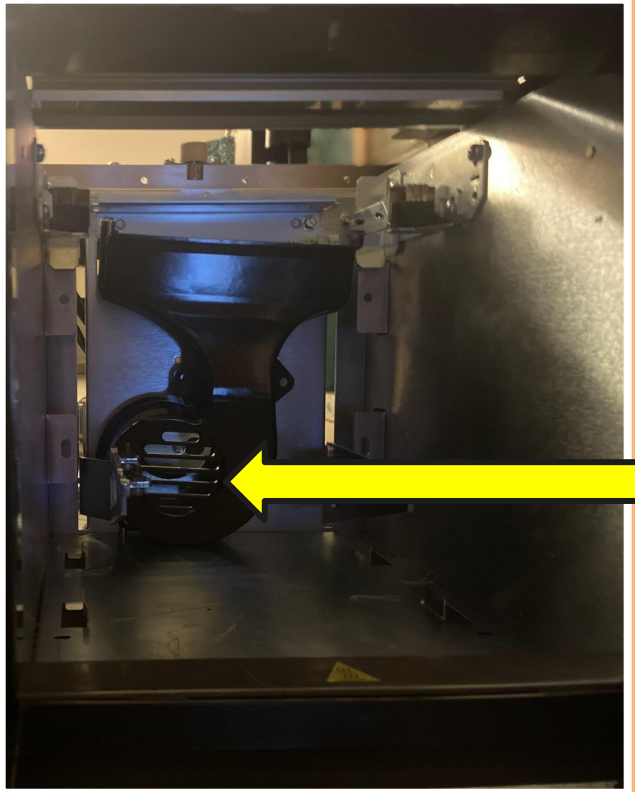
Metal tray that plastic tray latches onto



