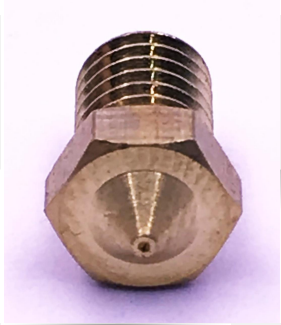
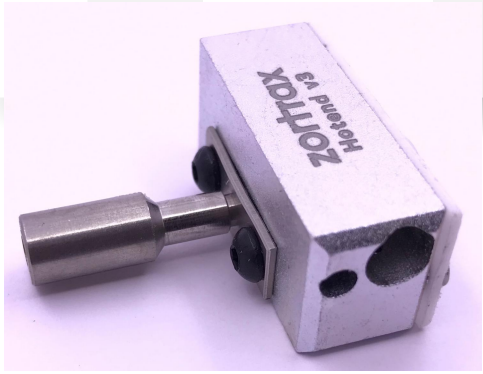
Basic 3D Printing



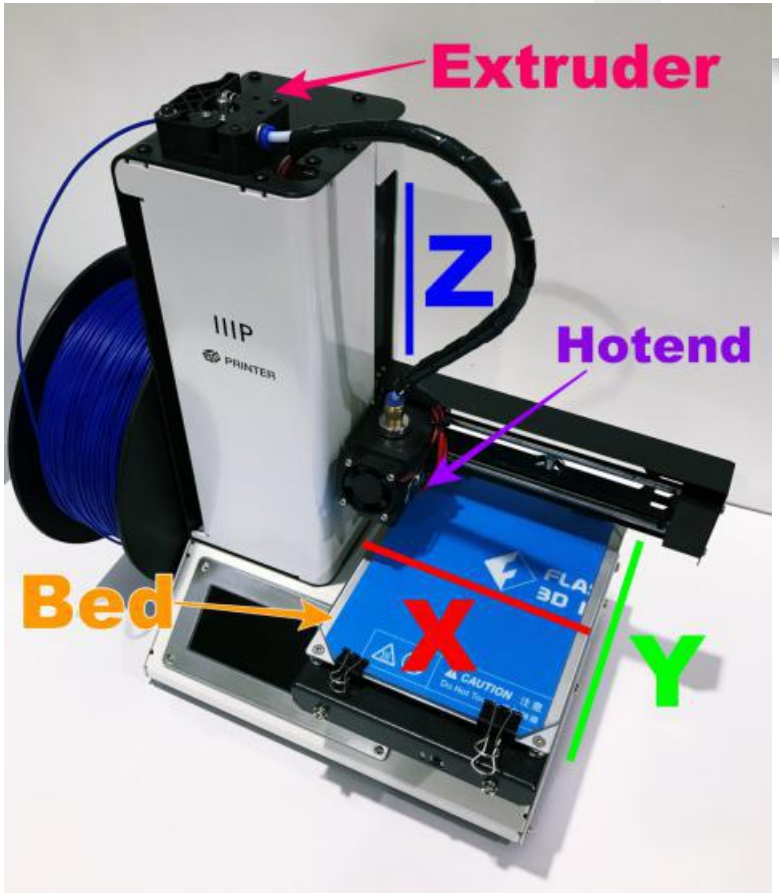


Cartesian System

The cartesian system uses an X, Y & Z "axis" movement for nozzle positioning.

- **X - is left to right.**
- **Y - is forward & back.**
- **Z - is up & down.**

All cartesian printers will have these axes.



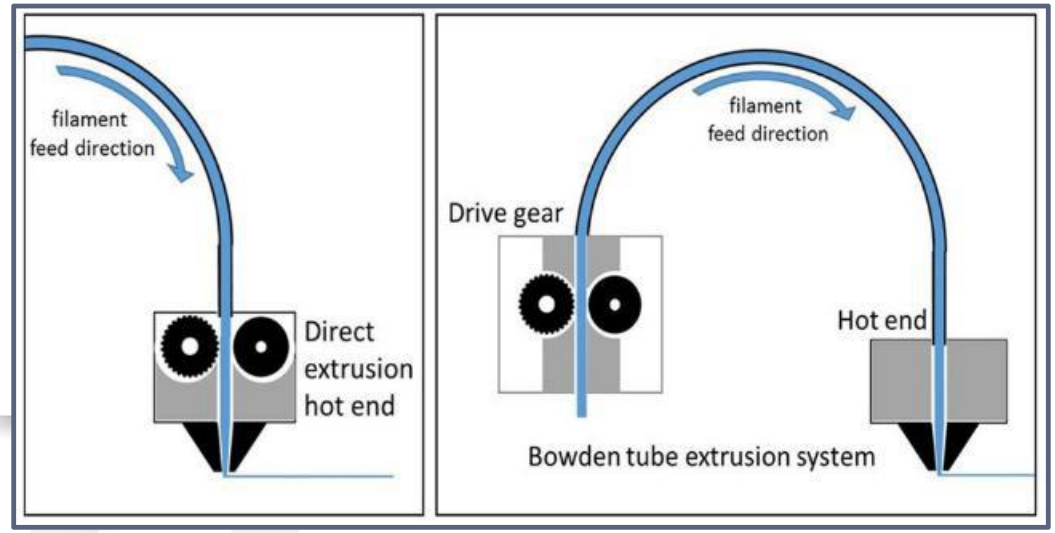
Extruder Types

Direct drive systems have the extruder mechanism & hotend mounted together.

- Good filament control
- Heavier, requiring slower speeds due to inertia

Bowden systems have the extruder mounted on the frame & filament fed through a teflon tube to the hotend.

- Less weight on gantry so can print faster
- Filament control not as easy
- Can't print flexible materials



Material Properties

Materials for use in FDM printers are many & varied.
They all have strengths & weaknesses.

The table below summarises the most common FDM material properties.

