

# 3D Printing

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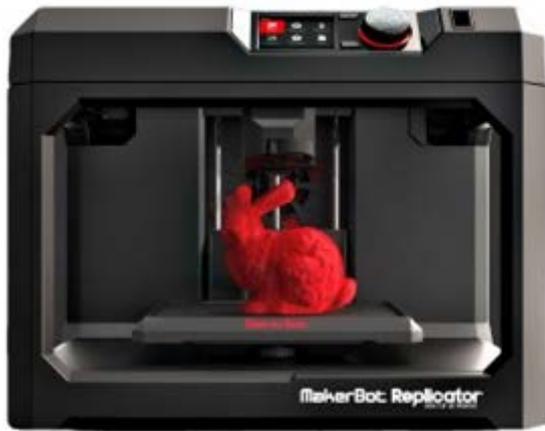
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# 3D Printers



# Manufacturing Methodologies

**Additive manufacturing** is a process of joining materials to make objects.

Example: 3D printing

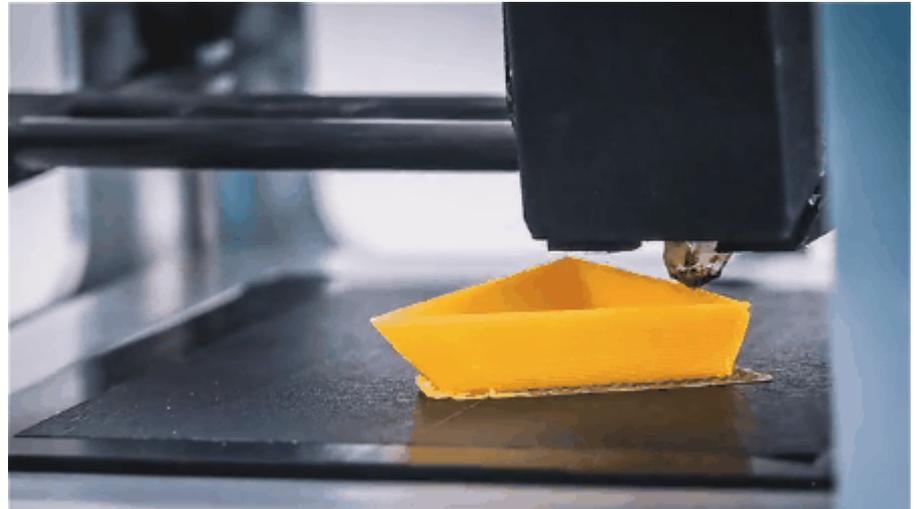
**Subtractive manufacturing** is a process of removing materials to make objects.

Example: CNC mill/router

# Fused Deposition Modeling (FDM)

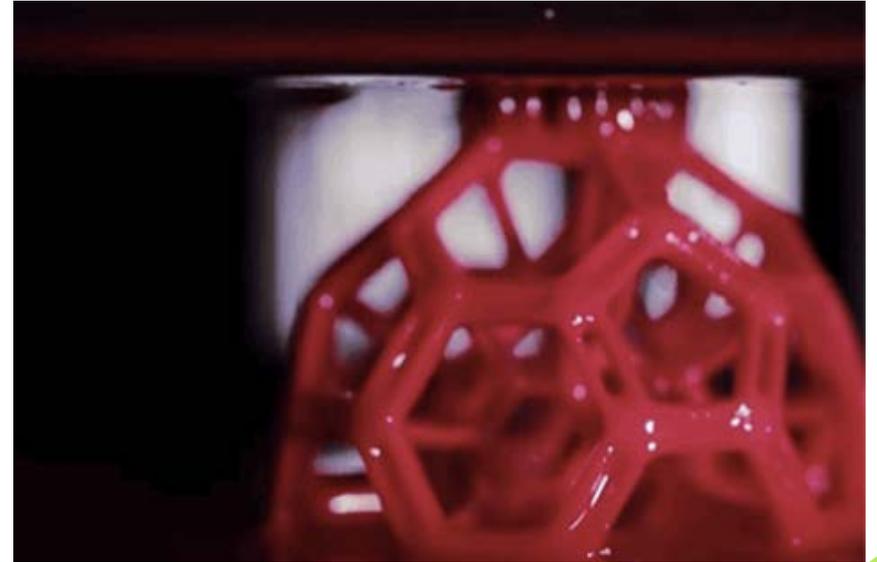
1. Filament is melted and extruded
2. Model is built by adding layer after layer

Cost effective but lower print quality.



# Stereolithography (SLA)

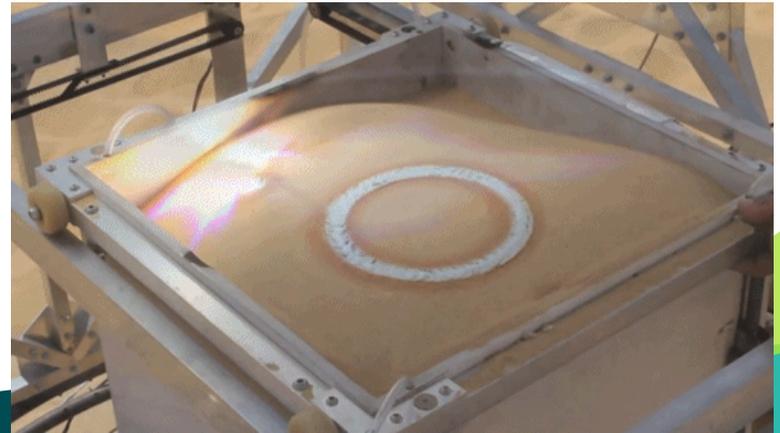
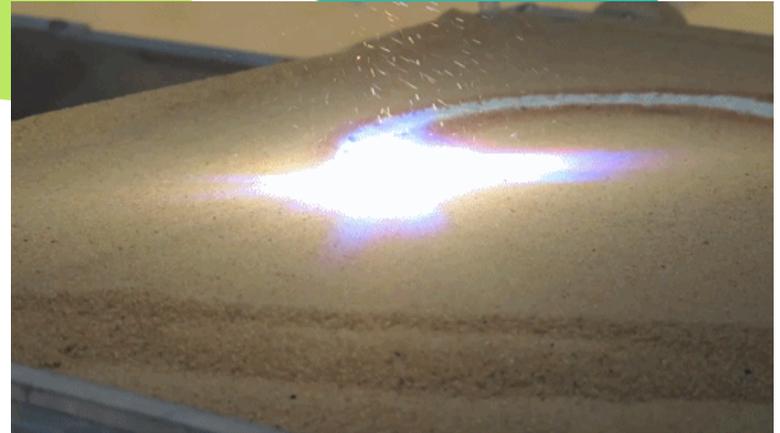
1. Print surface submerged in a resin and then lifted
  2. Light sensitive resin layer covers surface
  3. Light is projected onto surface.
  4. Object is lifted out of resin.
- Higher print quality but more expensive.



# Selective Laser Sintering (SLS)

1. Thin layer of powdered material spread over the print area
2. Laser fuses powder

High temp materials  
Metal printing



# Hardware

# PrintrBot Simple Metal



**Model:** 1403

**Build Volume:** 6" x 6" x 6" / 150mm x 150mm x 150mm / 216 cubic inches

**Print Resolution:** 50 Microns

**Print Speed:** 80mm/sec max recommended

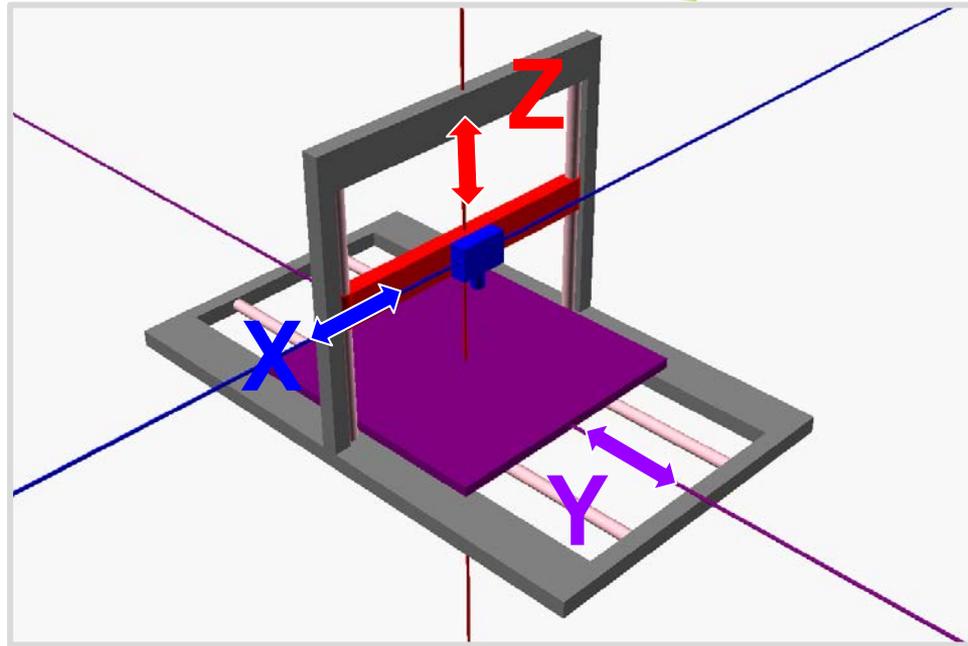
**Filament:** 1.75mm PLA

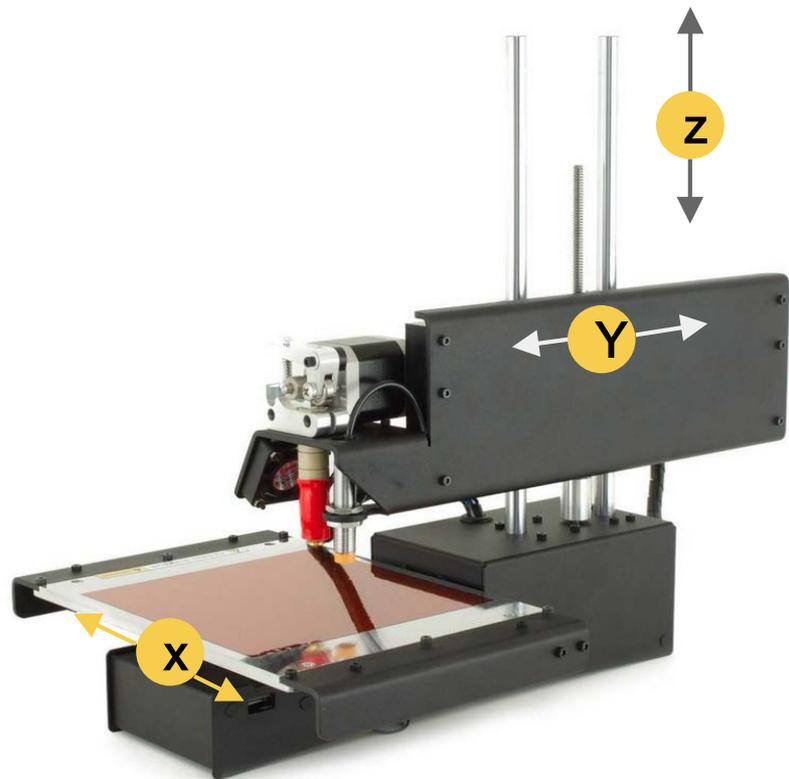
**Extruder:** Alu Extruder V2 (direct drive) with 1.75mm Ubis Hot End with 0.4mm nozzle

**Auto Leveling:** Auto-Leveling Probe

**Print Bed:** Not heated – powder coated 5052 aluminum (0.3mm level tolerance)

# 3D Printer Axis



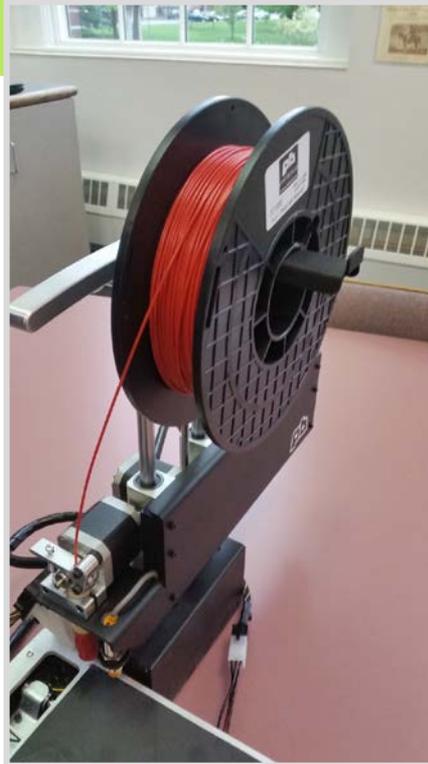


# Filament holder

Spools of filament can hang from the holder.