Before removing the front metal tray

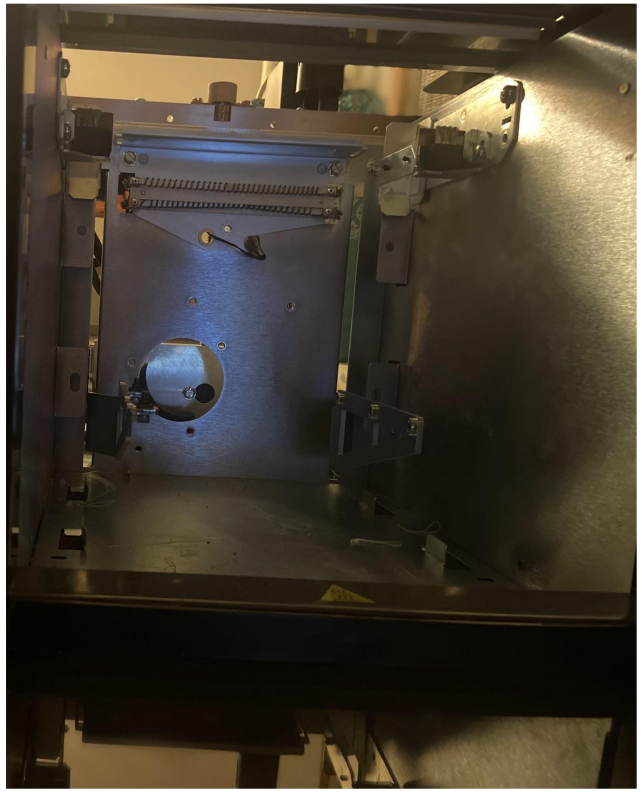
After removing the front tray

Removing the inside fan



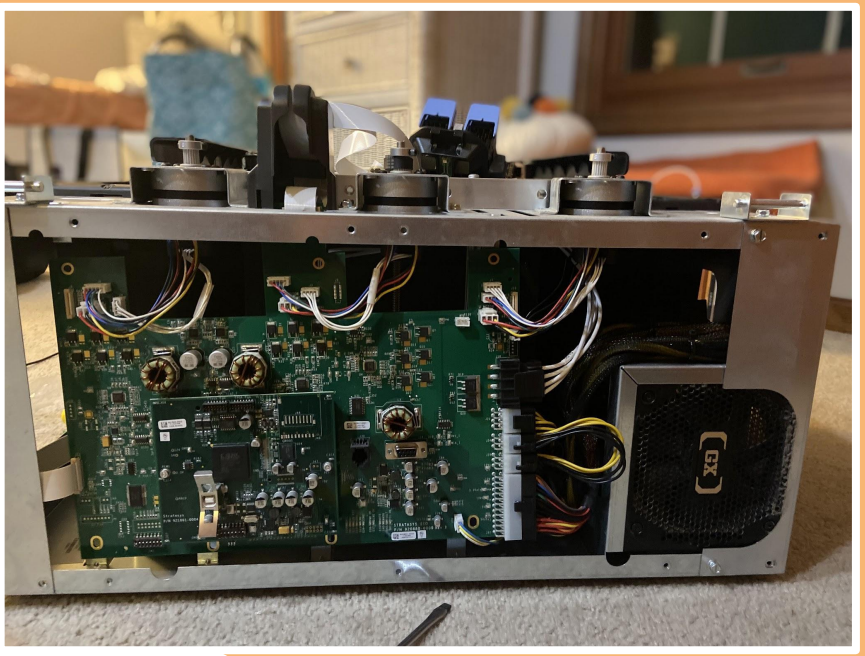
Inside fan that is being removed.

Before removing inside fan.

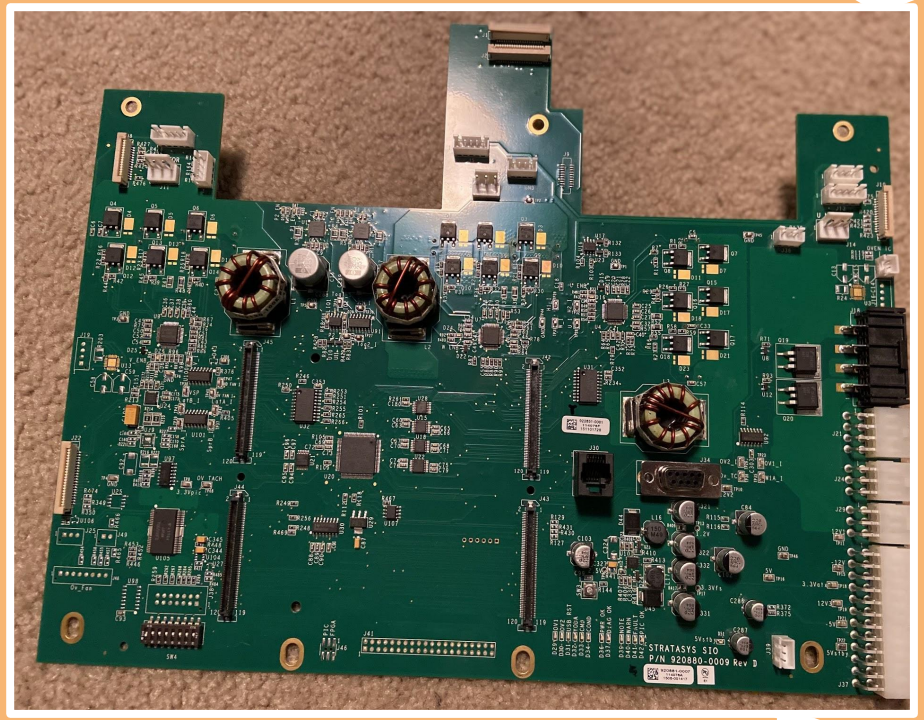


After removing the inside fan.