For more information on materials, visit:
https://www.simplify3d.com/support/materials-guide

Material	Printability	Toughness	Interlayer Bond	Shrinkage (warpage)	Fumes	Heated Bed?
PLA	Easy	Stiff but brittle	Moderate	Low	Minimal	zero to 60 degrees
PETG	Moderate	Flexible & strong	Exceptional	Moderate	Minimal	75 to 90 degrees
ABS	Moderate	Flexible & strong	Moderate	High	Yes	95 to 110 degrees
HIPS	Moderate	Flexible & strong	Moderate	Moderate	Yes	100 to 115 degrees
FLEXIBLE	Difficult	Very flexible	Exceptional	Low	Minimal	zero to 60 degrees

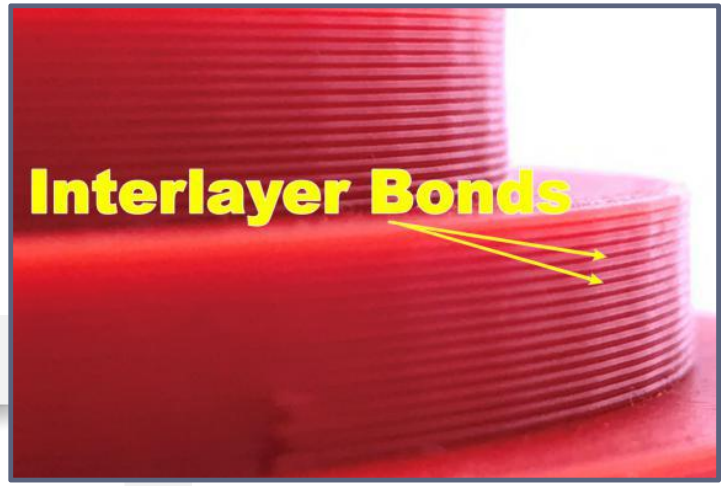
Interlayer Bond

The printed layers are bonded together by residual heat as the filament is extruded.

This bond between layers is called the "interlayer bond".

Different materials bond better than others.

The weakest part of a print is the bond between the layers.



Material	Interlayer Bond
PLA	Moderate
PETG	Exceptional
ABS	Moderate
HIPS	Moderate
FLEXIBLE	Exceptional

Build Plate Adhesion 1

The most important part of a print is the "first layer".
This is the layer that will stick to the build plate.

There are many methods of ensuring the model stays stuck to the build plate.

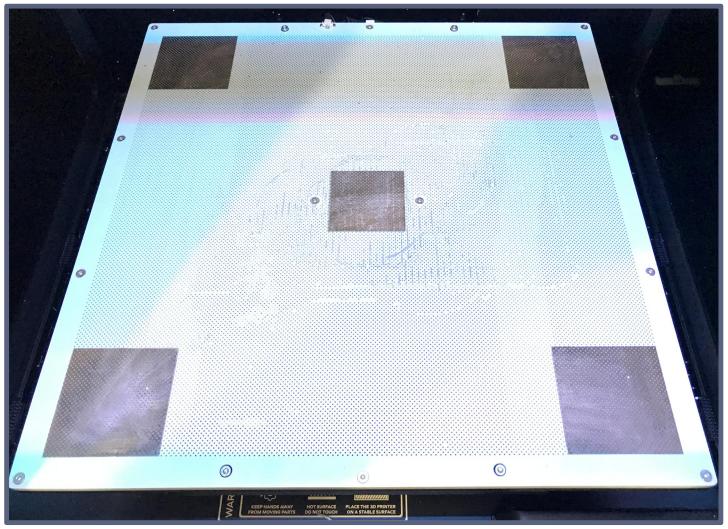
- **Specially designed build plate adhesives such as "Dimafix".**
- **Self adhesive build surfaces that are stuck to the build plate (BuildTak, PEI sheets, GeckoTech).**
- **Perfboard that has small holes that provide extra grip (must use a raft)**

Many others have had success with:

- **Hairspray (can get messy)**
- **Kapton tape**
- **Blue painters tape**
- **UHU glue sticks**

Borosilicate glass with self adhesive build surface

"Perfboard"



Build Plate Adhesion 2

The most important part of a print is the "first layer".
This is the layer that will stick to the build plate.

Sometimes a model will *still* lift from the build plate.

In these instances, there are some things that can be done during "slicing" to help.

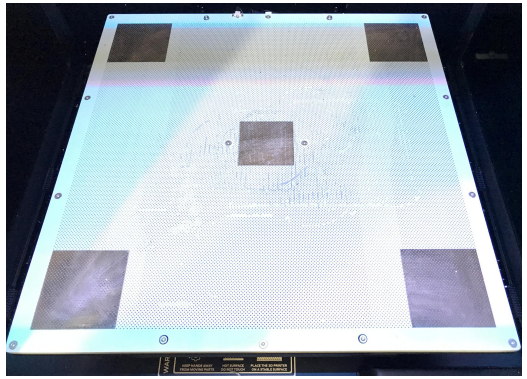
- **Reduce the infill percentage.**
- **Check bed temperature is correct. Possibly increase?**
- **Reduce part cooling fan speed.**
- **Instruct the slicer to add a "raft" or "brim".**
- **Instruct the slicer to make the first layer hotter.**

A "raft" compensates for any build platform disecepancies & also provides more area for adhesion to build plate. The models first layer is laid on the raft surface.

A "brim" is a skirt that is laid around the perimeter of the model & is usually one layer thick.

Raft (Didn't help!)

"Perfboard requires a raft"



Decisions before slicing

Before a model is sliced for printing, there are some things to consider.

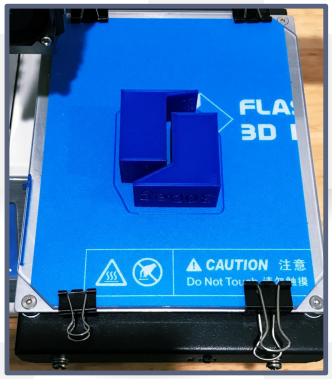
1. What material will I print with = Material choice based on model application
2. How do I want the model to look = Resolution & speed settings
3. How long am I prepared to allow for printing = Resolution & speed settings
4. What strength is required = Infill density, fill pattern & model orientation
5. Does the model require strength in a particular area = Model orientation
6. Do I want (or need) “supports” = Model orientation