Be sure the spool has free rotation around the spool holder.

Remove any tangles or knots and make sure there is enough filament to complete the print.



# Print bed & Buildtak

The surface that the print adheres to.

Buildtak is a textured surface that helps with print adhesion. Works well with PLA. Make sure print nozzle is about 0.25mm above surface.

Clean by scraping. Do not use solvents or chemicals.



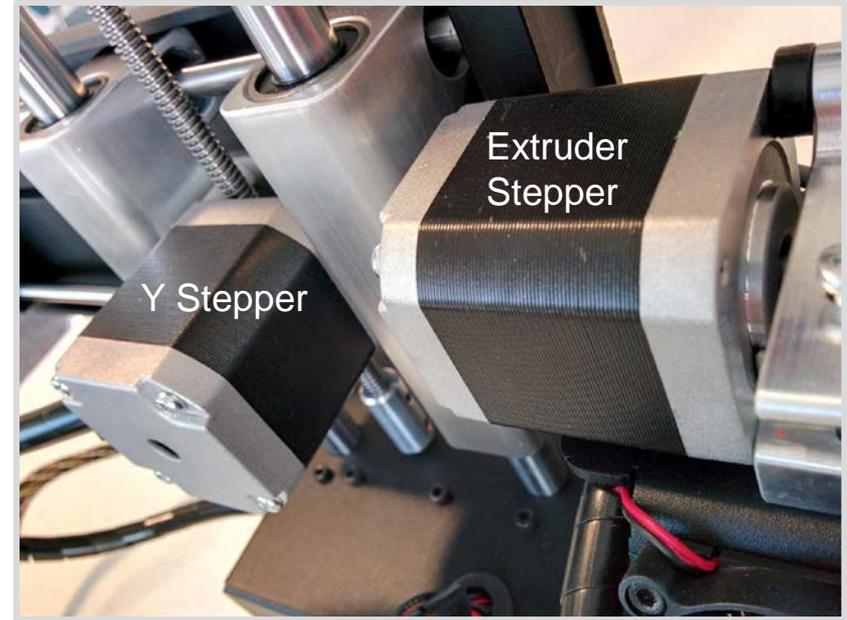
# Stepper motors

The printer controls distances and speeds by sending pulses to the motors.

200 pulses = 1 revolution

Four stepper motors on PrintrBot:

1. Extruder
2. X axis
3. Y axis
4. Z axis

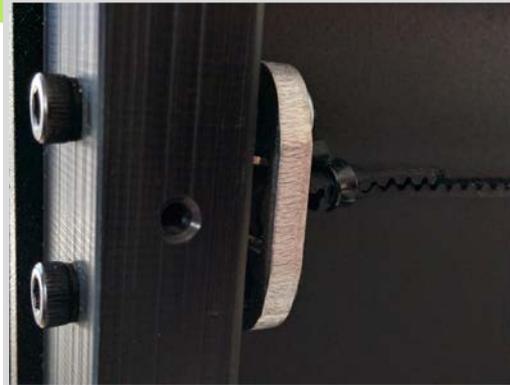


# Belt Tensioning

Belts need to be periodically tensioned over time.

Tighten allen bolts to increase belt tension.

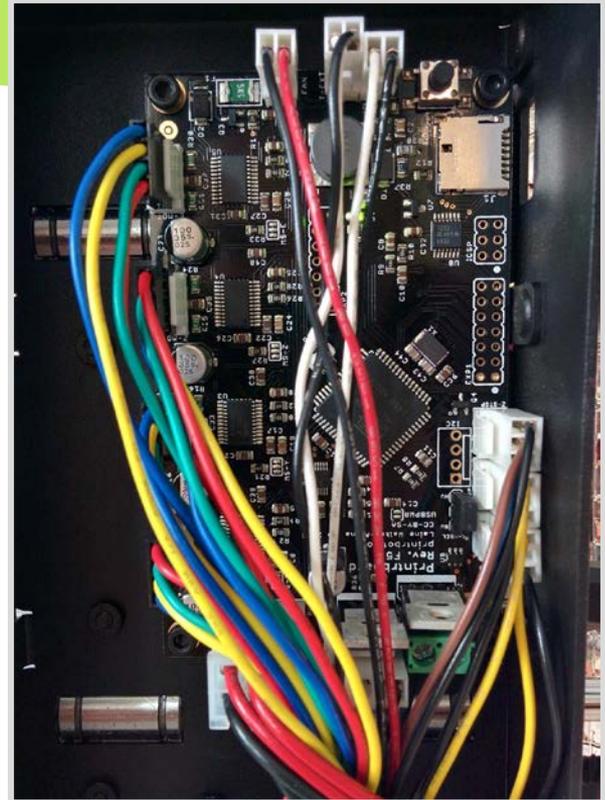
A sign of a loose belt will first show in print quality. Check belt tension.

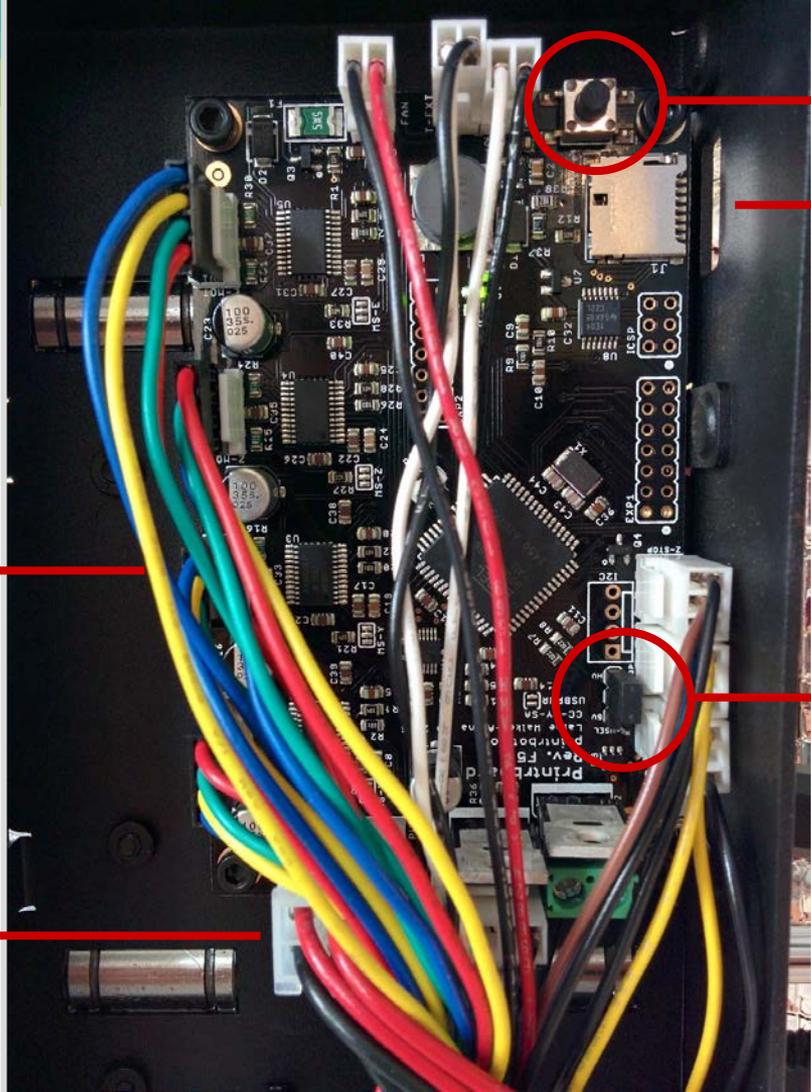


# Controller board

Interprets print commands coming from the computer and controls the stepper motors and nozzle/bed temperatures.

Located on underside of  
Printrbot.





Reset Button

SD card slot

Stepper motor wires

Power

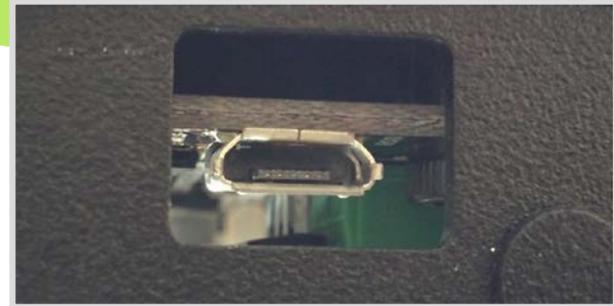
HV Jumper



# Micro USB cable

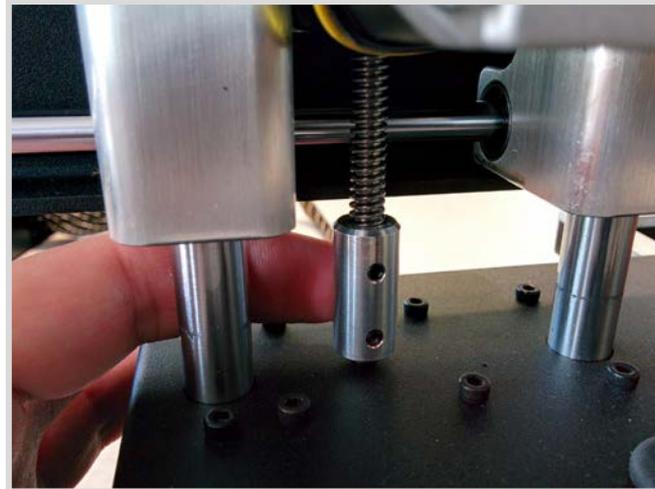
USB-A to USB Micro-B cable.

Be sure to use a data USB cable  
not a charging USB cable.