Board out of the inside

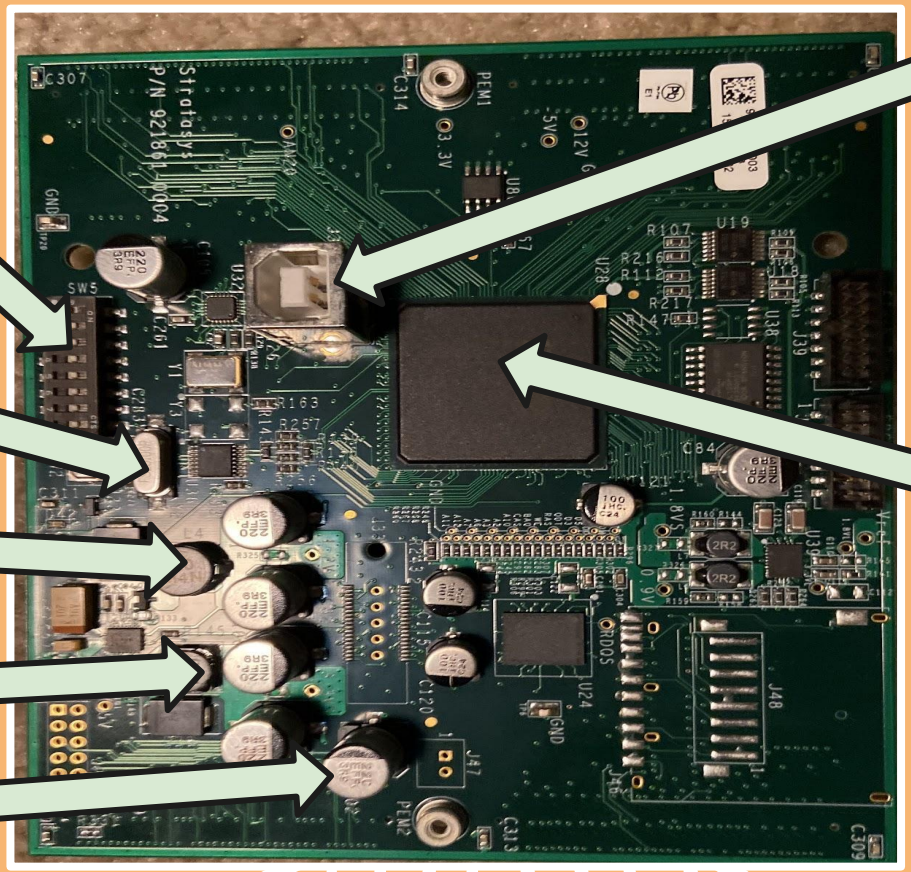


Before removing panel

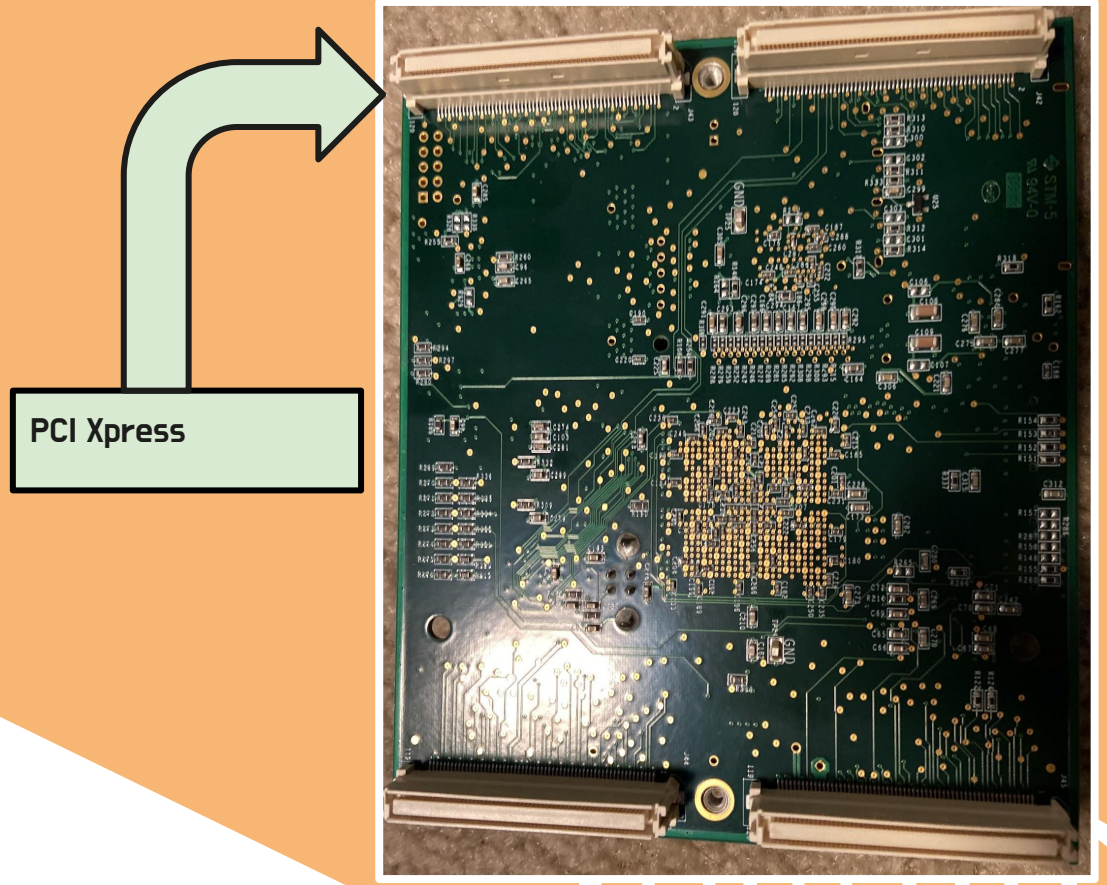


Removed motherboard

Motherboard front



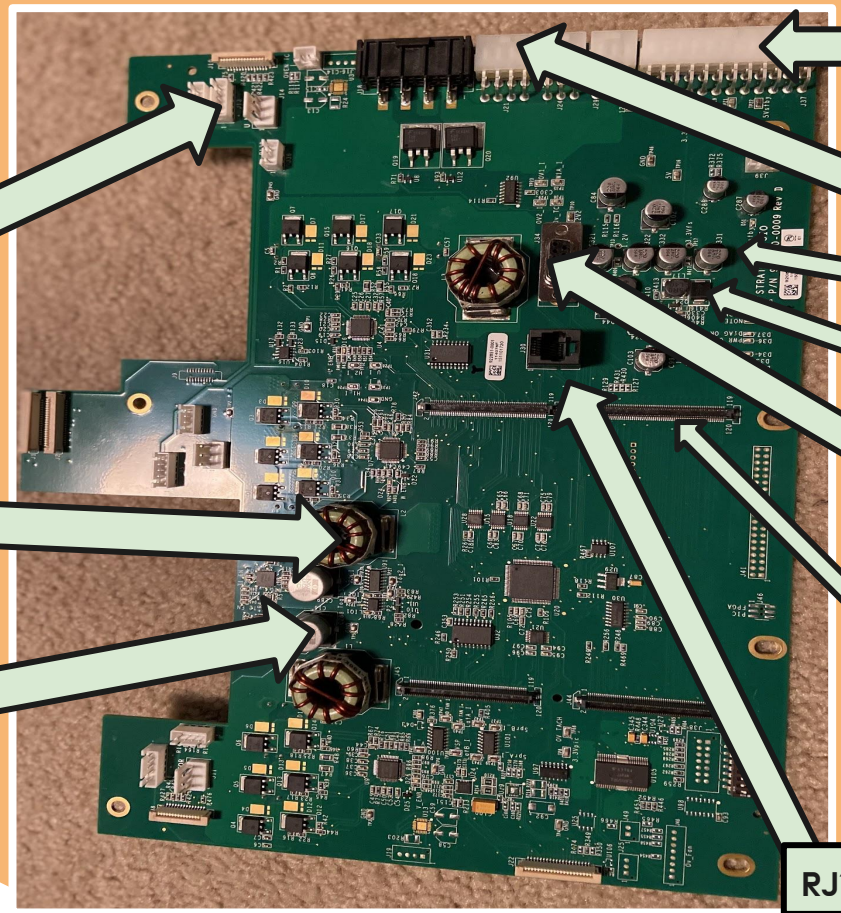
Motherboard back



Motherboard components

Piece	Use	Size
FOXSLDF/250FR-20	This helps chang and direct the flow of the current	0.5in x 0.125in
YC751 41K	Stores memory	199.85 KB
USB-B	Connects 3D printer to outside source	6.85 x 1.8mm
Electrolytic capacitors	Decoupling power supplies	220.150.100
Audio port	Transfers audio into or out to an external source	6.35mm
PCI X-press	Connecting high speed inputs/ outputs	1x 8x 16x 32mm
Lane switch	You can make currents run through one lane but not another	1 x 0.5 in