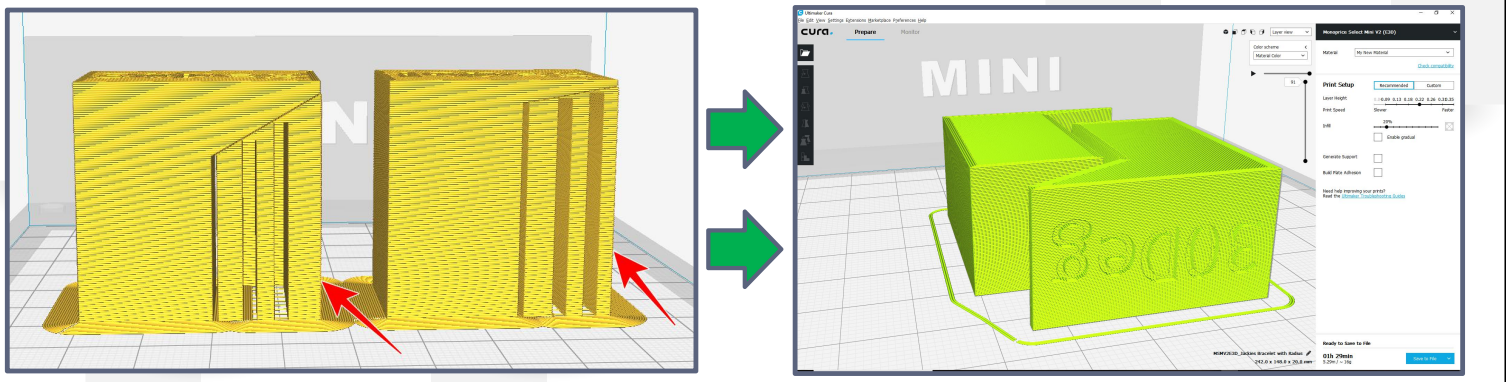
Model Orientation & Supports

Supports can sometimes be ELIMINATED or REDUCED, simply by printing the model in a different position.

Less support equals:

- Less material used.
- Less time to print.
- Better surface finish.
- Less frustration removing the supports.

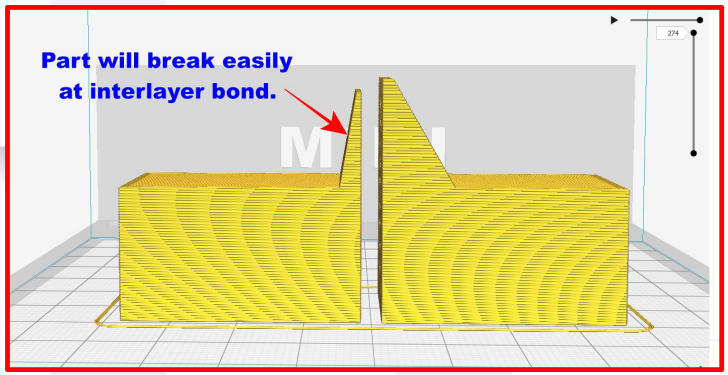




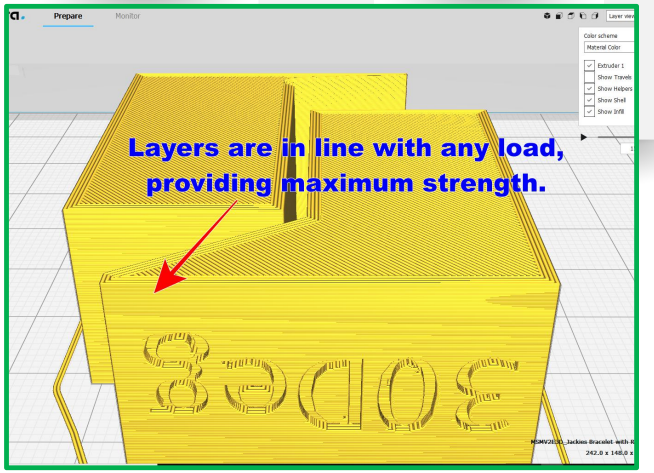
Model Orientation & Strength

If strength is required, the model should be printed in a position that applies minimal load to the interlayer bond.

**In this orientation, any load applied to the overhanging part will be applied to the interlayer bond.
It will break very easily.**

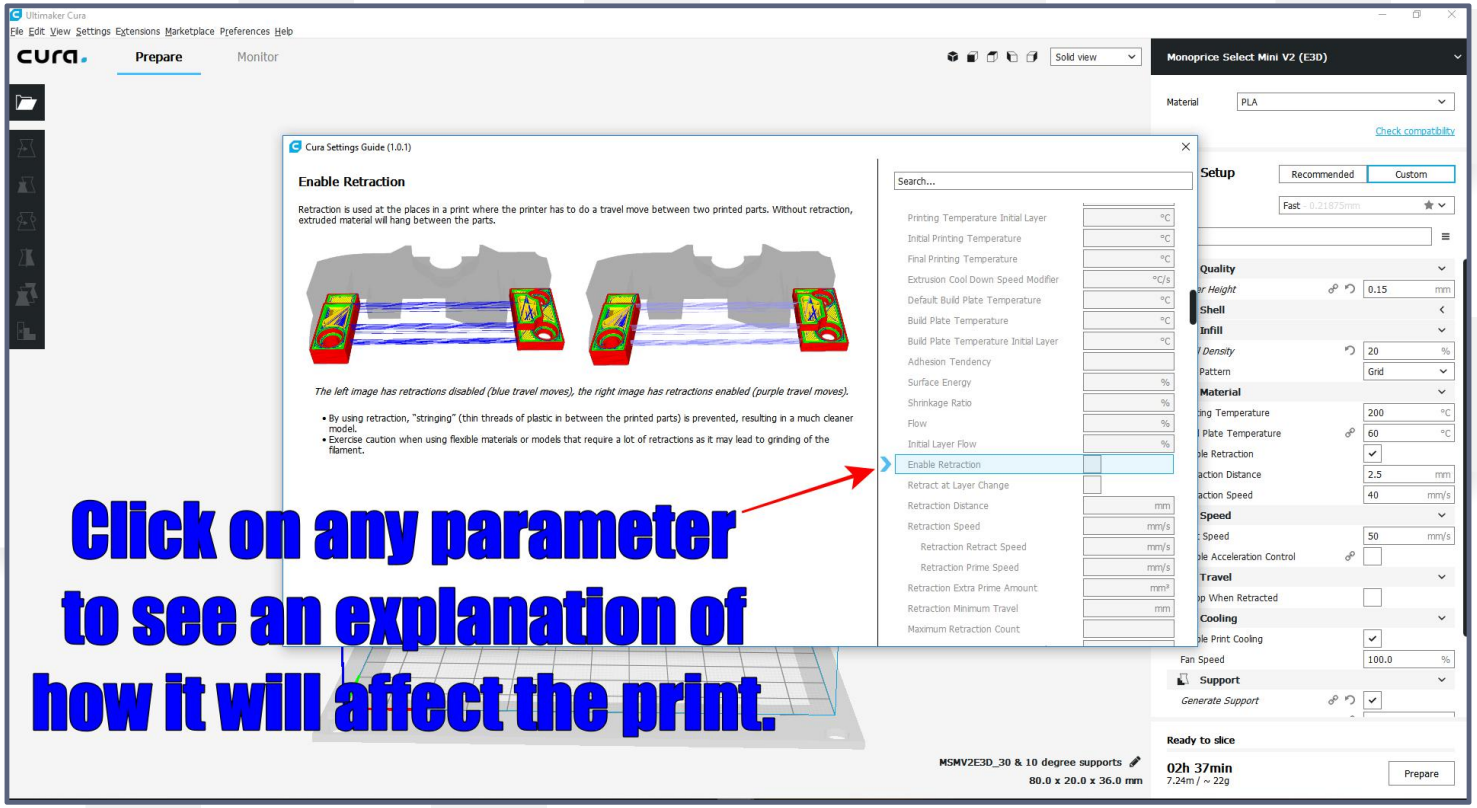


In this orientation, any load applied to the overhanging part is applied IN LINE with the layers, providing maximum strength.