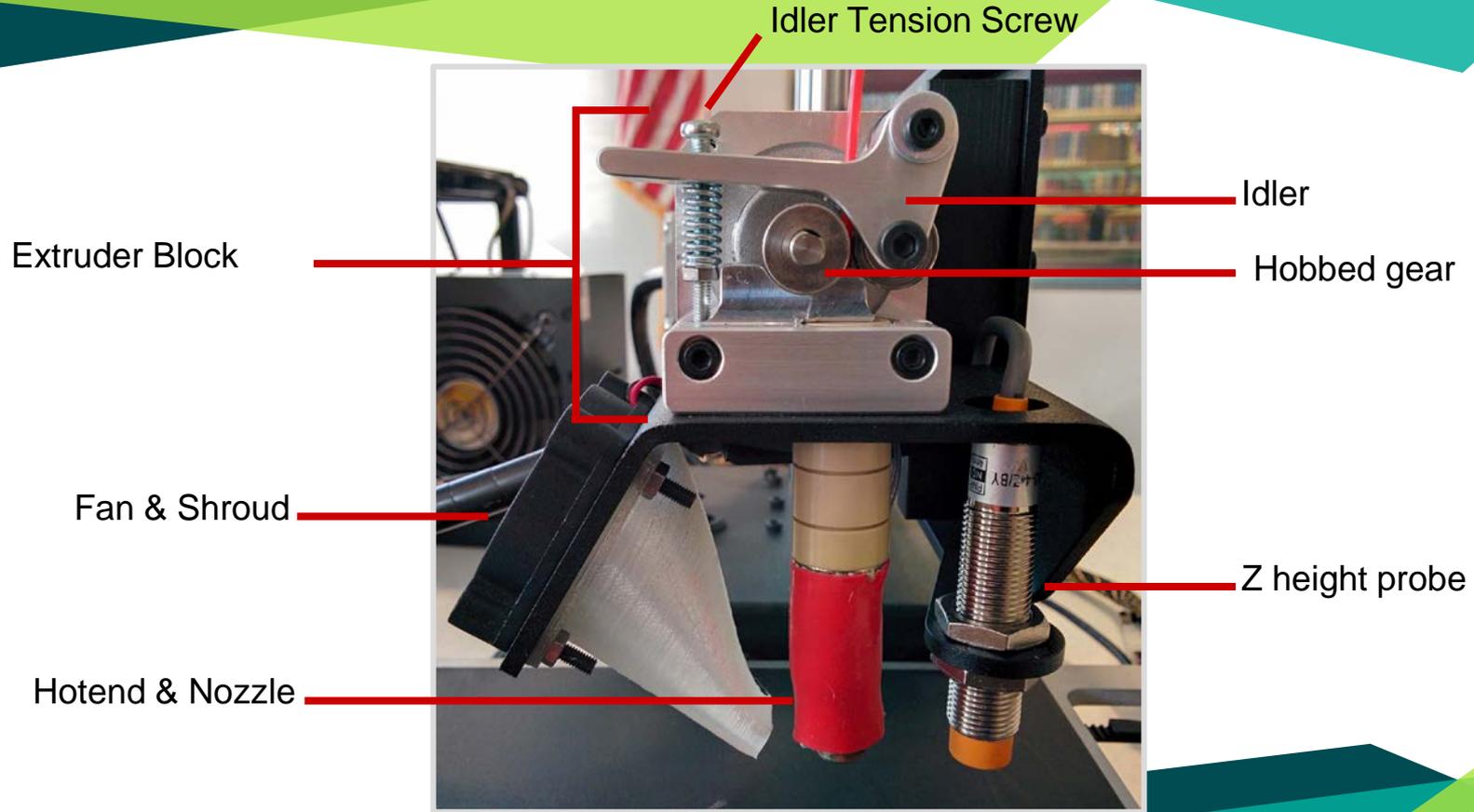


# Z lead screw

Controls the z height  
Connected to the z stepper  
motor

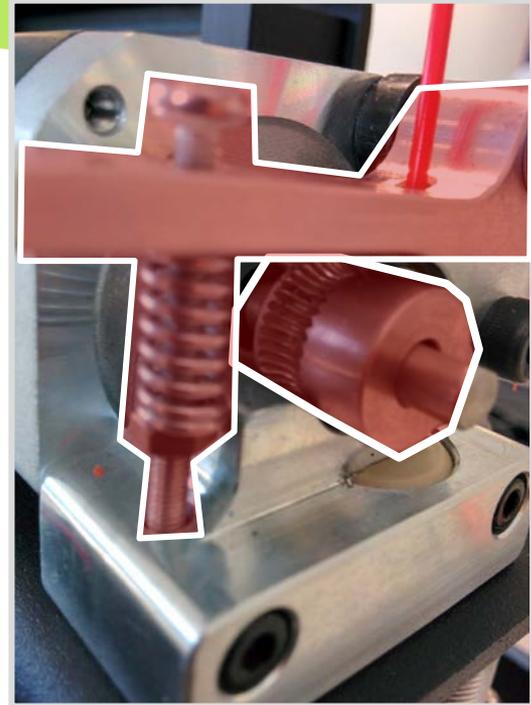


# Extruder Assembly



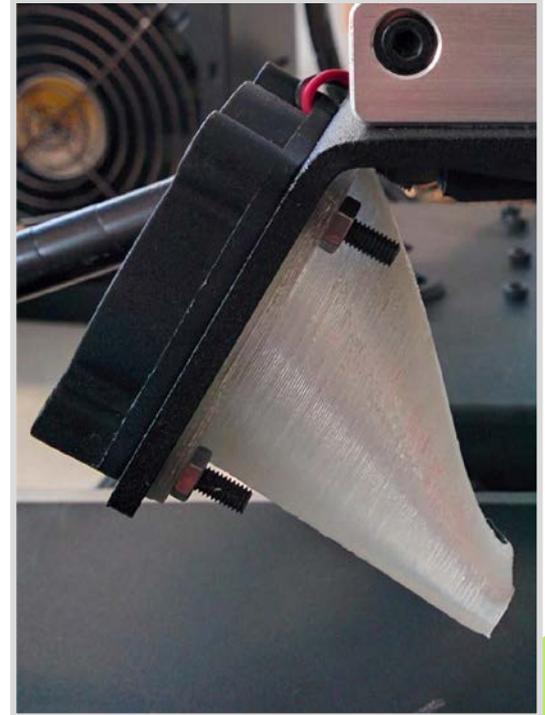
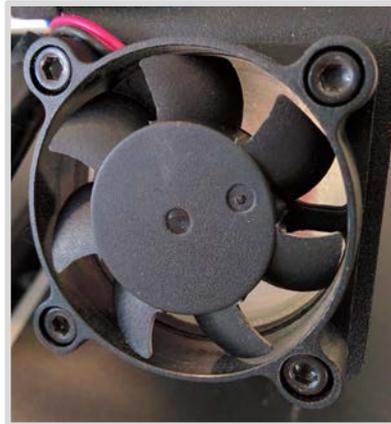
# Extruder

Hobbed bolt feeds filament  
Lever and spring grip filament  
Pressing lever releves grip on filament for removal  
Tightening nut reduces grip on filament



# Cooling Fan & Shroud

Helps cool print layers  
Shroud directs the air to  
the nozzle tip  
Helps with print quality  
Permits faster prints and  
bridging



# Hotend & Nozzle

The nozzle is where the filament is melted and forced out of a nozzle.  
Accepts 1.75 mm filament  
0.4mm nozzle diameter  
Red insulating silicone helps maintain nozzle temp. (do not touch)



# Z sensor

Inductive sensor that measures the height above the print bed.

Printer auto-levels at the beginning of every print by measuring at 3 locations on the print bed.

Light at the top indicates the bed has been detected.

Hex nuts for mechanical calibration.



The background consists of several overlapping, semi-transparent geometric shapes. A large, central horizontal band is a bright lime green. Above and below this band are various shapes in shades of teal and dark teal, creating a layered, mountain-like or abstract landscape effect. The overall aesthetic is modern and clean.

**Software**

# Download Required Files

Download the getting started package  
Download includes Cura 15.04.2 installation for PC/ Apple and Cura profile for the PrintrBot Simple.  
Extract to a folder on your Desktop.  
Start Cura

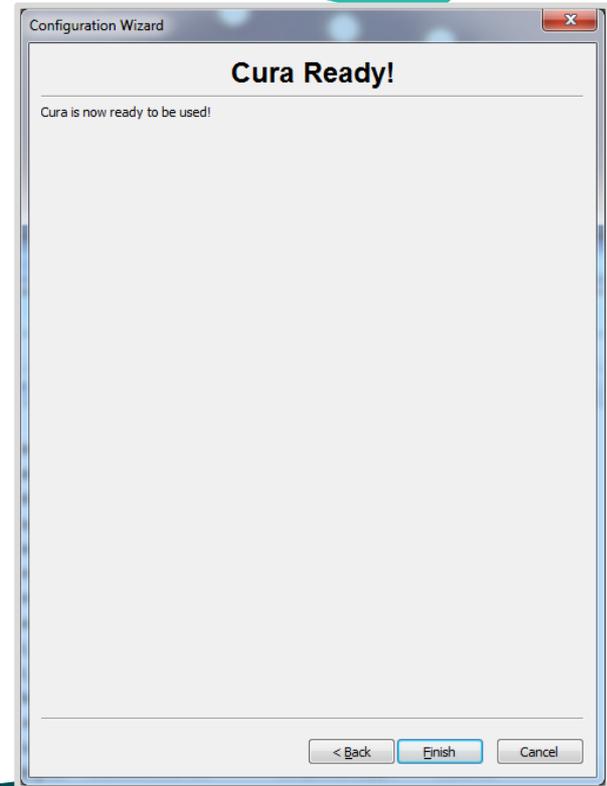
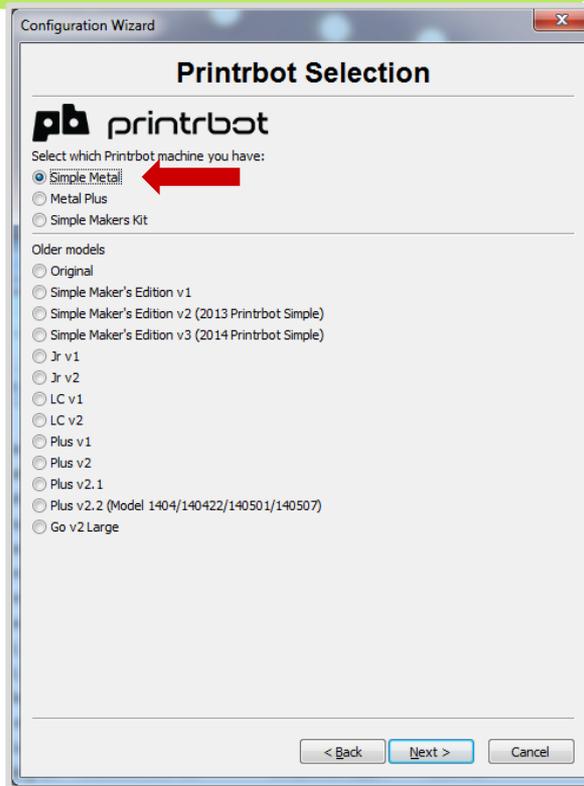
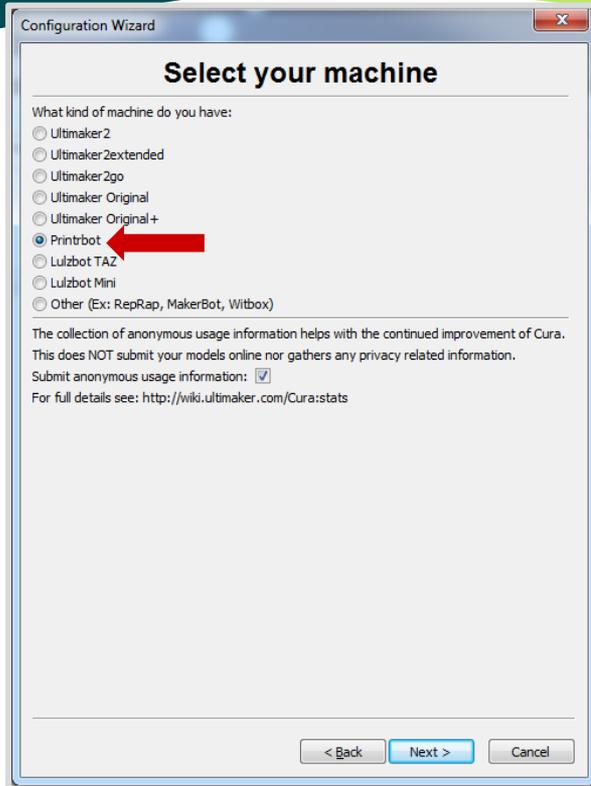
<http://printrbot.com/project/simple-metal/>

