Introduction to 3D Printing

“ I want to say one word to you. Just one word.…

Plastics”

The Graduate - 1967

What is 3D Printing

- Additive Manufacturing (Legos)
  - Subtractive (carving, milling)
- Material is pushed through a nozzle (extruded)
  - Filament is heated to allow this to happen
  - Icing or pastry bag
  - Hot Glue gun

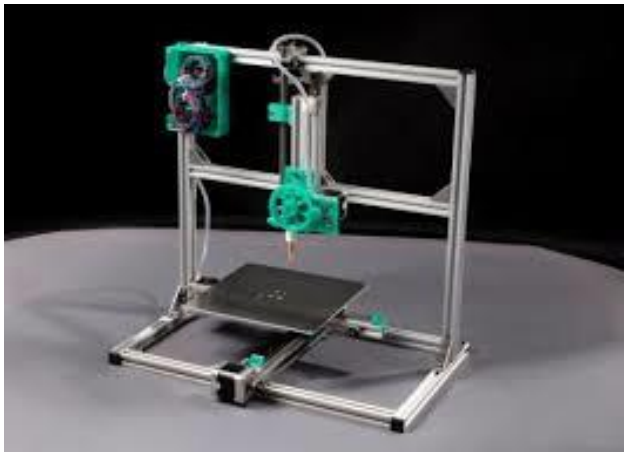
Uses for 3D Printers

- Prototyping
- Small lot manufacturing (cookie cutters)
- Specialized or hard to find items (car parts)
- Education (music, animals)
- To be determined!

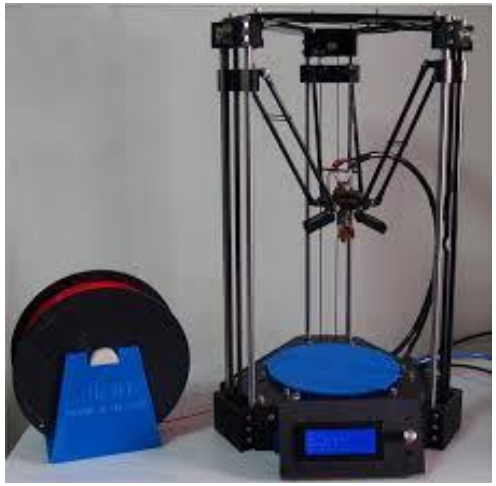
My Favorite Thing

- It was a Saturday morning….