Electronics board front



Outside Fan connector

Motor connector

Inside fan connector

Electrolytic 100 capacitor

Electrolytic 220 capacitor

High power inductor

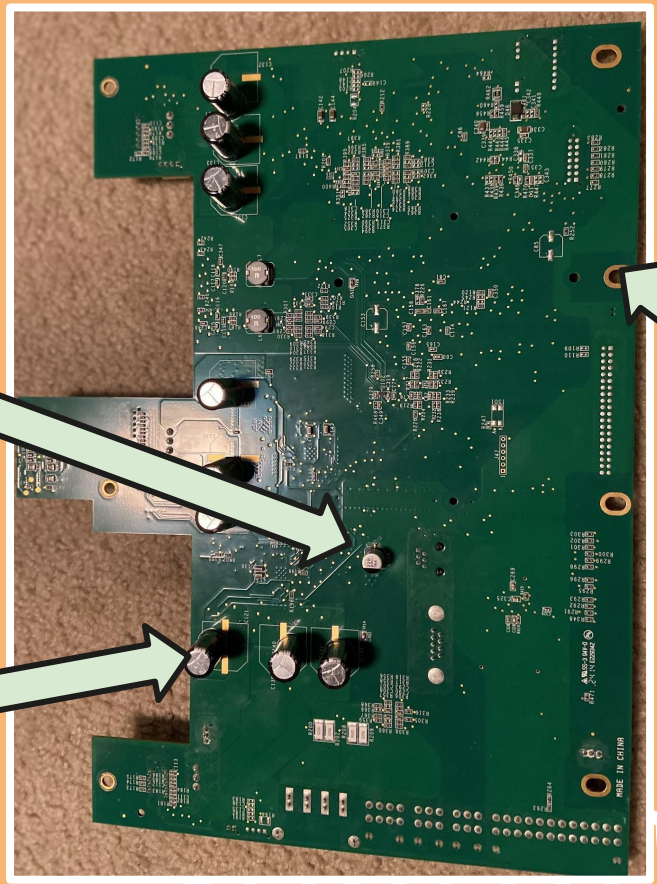
Audio port

PCI Xpress connector

Electrolytic 300 capacitor

RJ11 connector

Electronics board back



Electronics board parts

Piece	Use	Size
High power inductor	Used for storing and transferring energy in power converters.	30.5 mm
Electrolytic capacitor	Filtering devices in various power supplies to reduce voltage ripple	0.0625 in - 0.5 in
RJ11 connector	To connect the electrical panel to a computer via an external wire.	9.65 x 6.6 mm
Lane switch	When you flip one of the switches it allows current to flow through one lane on the circuit board but not another.	1 x 0.5 in

Sources we used

- https://www.tti.com/content/ttiinc/en/apps/part-detail.html?partsNumber=PM2120-100K-RC&mfgShortname=BOU
- https://www.digikey.be/htmldatasheets/production/1599100/0/0/1/foxsdlf-250fr-20-spec.html
- https://html.alldatasheet.com/html-pdf/163008/TI/YC751/22/1/YC751.html
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- https://www.grainger.com/category/motors/motor-capacitors/motor-start-capacitors?attrs=Capacitor+Voltage%7C220+to+250V+AC&filters=attrs
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- https://www.researchgate.net/figure/Distribution-of-3D-print-jobs-by-selfidentified-discipline-of-customers_fig3_268218125
- https://develop3d.com/develop3d-blog/the-big-3d-printing-survey-cast-your-votes/
- https://www.patsnap.com/resources/blog/5-disruptive-applications-of-3d-printing/

What did we learn from this project

Deconstructing a 3D printer has given us insights into its internal components, structure, and functionality. Before going into this project we did not know how complicated a 3D printer can be. For example, we didn't know much about the safety components they have added like fans for the toxic emissions that heating the filament makes. We also did not know how big and complicated an electronics panel a 3D printer had to complete its function, such as how all of the capacitors work, the function of the capacitors, and how the different capacitors work together. While 3D printers are complicated they use mainly basic mechanisms such as pulleys, corkscrews, hinges, and latches that we use while building our robot.

Apart from the actual printer, we learned why the 3D printer is in so high demand and how different industries are using them to improve your day-to-day life. Another thing that we learned about was how they are 3D printing organs and ceramics that coral reefs could grow onto. Hopefully, the use of these printers will help save and improve the lives of not only humans who desperately need organ transplants but also animals that live in the coral reefs that are dying due to climate change.

Not only did we learn a lot but we gained a bunch of connections with people that we might have not met. Some of the people we met were the head of our school's technology department, and one of our coaches Mr.Toll. The head of electronics helped us determine what make and model some the the electronic components are. Mr Toll helped us in helping us learn what the different parts of the motherboard do and why they are necessary.

Thank you for reading the 1024 Ninjas STEM Project !