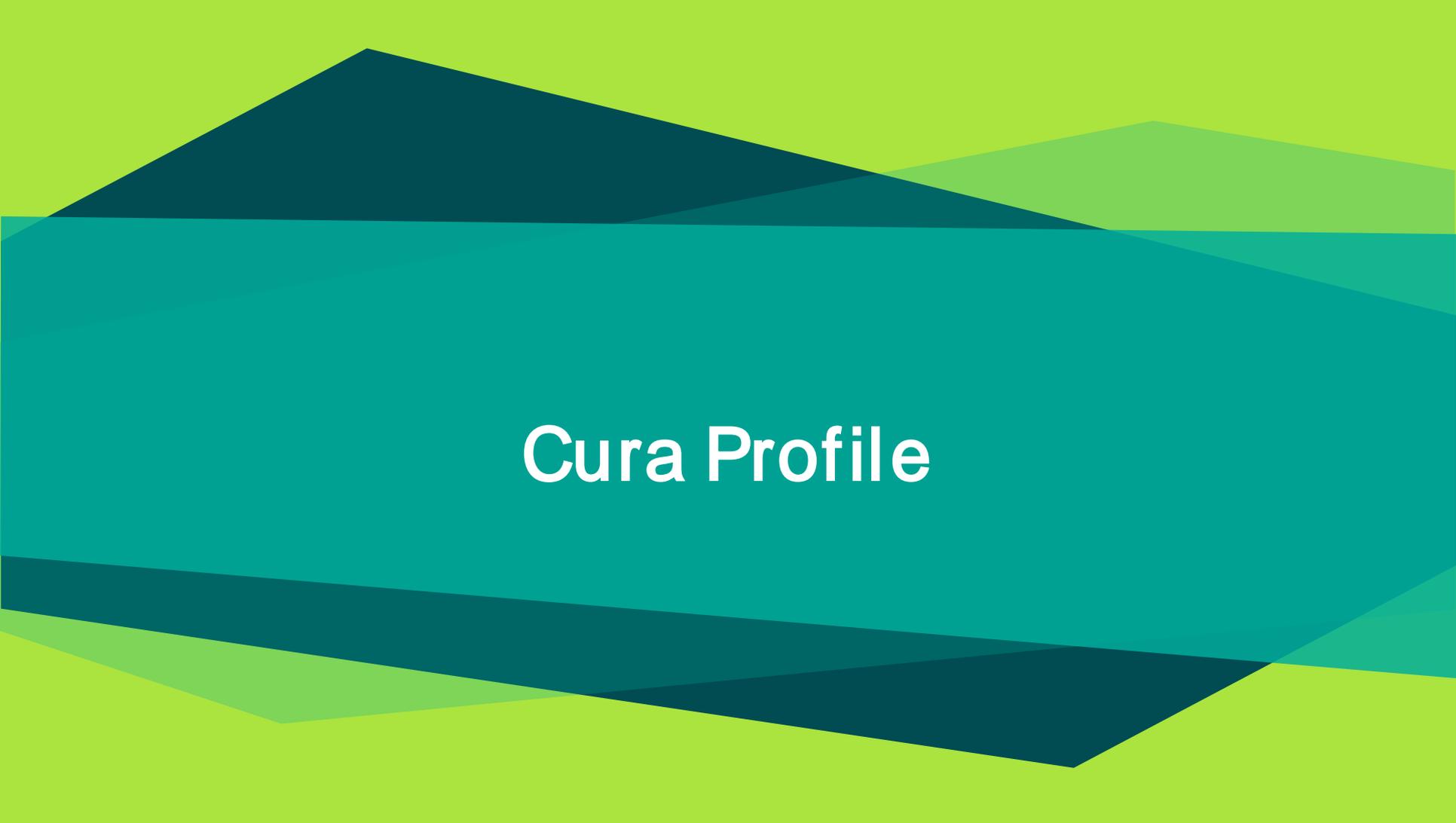
## Required Downloads

Install your free software, and get the other necessary files before starting your first print.

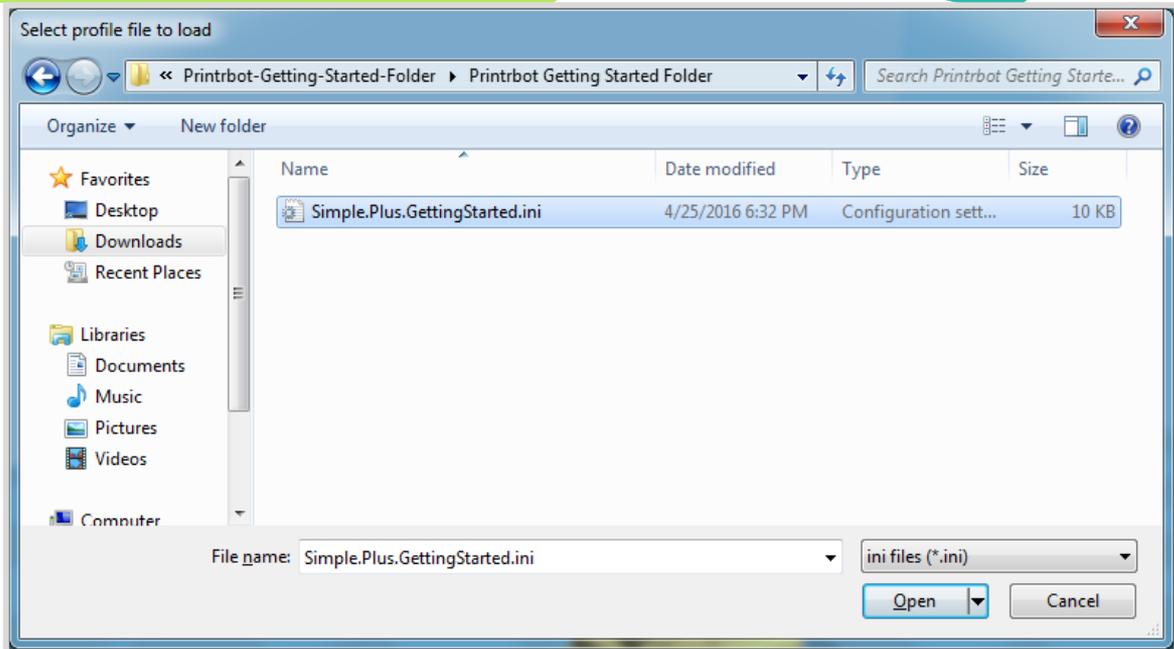
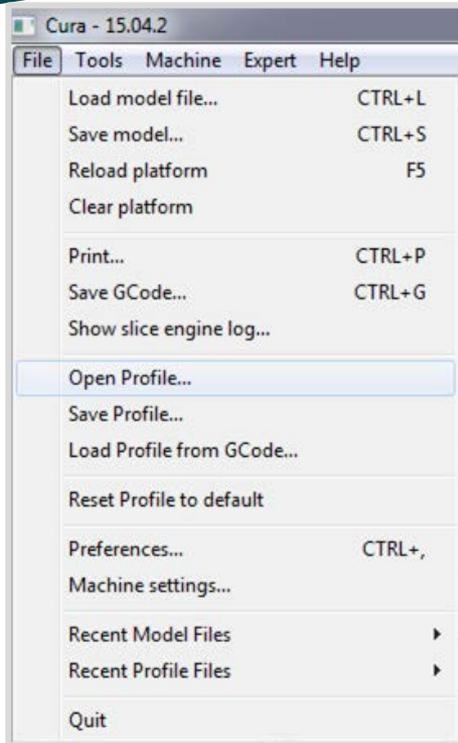
Click to Download

# One time setup: Select Machine



The background features a central teal-colored area with the text 'Cura Profile' in white. This teal area is framed by dark teal and lime green geometric shapes that create a layered, mountain-like effect. The overall design is modern and minimalist.

# Cura Profile



Cura - 15.04.2

File Tools Machine Expert Help

Basic Advanced Plugins Start/End-GCode

---

**Quality**

Layer height (mm)

Shell thickness (mm)

Enable retraction

---

**Fill**

Bottom/Top thickness (mm)

Fill Density (%)

---

**Speed and Temperature**

Print speed (mm/s)

Printing temperature (C)

---

**Support**

Support type

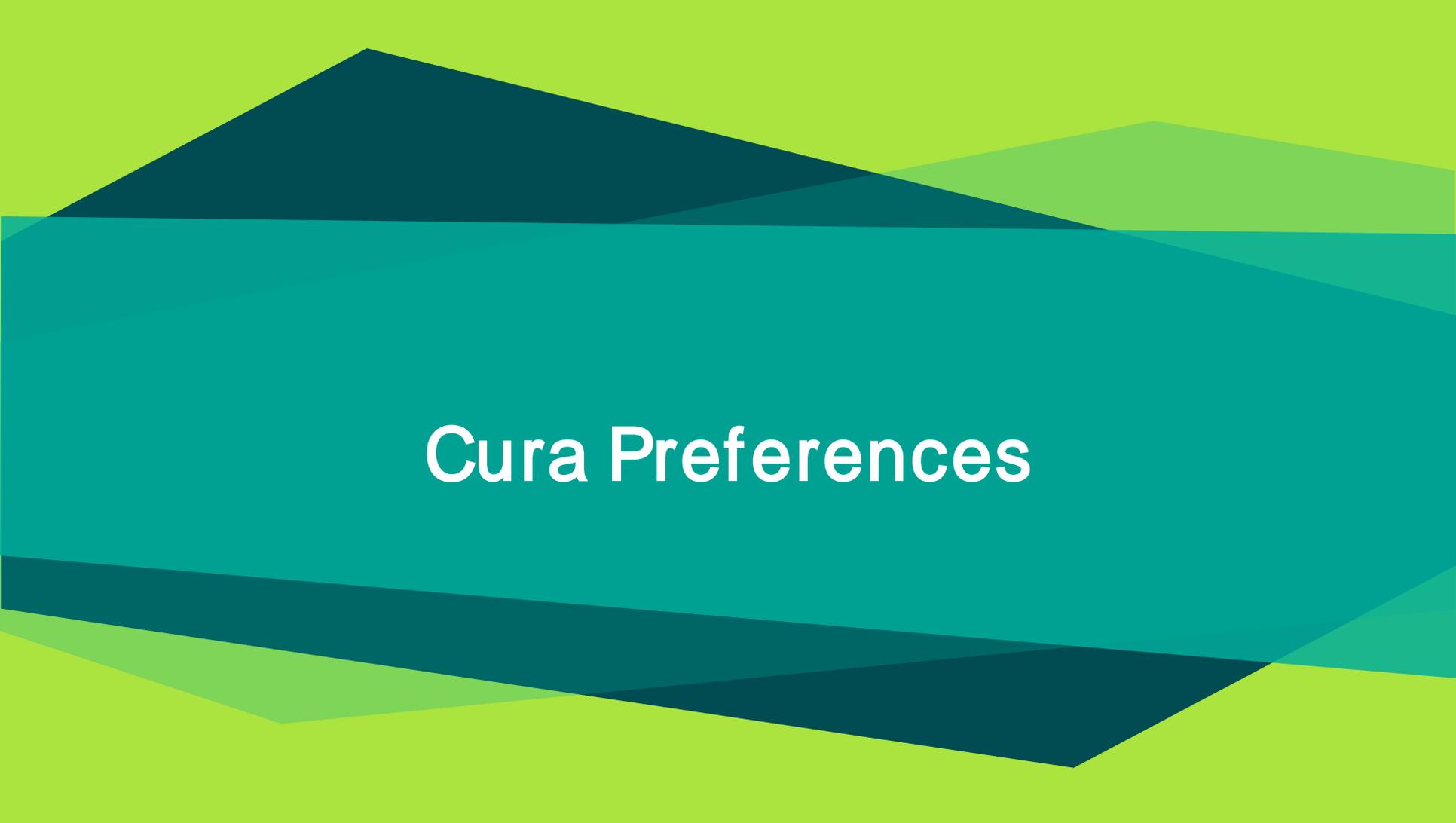
Platform adhesion type

---

**Filament**

Diameter (mm)