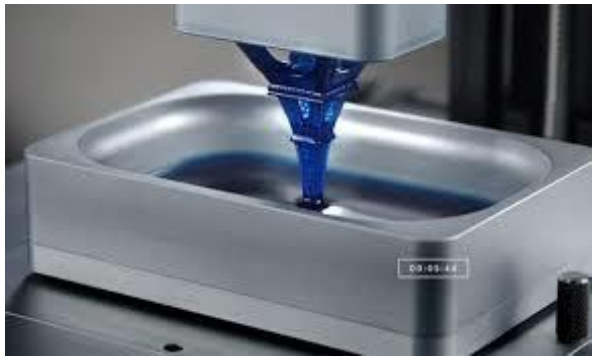
3D Pinter Types



Cartesian

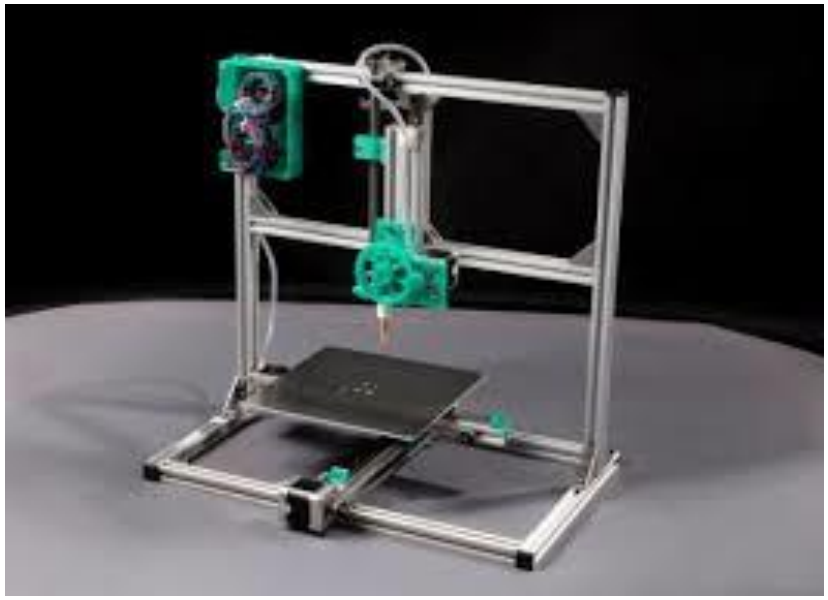


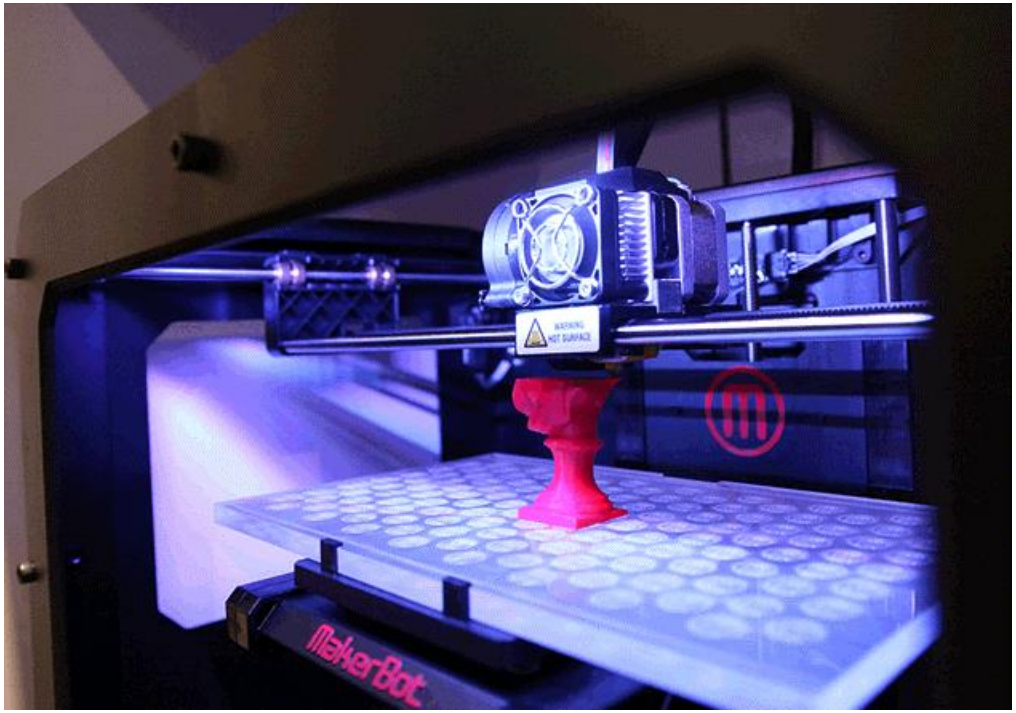
Delta



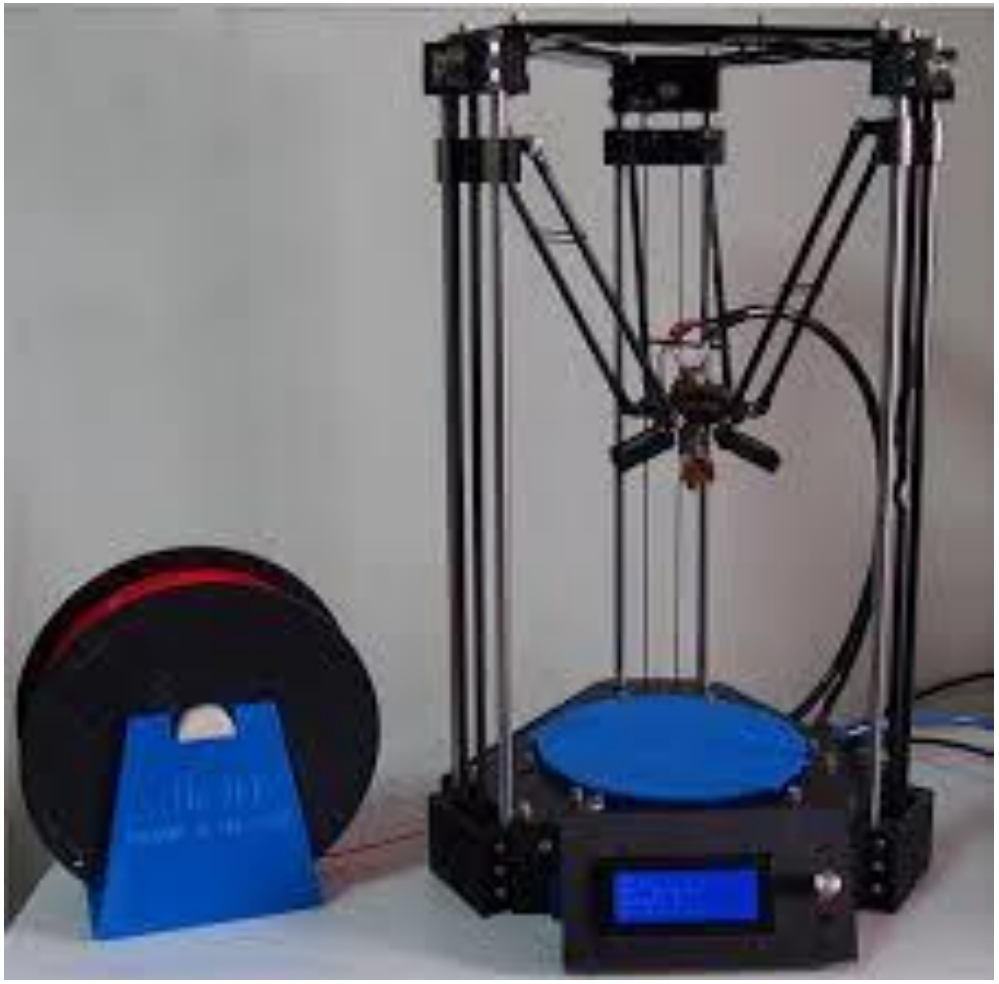
DLP

Cartesian





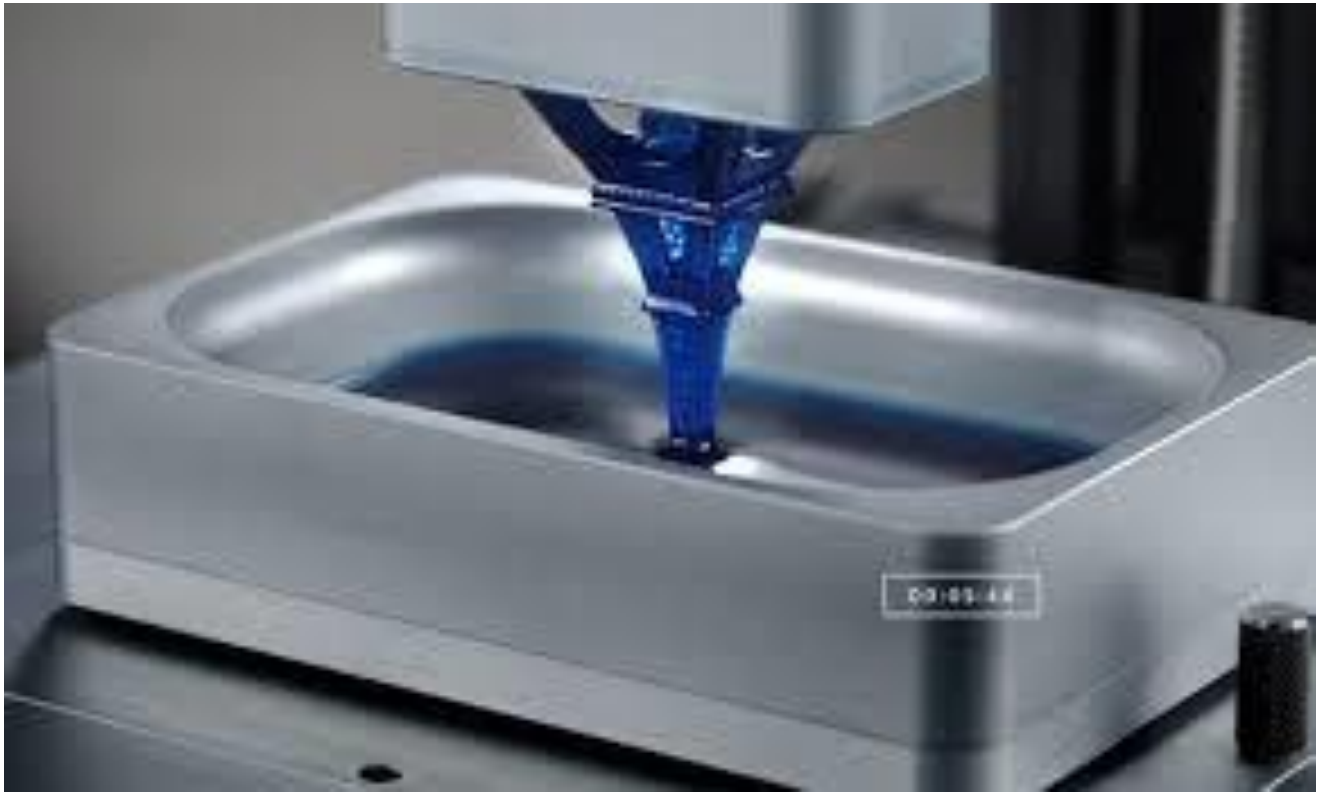
Delta



Delta Style Printer (video)

(https://www.youtube.com/watch?feature=player_embedded&v=zQxa920YGaU)

DLP



DLP Style Printer

(https://www.youtube.com/watch?feature=player_embedded&v=nxhUjPmxrP0)

Money, Money, Money

- Overall price range $500 - $2500+
- Why the difference?
- Technology (type) and build volume.

Differences

- Technology (material)
  - Filament