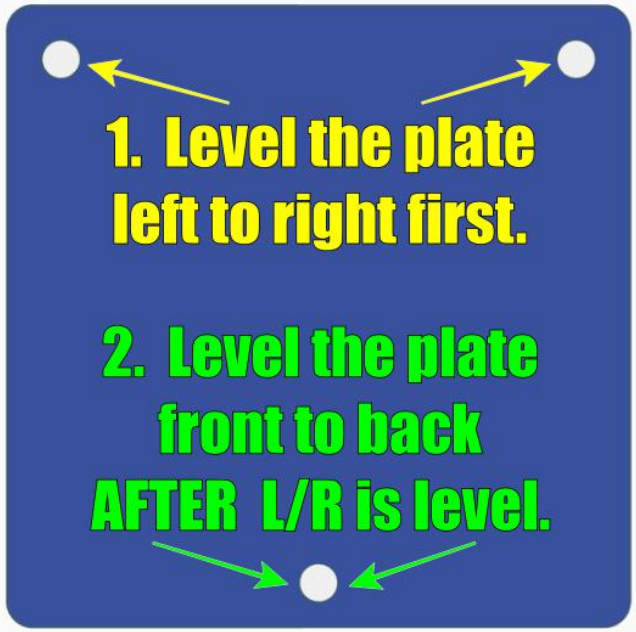
CURA Settings Guide

Click on any parameter for an explanation of what that setting is & how it will affect your print.



3 Pnt Bed Levelling

- 3 point beds are the easiest to adjust.
- First adjust the bed left to right.
- When level left to right, adjust front to back using the remaining adjuster.
- Recheck left to right again.

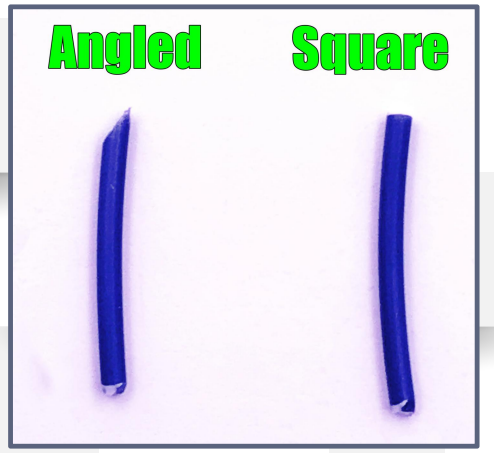


4 Pnt Bed Levelling

- 4 point beds require a different approach.
- Find the worst corner & adjust SLIGHTLY.
- Work around the build plate & adjust other points slightly as required.
- Continue this process until the bed is level.
- DON'T attempt to over adjust one point as you may bend the build plate!!

Changing Filament

- Different printers have different ways of loading filament. Follow your printers instructions!
- There may be a setting on you printer for “loading” & “unloading” the filament.
- When active, this setting will heat the hotend & start the extruder motor moving in the correct direction.
- Some printers simply require the hotend to be heated & the filament manually pulled out or inserted.
- Some printers prefer the filament is cut “square”, while others prefer the filament is cut at an angle to facilitate easier feeding into the extruder.
- Follow your printers instructions!



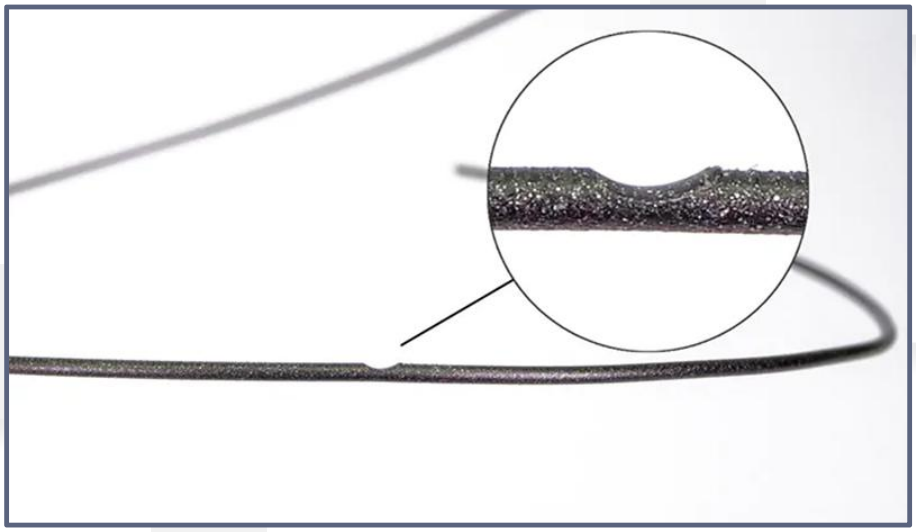
Common Printing Issues

“Filament Grinding”

Filament grinding is when the toothed wheel chews into the filament.

Possible Reasons:

- **Blocked nozzle.**
- **Extrusion temperature too low for filament.**
- **Nozzle height too low.**
- **Extruder tension too high or low.**
- **Filament reel tangled or jammed.**