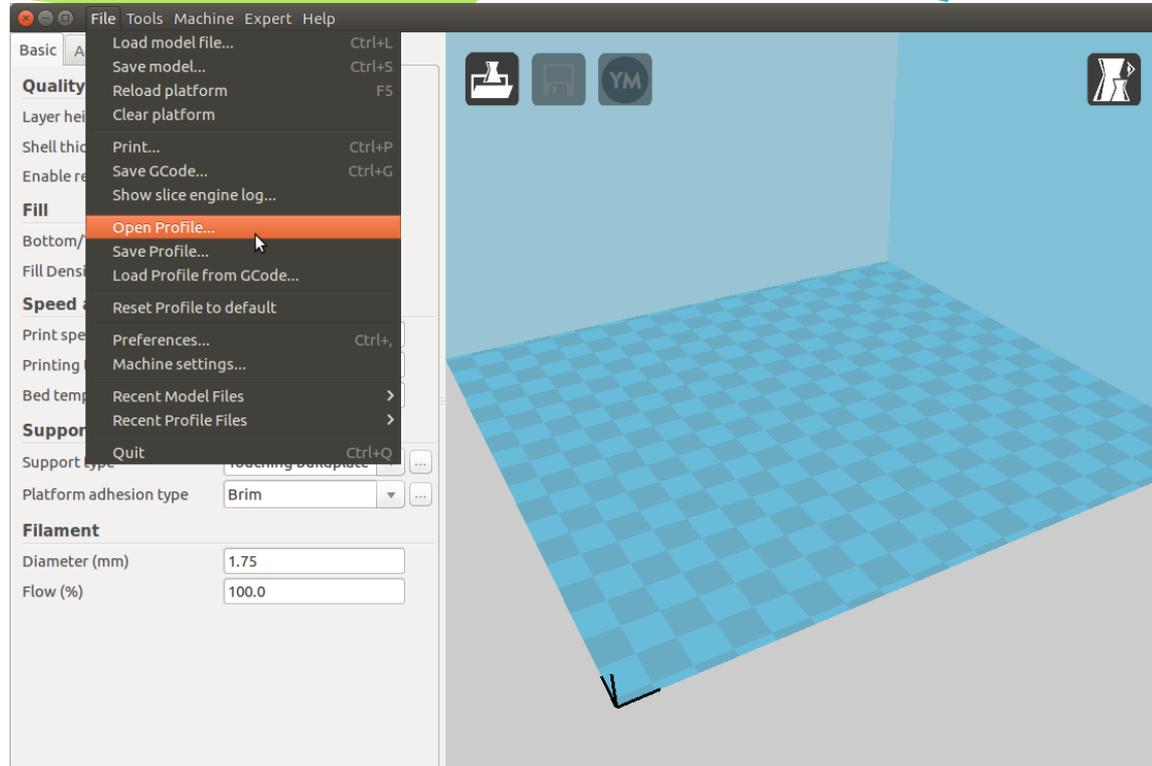
Flow (%)

The background features a series of overlapping, semi-transparent geometric shapes in shades of teal and lime green, creating a layered, mountain-like effect. The central text is white and stands out against the teal background.

# Cura Preferences

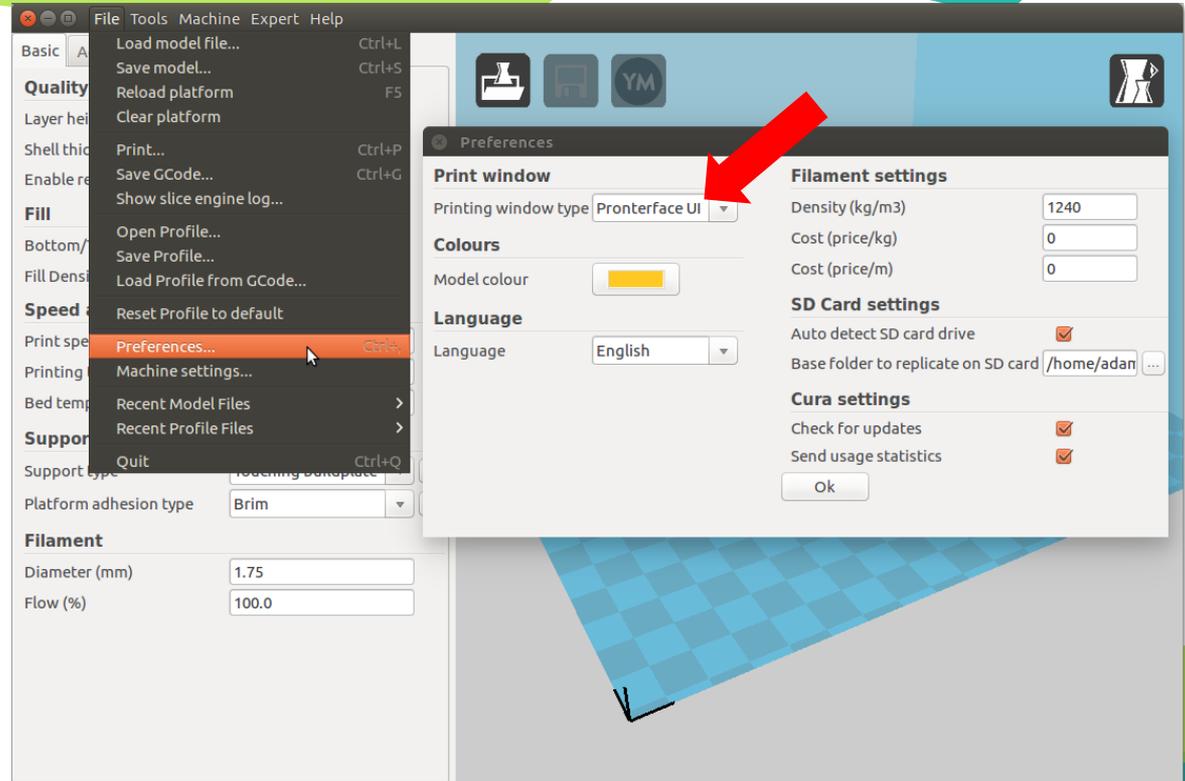
# One time setup: Load Profile

Under the **File** menu  
click on **Open Profile...**  
point it to the file  
called:  
**Simple.Plus.GettingStarted.ini**



# One time setup: Cura Preferences

In preferences  
change the Print  
Window option to  
Pronterface UI.



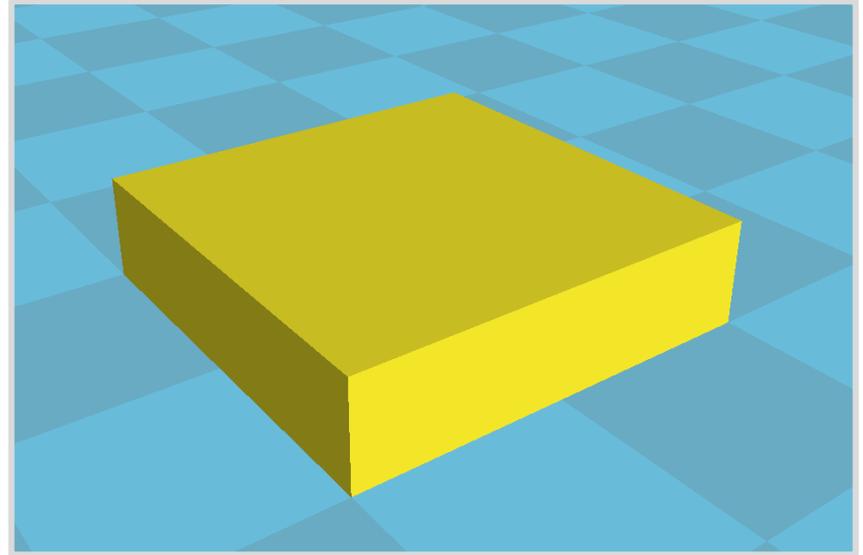
The background consists of several overlapping, semi-transparent geometric shapes. A large teal shape forms a central horizontal band. Above and below this band are darker teal shapes that resemble mountain peaks or angular folds. The remaining space is filled with a bright lime green color. The overall effect is a modern, layered, and abstract design.

# First Print!!

Calibration Cube

# Process Overview

1. Download calibration cube  
<http://www.thingiverse.com/thing:1538876>
2. Load calibration cube into Cura
3. Review slice settings
  - a. Layer height
  - b. Temps
  - c. Speeds
4. Make sure printer is detected
5. Start print



# Load Model File

You can load the calibration cube STL file a few ways:

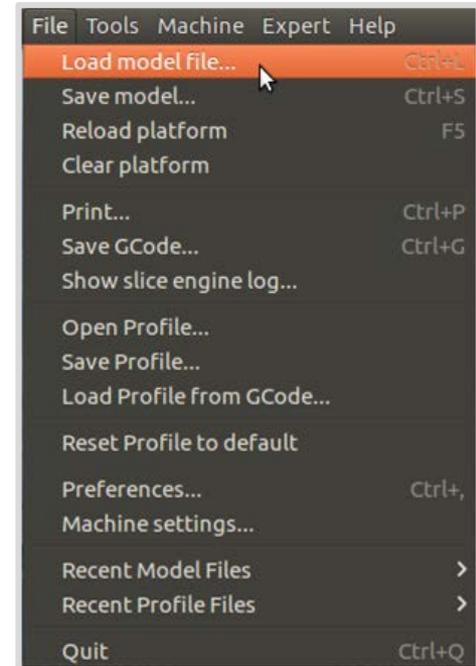
- Double clicking on the .stl file

- Clicking the **load model** button

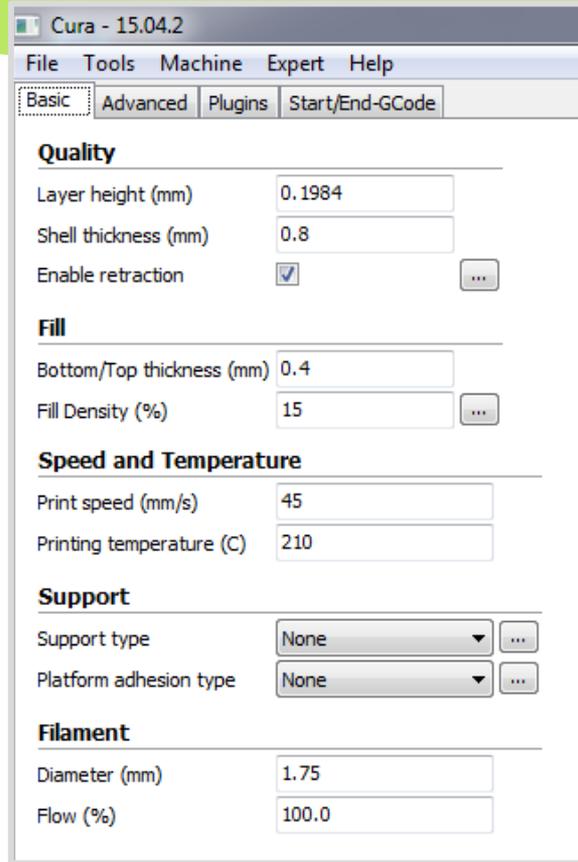
- File > Load model file ...