    - PLA ($500 kit)
    - ABS (heated bed) (+$100)
    - Assembled (+$150)
    - Dual Head (+$200)
  - Resin (DLP)

Differences

- Build Volume
  - 4” x 4” x 4” ($400)
  - 10” x 10” x 10” ($1000+)
  - 7” x 15” x 7” DLP ($2500+)

Filament

- Size 1.75mm (standard) & 3.00mm (old)
- Material
  - PLA (Strong, stiff, fast print)
  - ABS (Heated bed, higher temp, slight flex)
  - Flex (rubber like)

Filament Exotics

- Material
  - Nylon (Very Strong, very high print temp)
  - Wood
  - Conductive
  - Metallic (bronze, iron, etc)
  - Ceramic

What to Print?

- You need a 3D model (.stl file)
  - Use an existing model
    - www.thingiverse.com
  - Make your own model
    - Tinkercad (web based www.tinkercad.com)
    - Meshmixer
    - Blender (open source)
    - Autocad 123D Design

How to Print?

- 3D printers use GCode
  - Set of instructions (movement, speed, temp, etc)

```
(**** start.gcode for The Replicator, dual head ****)
M103 (disable RPM)
M73 P0 (enable build progress)
G21 (set units to mm)
G90 (set positioning to absolute)
M109 S065 T0 (set HBP temperature)
M104 S220 T0 (set extruder temperature) (temp updated by printOMatic)
…
G1 X-29.91 Y-29.91 Z0.1 F1080.0 E1.0
G1 X-23.5 Y-35.17 Z0.1 F1080.0 E1.3
G1 X-16.19 Y-39.08 Z0.1 F1080.0 E1.6
G1 X-8.25 Y-41.49 Z0.1 F1080.0 E1.9
```