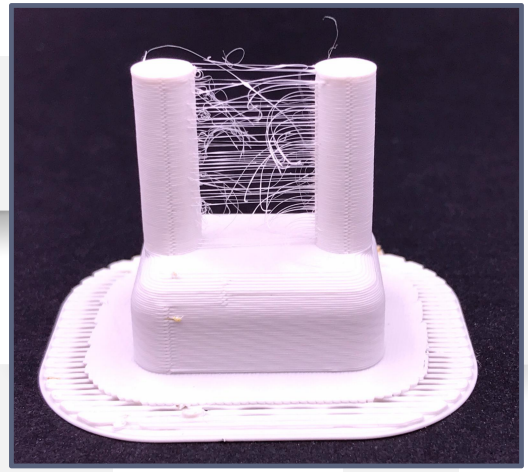


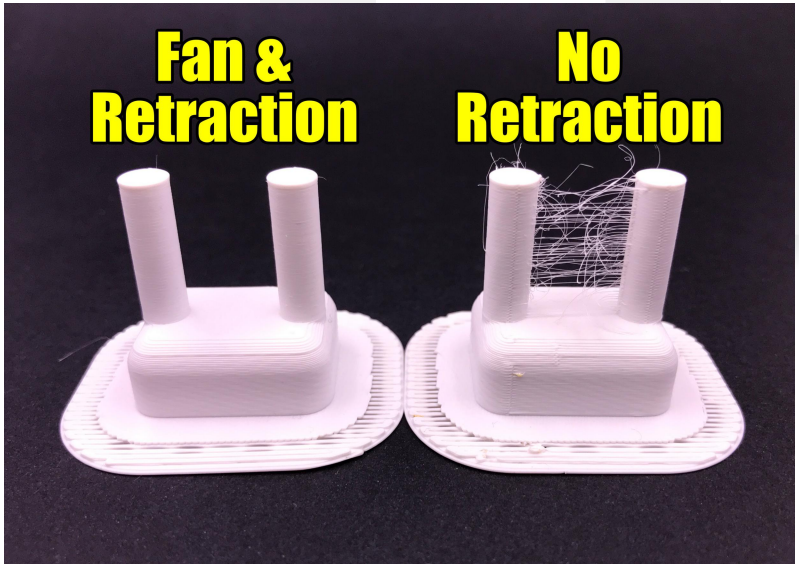
“Stringing”

Stringing is like spiderwebs of plastic.
Its caused by print material oozing from the nozzle as the print head travels.

Possible solutions:

- Increase retraction for material used.
- Lower the extrusion temperature.
- Increase fan speed.
- Increase travel speed.



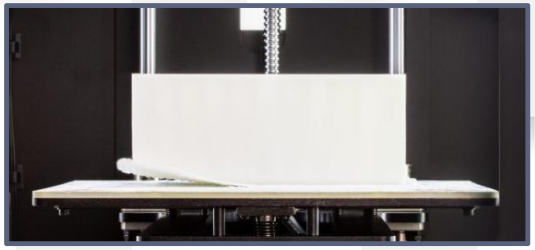


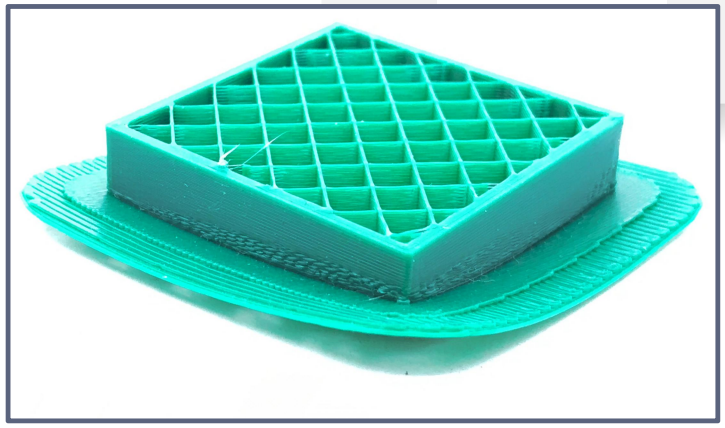
“Warping”

Warping is caused by the extruded material shrinking as it cools. This causes the upper layers to apply tension to the lower ones.

Possible solutions:

- Increase bed temperature.
- Enclose the printer to reduce draughts.
- Reduce fan speed or turn it off.
- Reduce infill percentage.
- Use a better build plate adhesive.
- Incorporate a raft when slicing.



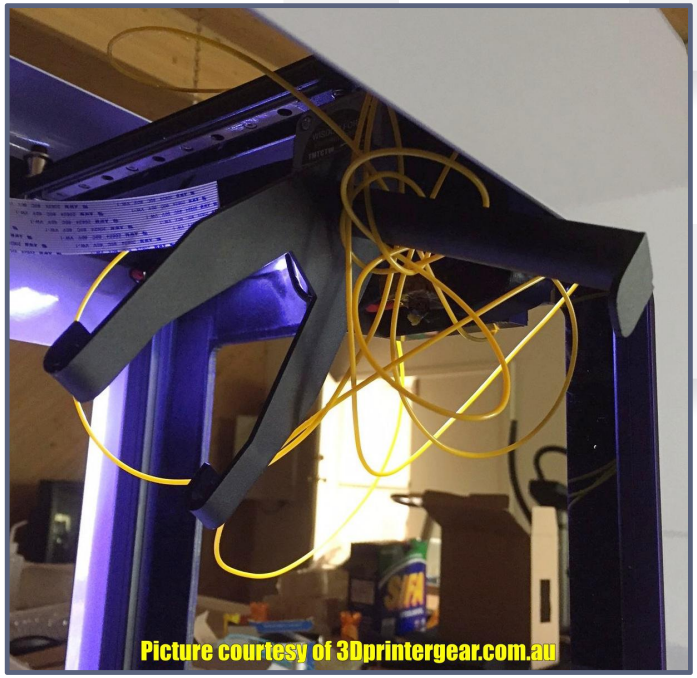


“Filament Tangle”

Filament tangle is usually caused by the filament being allowed to “spring” off the reel & not being checked for tangles before re-reeling.

Prevention measures:

- **Avoid allowing filament end to be unrestrained.**
- **Unroll several loops of filament before re-reeling to check for tangles.**

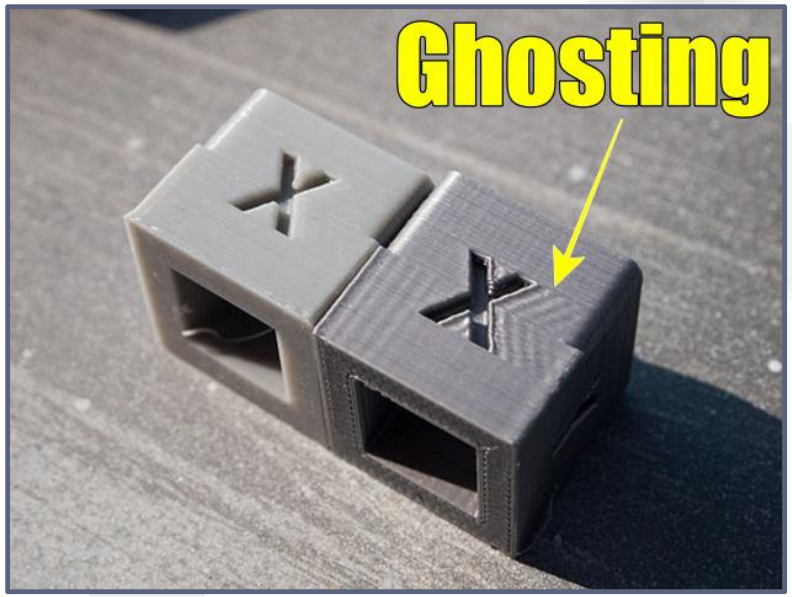


“Ghosting ” or “Echoing”

Ghosting is caused by the mechanical parts of the printer vibrating. This is usually from rapid stops or direction changes.