Model file needs to be in .stl format.

Example: calibrationCube.stl



# Review Slice Settings



Cura - 15.04.2

File Tools Machine Expert Help

Basic Advanced Plugins Start/End-GCode

**Quality**

Layer height (mm) 0.1984

Shell thickness (mm) 0.8

Enable retraction  ...

**Fill**

Bottom/Top thickness (mm) 0.4

Fill Density (%) 15 ...

**Speed and Temperature**

Print speed (mm/s) 45

Printing temperature (C) 210

**Support**

Support type None ...

Platform adhesion type None ...

**Filament**

Diameter (mm) 1.75

Flow (%) 100.0

# Device Detection

Make sure the printer is powered on and the USB cable is connected.



Printer detected

Print with USB



21 minutes  
1.14 meter 3 gram



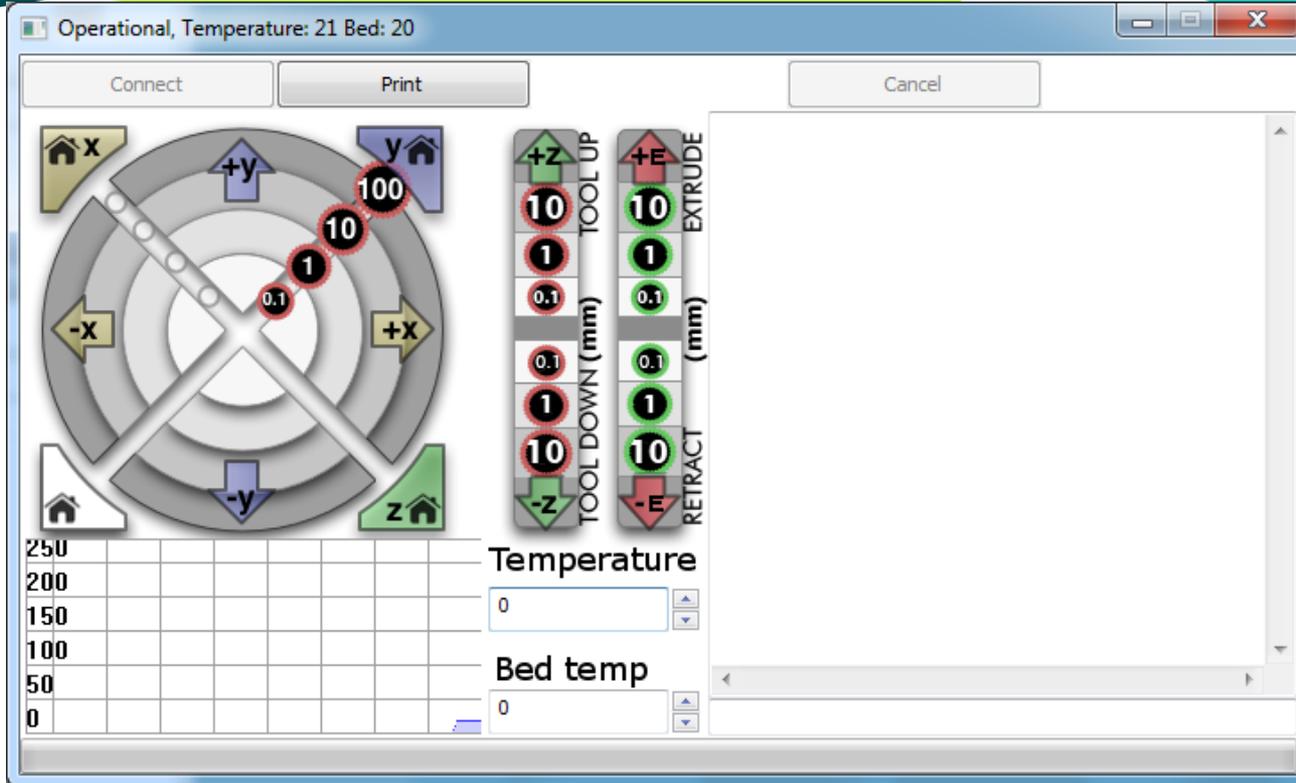
Printer not detected

Save toolpath



21 minutes  
1.14 meter 3 gram

# Pronterface Overview



# Pronterface: Status Bar

Print with USB

1  Opening serial port, Temperature: 21 Bed: 20

2  Detecting baudrate, Temperature: 21 Bed: 20

3  Operational, Temperature: 21 Bed: 20

Pronterface Print Button

1  Printing on COM3

2  Printing, Temperature: 21 Bed: 20

# Things to watch for

Make sure the temperatures are what you expect.

The printer homes and calibrates.

Make sure the nozzle doesn't crash into the bed.

Be ready on the power.

Watch the first layer. Check for good bed adhesion .

If the first layer doesn't stick or lifts off the bed, cancel the print, home the printer and restart.

If the printer doesn't seem to be responding: close out of all software and power off the printer. Power on the print and start Cura.

# Calipers

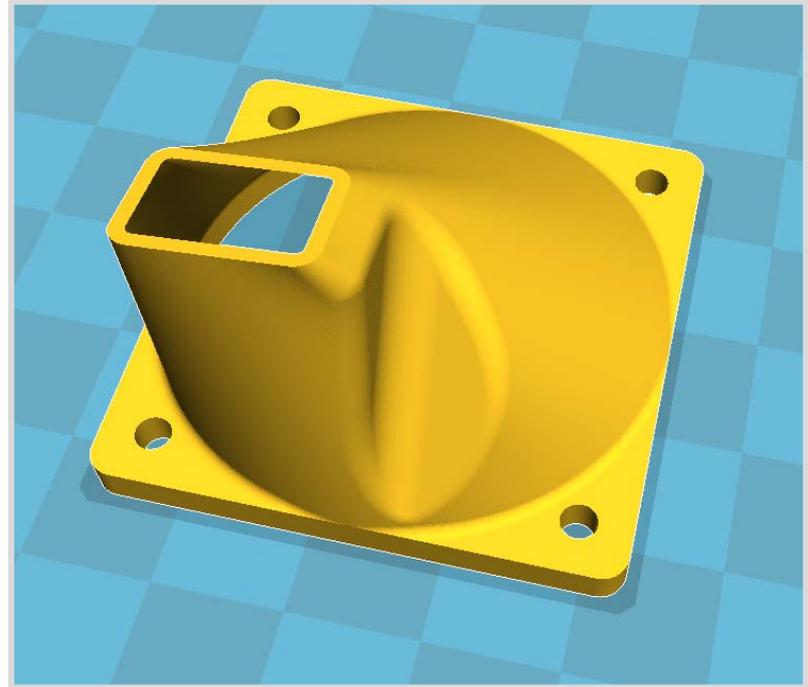
Loosen nut if calipers will  
not move freely  
Turn calipers on  
Close all the way and press  
the zero button  
Measure object



# Fan Shroud

Print the fan shroud from  
PrintrBot and attach it to your  
printer.

<http://printrbot.com/project/simple-metal/>





# Print Challenge!

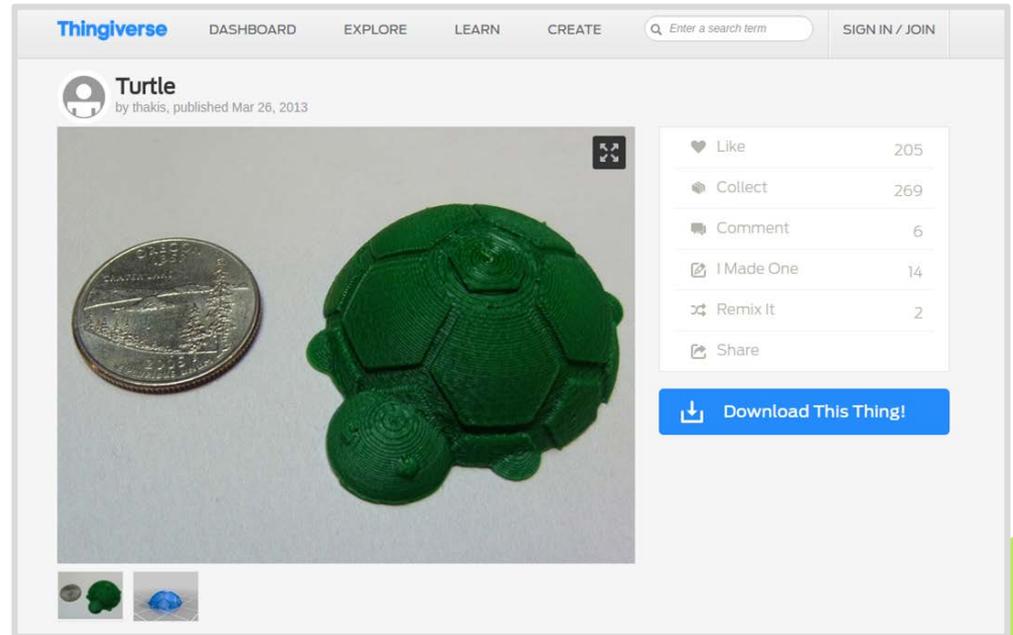
Thingiverse is a vast and wonderful place



<http://www.thingiverse.com>

# Finding an object on Thingiverse

<http://www.thingiverse.com/thing:66181>



The screenshot shows the Thingiverse website interface. At the top, there are navigation links: DASHBOARD, EXPLORE, LEARN, and CREATE. A search bar contains the text "Enter a search term". On the right, there is a "SIGN IN / JOIN" link. The main content area features a user profile for "Turtle" by "thakis", published on "Mar 26, 2013". The central image shows a green 3D printed turtle shell next to a US quarter coin for scale. To the right of the image is a list of actions with their respective counts:

Like	205
Collect	269
Comment	6
I Made One	14
Remix It	2
Share	

Below this list is a blue button labeled "Download This Thing!". At the bottom left of the image area, there are two small thumbnail images: one of the green turtle shell and one of a blue object.



A 3D Printer goes...

“Doooodle-doodle-doodle-dooo-doodle-do-do-do-doooodle”

# Infill

Infill is the computer generated paths inside of the geometry.