Slicers

- Convert Models to GCode
  - Skeinforge used in ReplicatorG (oldie but a goodie)
  - Repetier (includes Slic3r)
  - Slic3r
  - KISSlicer
  - Makerware (Makerbot)
  - Simplify3D ($$$)

Terminology / Settings

- Layer Height
- Shells
- Infill
- Support
- Skirt (brim)
- Raft

Terminology / Settings

- Layer Height
  - 0.1 mm, (fine)
  - 0.2 mm, (med)
  - 0.3 mm (coarse)

Bed Leveling is Important

- Layer height (0.1, 0.2, 0.3mm)
  - 1/64” ~ 0.4mm
  - Sheet of paper is ~ 0.05mm thick

Terminology / Settings

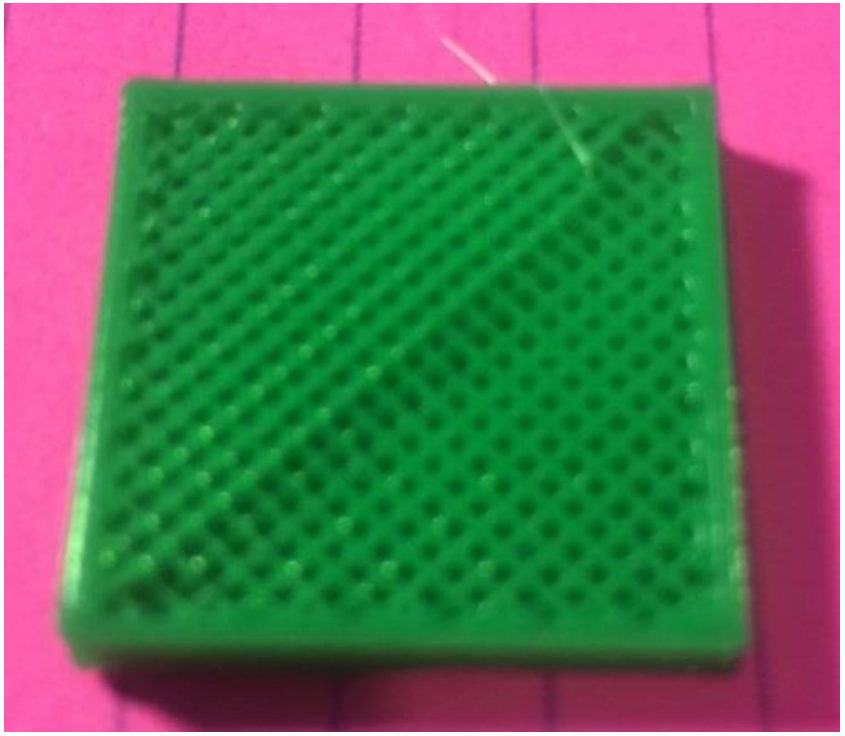
- Shells –
  - How many layers around the outside
  - 1,2,…? (2 is common, 4 or more extreme)