Possible solutions:

- **Reduce printer speed**
- **Decrease acceleration in advanced settings**

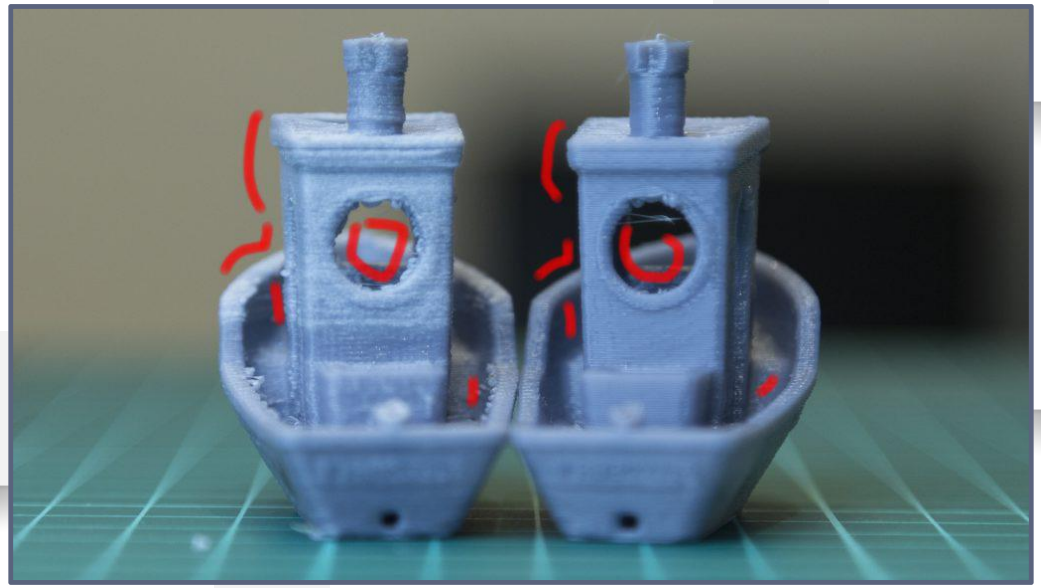


“Contaminated Filament”

Excess moisture in filament can cause bad quality prints & may even cause a blocked nozzle.

Possible solutions:

- **Dry filament in an oven at 70 degrees for 6 hours**
- **Store filament in airtight containers or bags with a dessicant.**

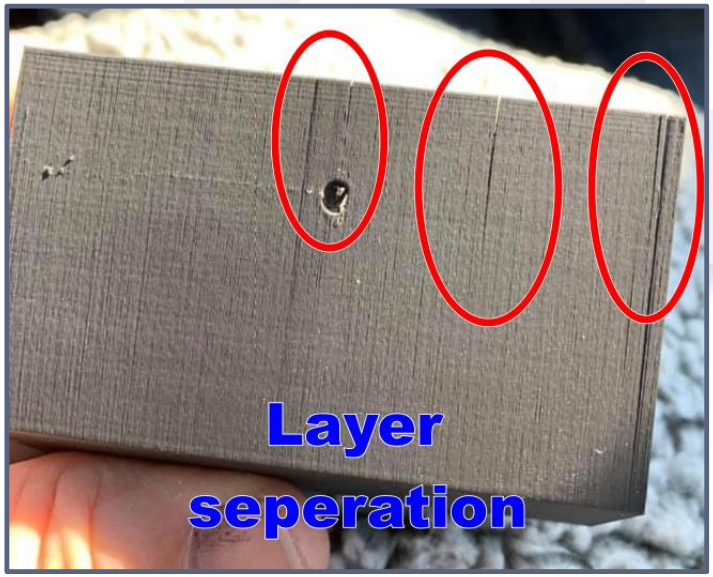


Layer Seperation or "Splitting"

Splitting is caused by the extruded material shrinking as it cools & the interlayer bond not being strong enough.

Possible solutions:

- Enclose the printer to reduce draughts.
- Reduce the fan speed or turn it off.
- Increase print temperature.
- Possibly try reducing the infill percentage.

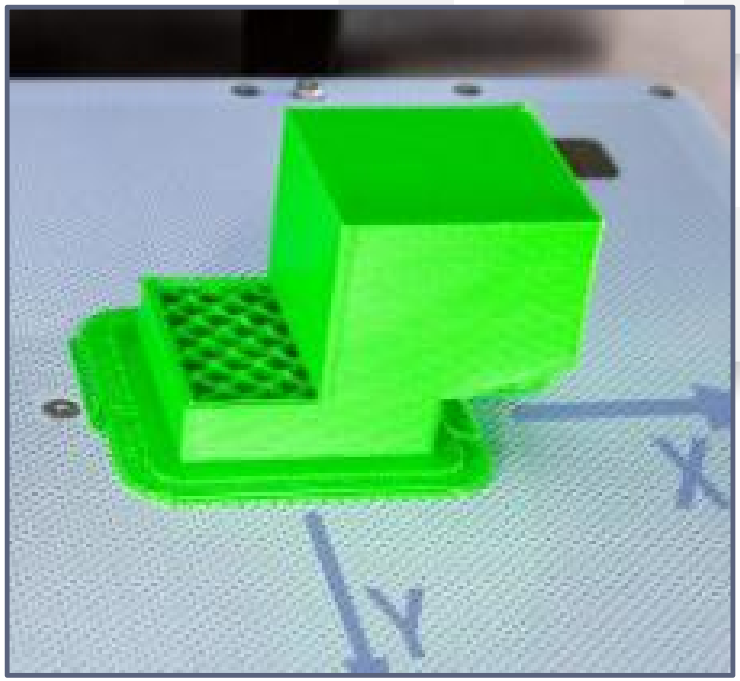


“Layer shift”

Layer shift is caused by an axis not moving as it should.