0% is hollow

95% to 100% is solid

Cura only uses Rectilinear infill

Slic3r also has honeycomb infill



# Scale

Click on the **scale** icon

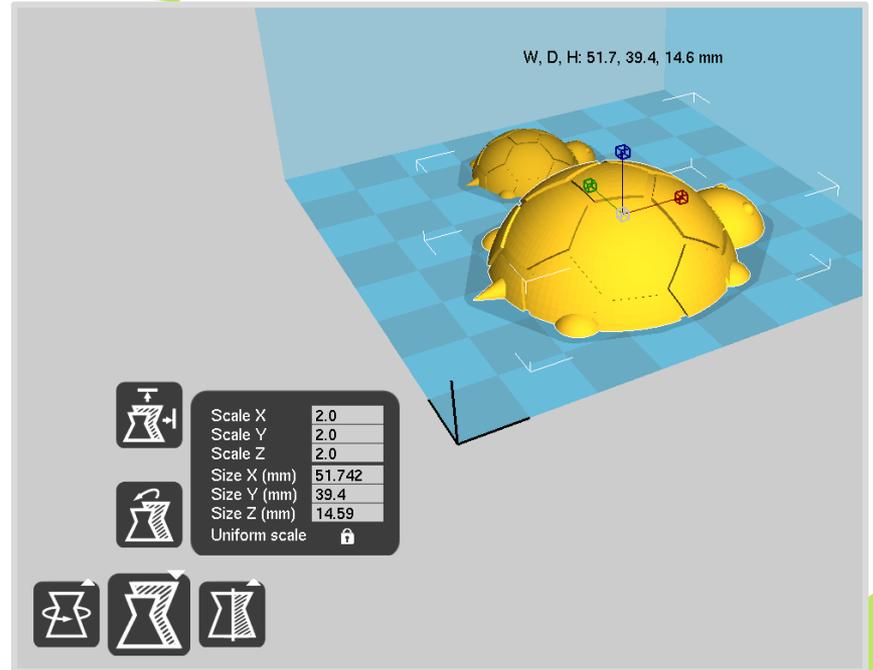
Type a number into **Scale X**

1.0 is the original object size

2.0 is 200% of the size

0.5 is 50% of the size

Click the lock to allow stretching of the part



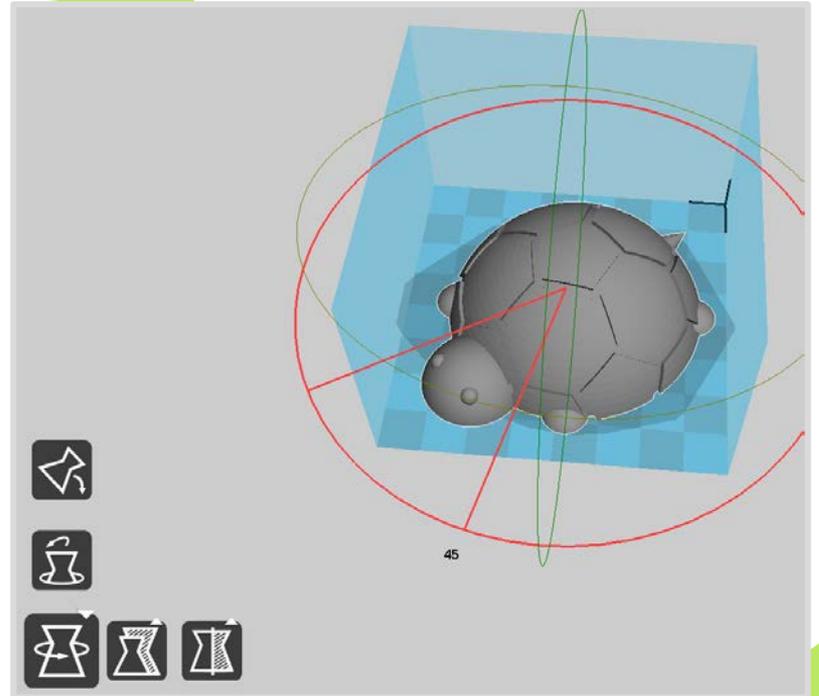
# Rotate

Click on the **rotate** icon

Locate the circle that represents the desired plane of rotation

Click on the circle and rotate to desired angle

On the bed plane it can be used to better fit large or multiple objects.



# Multiple Objects

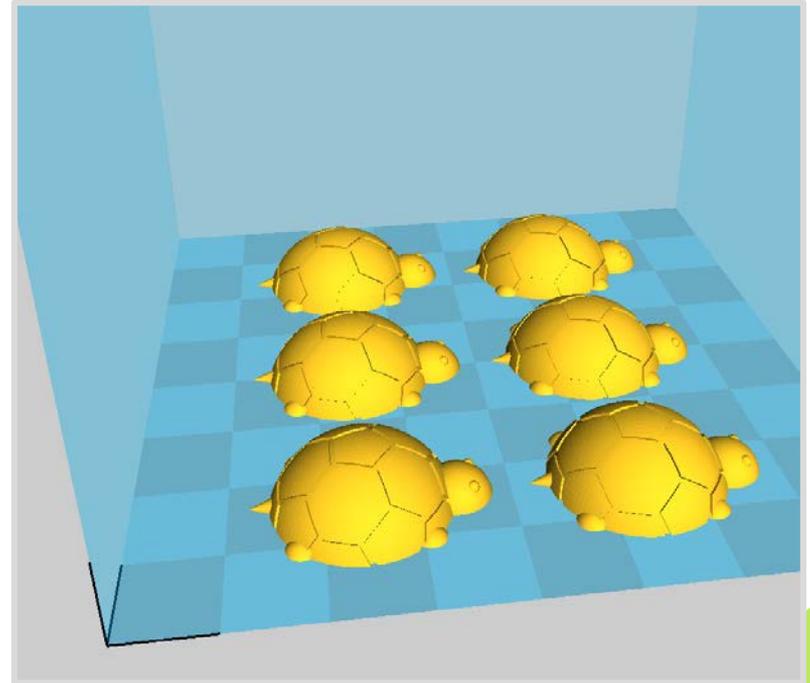
Right click on the object

Click **Multiply Object**

Type in the number of objects

Cura will limit to the number that will fit on the bed

Objects can be deleted by pressing the “**delete**” key  
Drag and drop to add other objects

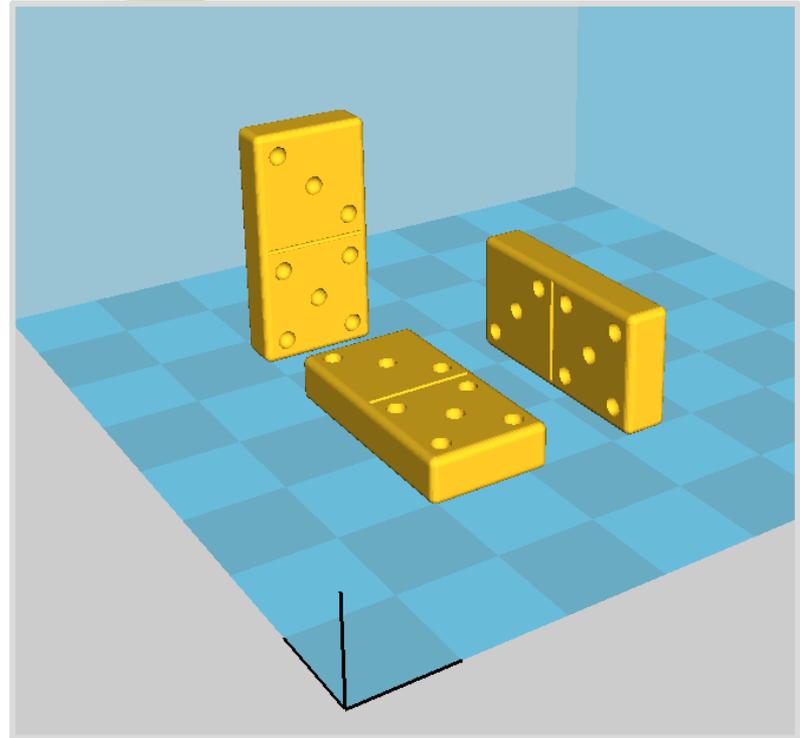


# Print Object Orientation

Usually the best object orientation has already been selected by the creator.

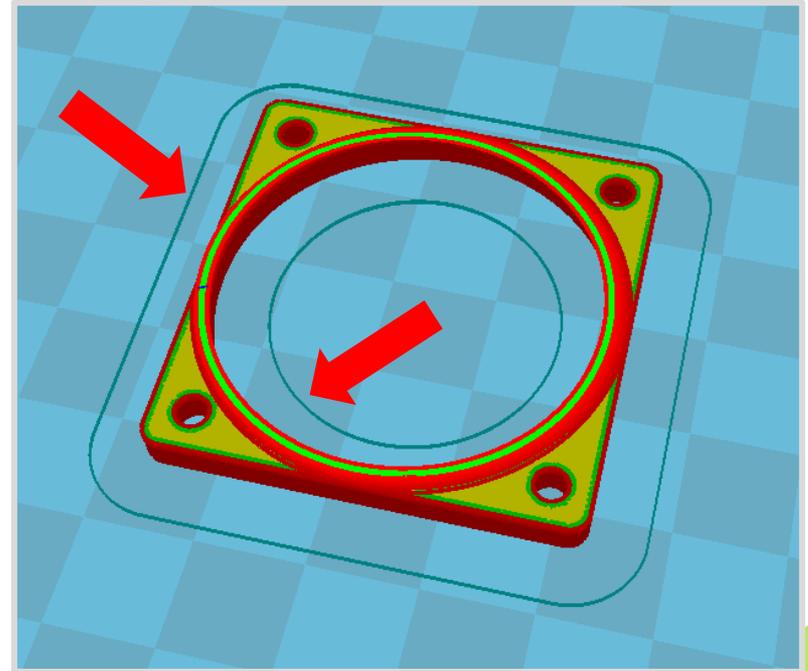
Usually the largest flat surface is chosen to be against the bed.

Other configurations may be desirable for better print quality or more objects per print batch.



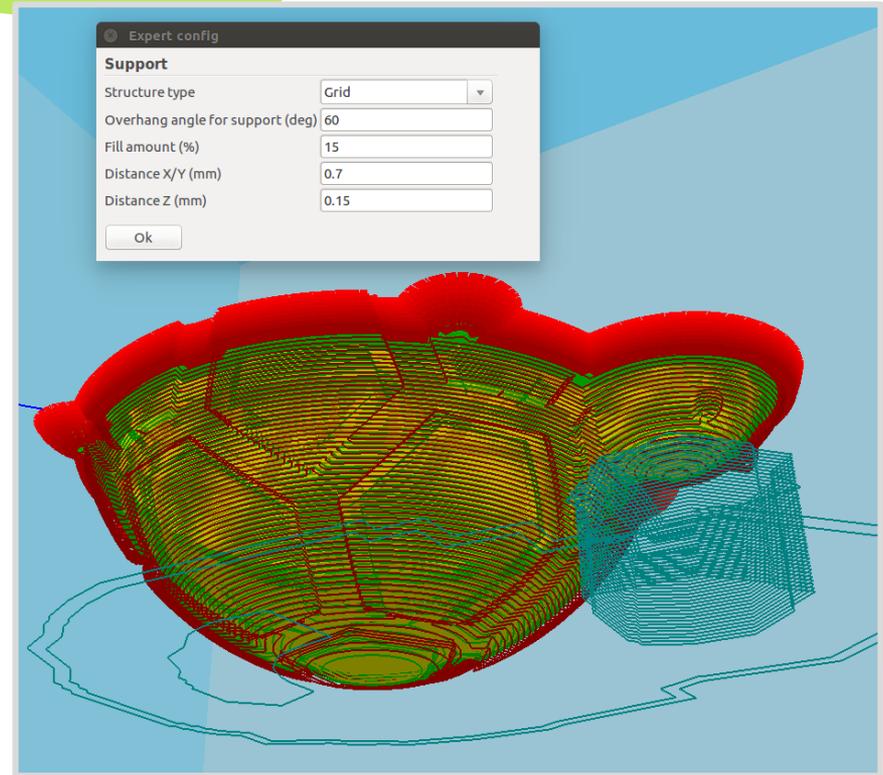
# Skirt

Shows the bounds of the print.  
Helps you verify bed  
adhesion.  
Helpful for priming the  
nozzle before the object is  
printed.