Terminology / Settings

- Infill –
  - 10% - 100%
  - 10% - 20% is common

Infill

10%



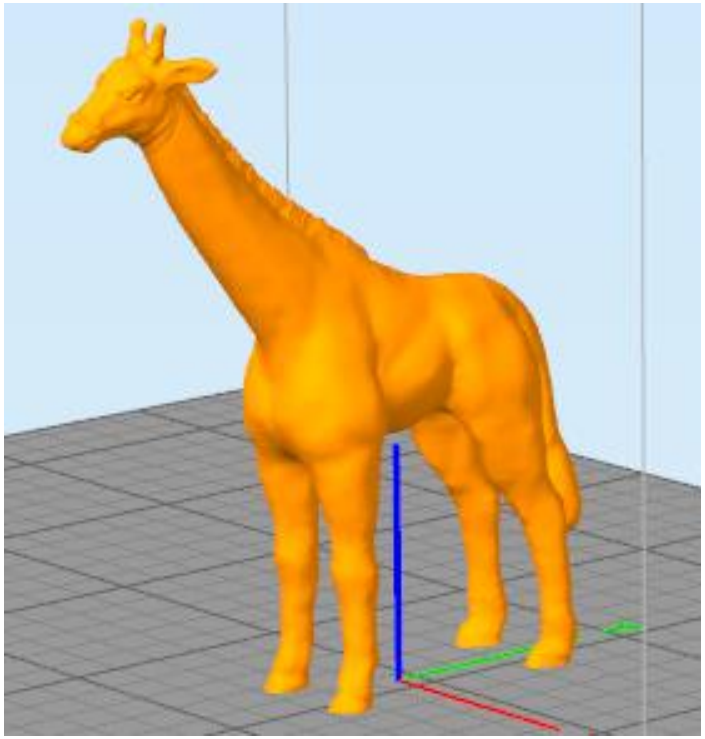
40%

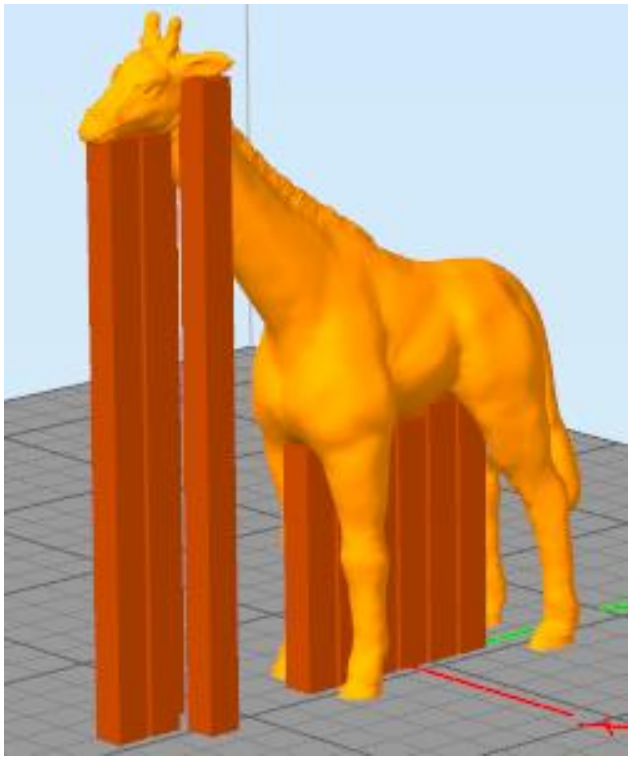
Terminology / Settings

- Support
  - Printed material that is not part of the finished model
  - scaffolding