Possible causes:

- **Stepper motor wire loose or broken.**
- **Belts loose.**
- **Pulleys loose.**
- **Stepper drivers overheating.**
- **Axes binding up.**

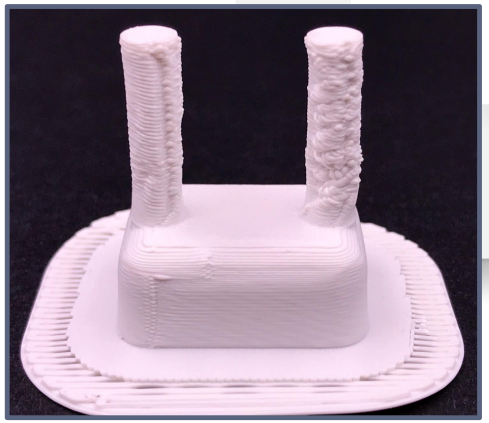


“Inadequate cooling”

Layers haven't had enough time to cool & have sagged.

Possible solutions:

- Increase the fan speed.
- Slow the print speed down.
- Add a pause between layers.
- Reduce the printing temperature.
- Print more than one item.

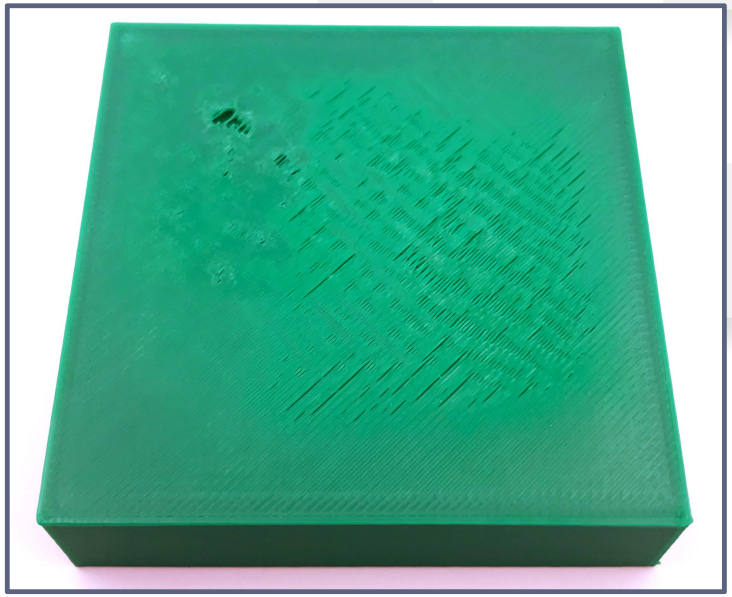


“Pillowing”

Top surface is too thin & has holes.

Possible solutions:

- **Increase the number of top layers.**
- **Slow the print speed down.**
- **Increase the infill percentage.**

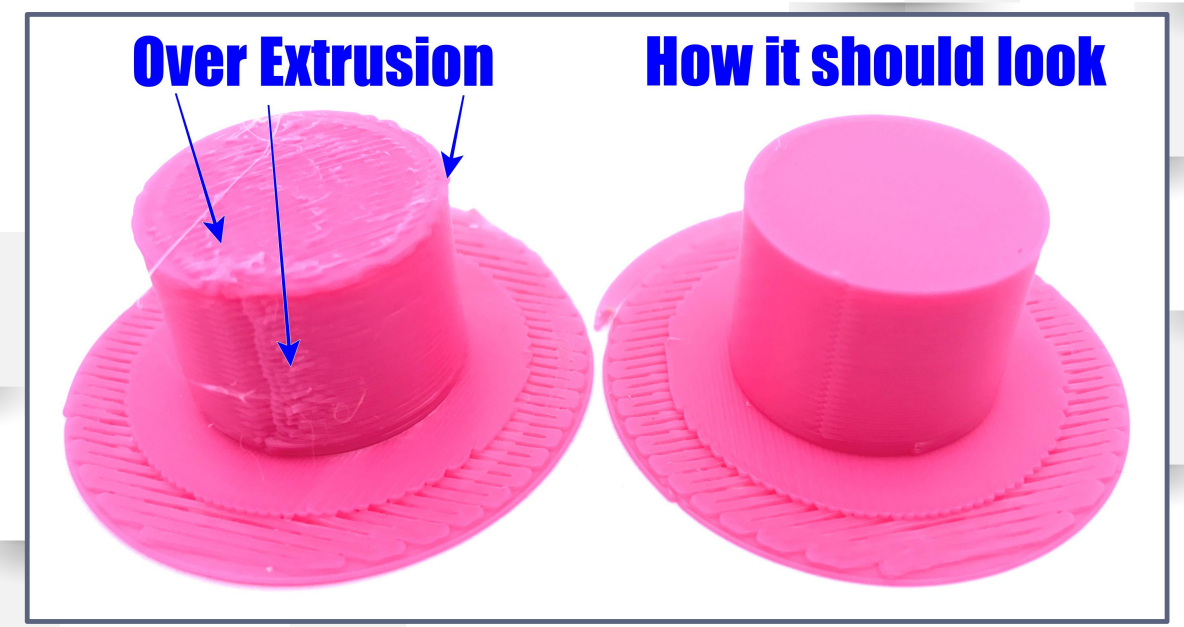


“Over extrusion”

Blobs & rough finish on print.

Possible solutions:

- **Change extruder flow ratio.**
- **Filament diameter may be off “spec” (too large).**

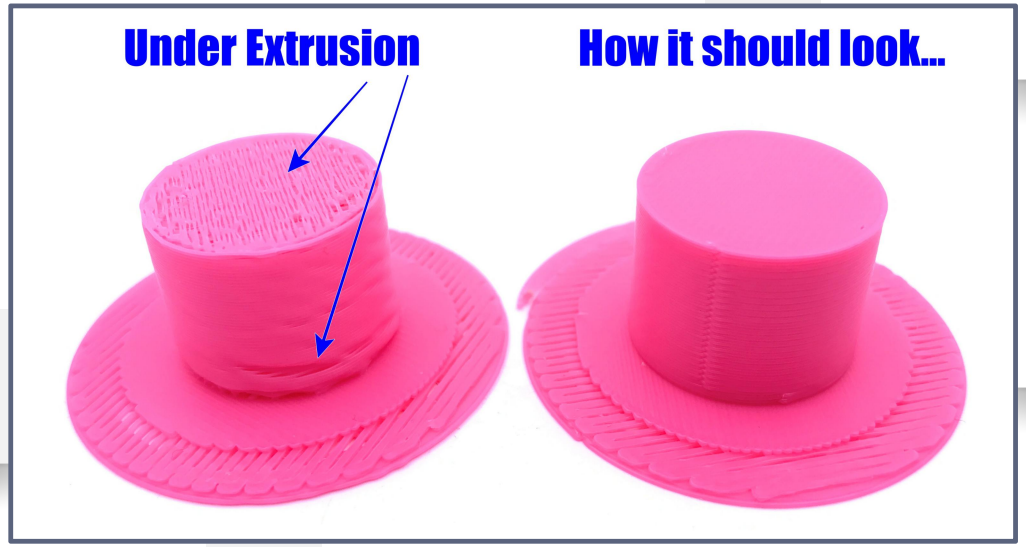


“Under extrusion”

Holes & cavities in layers.