# Scaffolding

Scaffolding is removable computer generated print material to aid in printing object overhangs. When part of the object's geometry exceeds the "overhang angle" scaffolding is added below it. When possible rotate your object to avoid needing scaffolding.



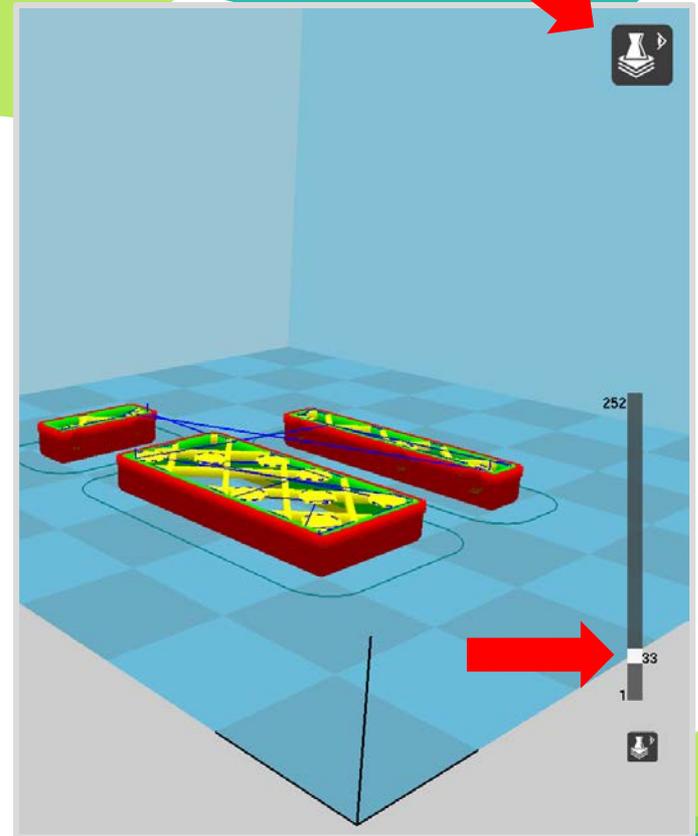
# View Modes

Click on the **view** mode icon

Click on **Layer**

Drag the slider at the right to see the print at various stages.

This is useful for seeing infill and printer operations before the print starts



# Shell Thickness

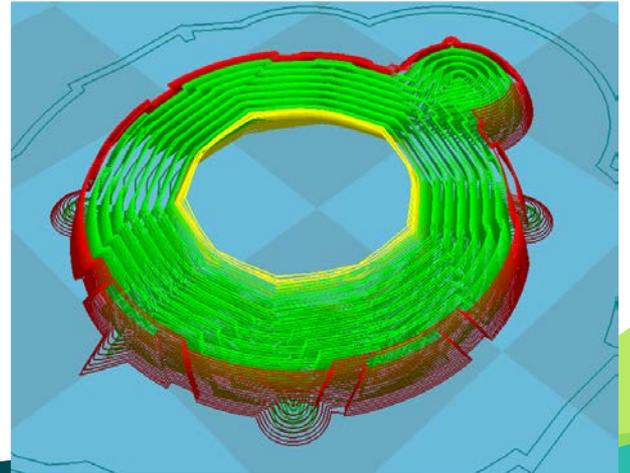
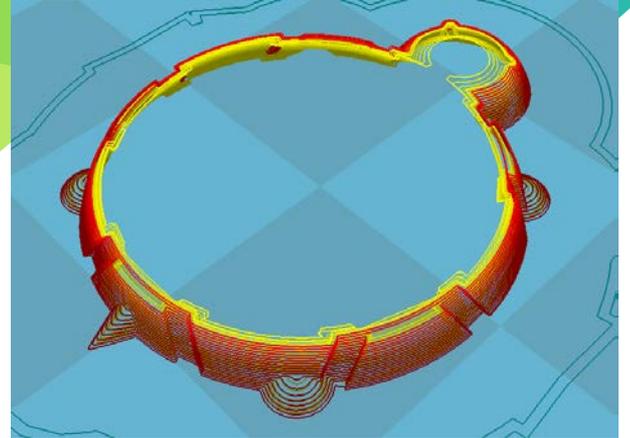
**Top turtle: 2 shells**

**Bottom turtle: 10 shells**

Shell thickness/ nozzle diameter = # of shells

4mm/ 0.4mm = 10 shells

A shell is one nozzle wide perimeter pass  
Increases wall thickness  
Lots of shells is one method of making  
solid objects.  
Balance with infill for good strength vs  
weight.



# Layer Height



0.4mm  
Layer Height



0.3mm  
Layer Height



0.2mm  
Layer Height



0.1mm  
Layer Height



15min 45sec  
Print Time



20min 14sec  
Print Time



28min 15sec  
Print Time



55min 44sec  
Print Time

The background features a central teal-colored area with the text 'Print Troubleshooting' in white. This teal area is framed by dark teal and lime green geometric shapes that create a layered, mountain-like effect. The overall design is clean and modern.

# Print Troubleshooting

# Quality vs Time

## **Taking too Long**

**Cura time estimate**

Increase layer height

Decrease infill percentage

Reduce scale (if possible)

**Advanced**

Increase travel speed

## **Print is Low Quality**

**Check for bigger problems first**

Decrease layer height

Increase infill percentage

Increase scale (if possible)

**Advanced**

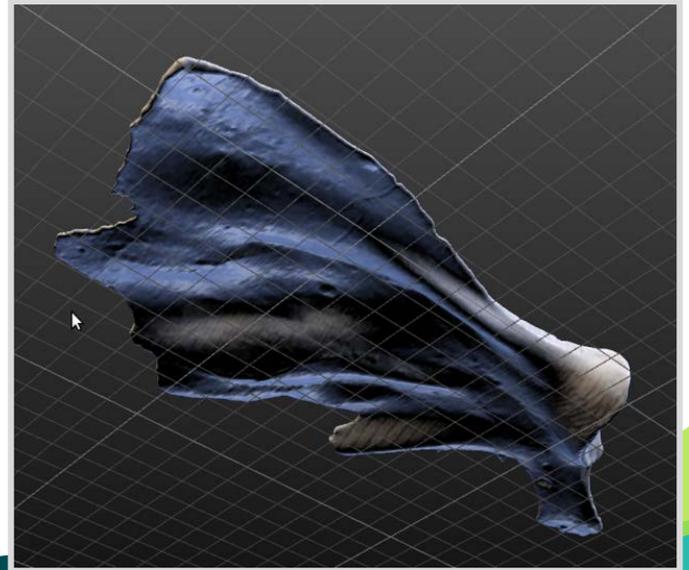
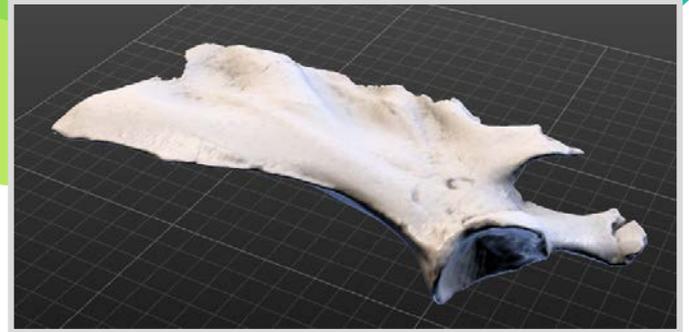
Decrease travel speed

# Object Selection

Think about how the print will be oriented on the bed. Some 3D models won't be easy to place flat on the print surface.

Example:

<http://3d.si.edu/explorer?modelid=1336>



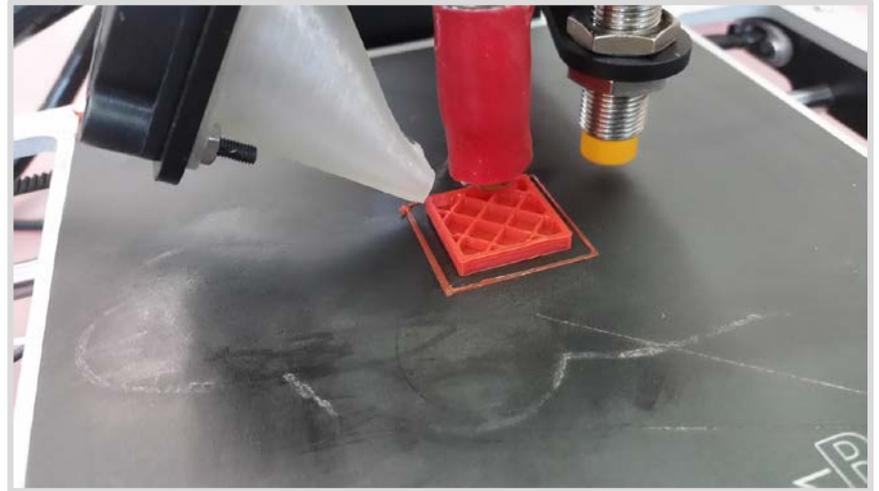
# Watching a Print

If a print fails you can cancel it at any time from Pronterface.

Nozzle clogged

Ran out of filament

Did not adhere to bed

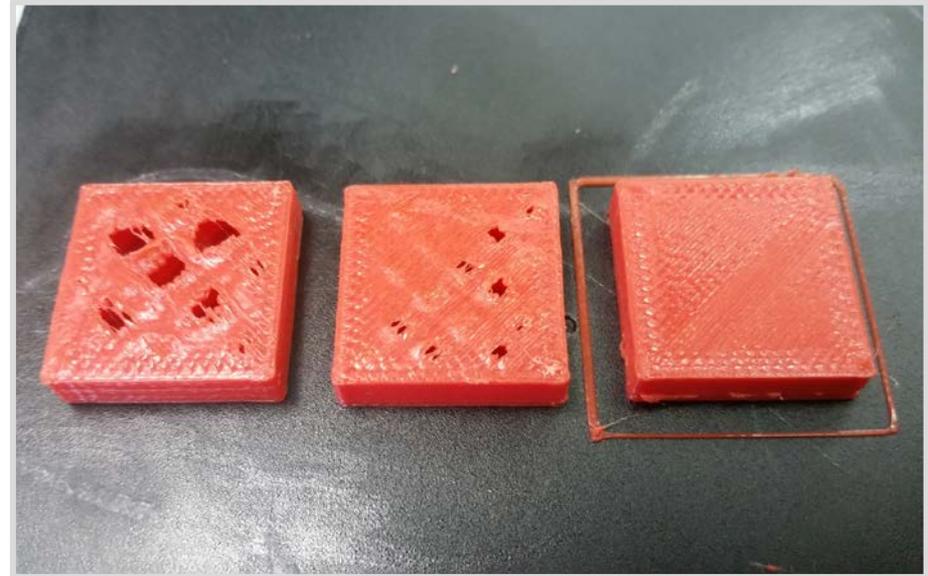


# Infill & Top Layers

Increased percentage of infill will increase the top of the print quality.

From left to right, 15%, 20%, 25%

Rectilinear infill (squares)



# Removing a print

Wait for the print to cool to avoid warping.  
Use a scraper and pry one corner with steady pressure.  
Do not hammer or pound on bed because it may damage the printer or you.