Possible solutions:

- **Nozzle may be blocked (CHECK THIS FIRST).**
- **Filament diameter may be off “spec” (too small).**
- **Chnage extruder flow ratio.**



Extruder “Clicking””

Possible solutions:

- **Nozzle may be blocked (CHECK THIS FIRST).**
- **Nozzle height could be too low, blocking hotend**
- **Wiring to stepper motor could be broken**

Useful Links 1

Printing issues Help:

- https://rigid.ink/pages/ultimate-troubleshooting-guide
- https://all3dp.com/1/common-3d-printing-problems-troubleshooting-3d-printer-issues/

Materials & their properties:

- https://www.simplify3d.com/support/materials-guide/
- https://www.simplify3d.com/support/materials-guide/properties-table/

Tutorials in CURA & Other Programs

- https://all3dp.com/1/cura-tutorial-software-slicer-cura-3d/
- https://ultimaker.com/en/resources/21896-how-to-use-different-softwares

Useful Links 2

CAD File Checkers/Repairers

- https://service.netfabb.com/service.php
- https://makeprintable.com/

Massive Thank You To:

- https://zortrax.com/
- https://ultimaker.com/
- https://www.3dprintergear.com.au/

Glossary of Terms 1

Term	Definition
Extruder	Forces the filament into the hotend
Hotend	Part of the printer that heats the filament to make it melt.
Nozzle	This is where the plastic comes out when melted
Print head	Name given to assembly that includes hotend & nozzle
Direct Drive	Refers to extruder being mounted to the hotend
Bowden	Tube - Refers to extruder mounted seperately from hotend
Toothed Wheel	Part of extruder that grips the filament
Extrusion temperature	The temperature that the hotend maintains in order to melt the filament
Bed	Flat plate that is used to hold the build plate. Sometimes heated
Build Plate	Flat plate that the model is printed onto. Fastened to bed.
Gantry	Name given to support framework for print head
Stepper Motor	Motor used to accurately drive the extruder & gantries
Toothed Belt	Most commonly used to transfer motion from motor to gantries
Home switch	Tells printer controller that axis has reached "home" position
Home position	The position the axes are in when all home switches are activated
Bed adjuster	Screws that are used to alter the bed angle in order to get it level
Nozzle height	Set height of nozzle above the build plate when in the home position

Glossary of Terms 2

Term	Definition
Layer Height	The height of one layer of a print. Also referred to as resolution
Resolution	The height of one layer of a print. Also referred to as layer height
Seam	The join where a single layer starts & finishes
Infill	Material printed inside the model for support
Infill pattern	Pattern of infill material. Different patterns have different mechanical advantages
Retraction	Refers to filament being withdrawn into nozzle when travelling
Part cooling fan	Cools the plastic as it's extruded from the nozzle
Filament	Material loaded into the printer (ABS, PLA, Etc)
ABS	3D printing plastic Short for Acrylonitrile butadiene styrene
PLA	3D printing plastic Short for Polylactic acid
Hygroscopic	Having property of absorbing moisture from the air.
Warp	A warp is when the model bends (warps) away from the build plate
Interlayer Bond	The bond between layers. Typically weakest part of print.
Raft	Flat plastic surface printed for model to sit on. Improves bed adhesion
Brim	Single layer of plastic printed around a model. Used to improve bed adhesion
Support	Platsic construct printed with model to support overhanging parts.

Glossary of Terms 3

Term	Definition
CURA	Free slicer available for download
CAD	Acronym for "Computer Aided Design"
GCODE	Computer file type used by 3D printers
STL	One form of solid model that can be used by Slicers to produce Gcode
OBJ	One form of solid model that can be used by Slicers to produce Gcode
FDM	Acronym for Filament Deposition Modelling
Slicer	Program that converts CAD files into Gcode for printing
Cartesian	Describes a printer that has axes corresponding to X, Y & Z directions of travel
Delta	Describes a printer that uses triangulation to locate the printer head in X, Y & Z axes

Zortrax Parts ID

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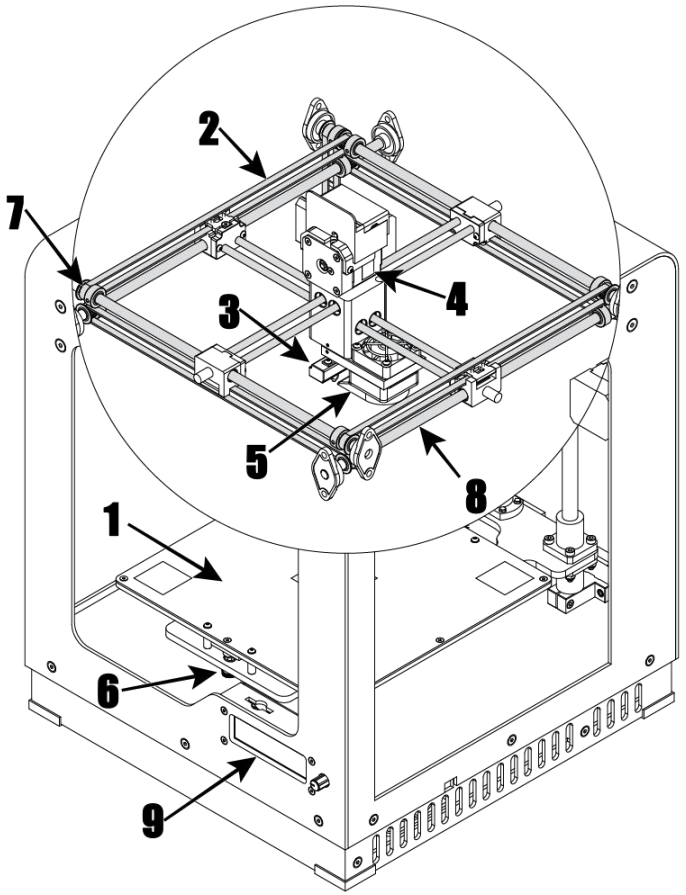

Flashforge Parts ID

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