Support

- Overhangs



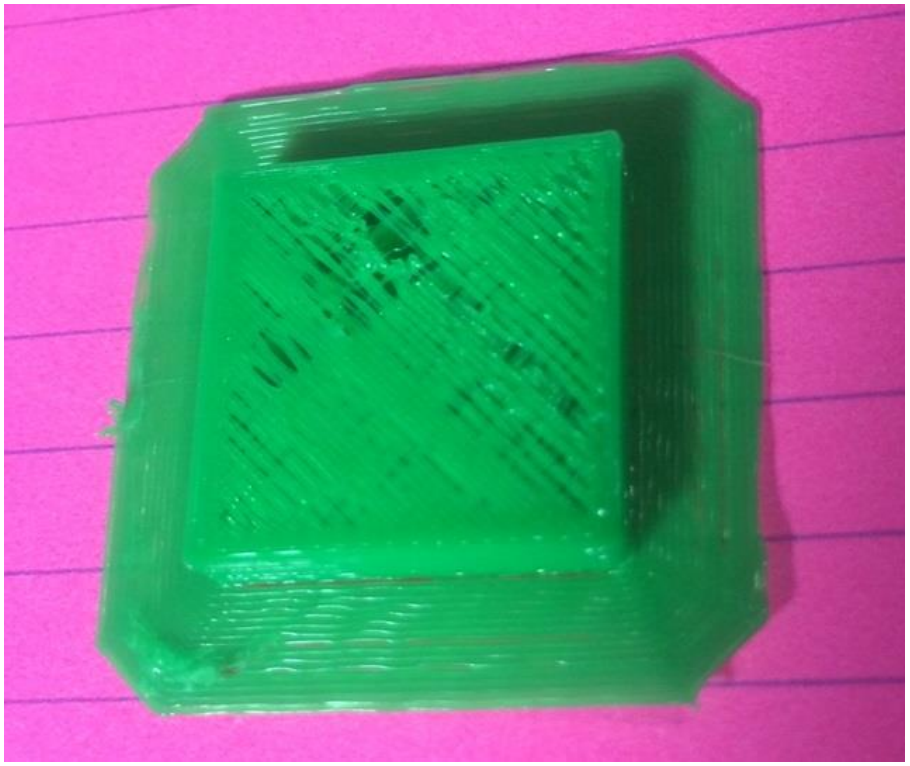


Terminology / Settings

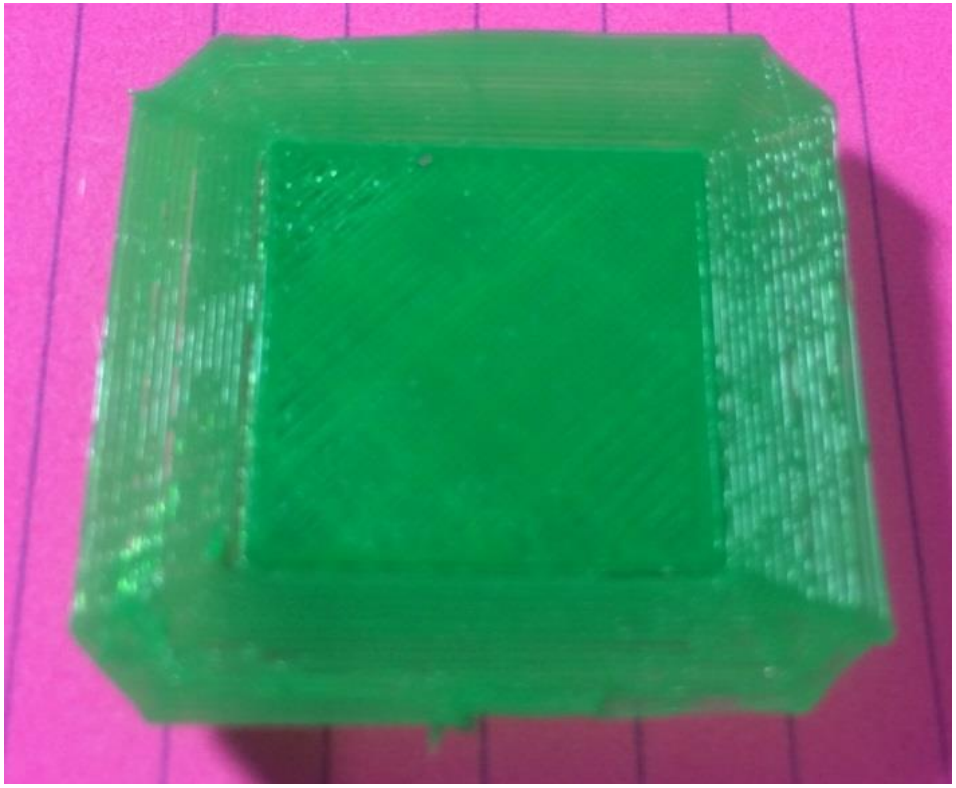
- Skirt (brim)
- Raft

These are both used to help the model stick to the build platform and reduce warping

Skirt / Brim



Top



Bottom

Raft

Top

Bottom

Stick It

- First layer is the most important layer
- Getting the first layer to adhere to the print bed
  - Painters tape (blue tape) – PLA only
  - Glass with hairspray
  - Kapton tape
  - ABS juice (ABS and acetone)

Danger! Danger! Will Robinson!

Plastic	Bed / Table		Nozzle	
	C	F	C	F
PLA	0 – 65	0 - 149	200 - 210	392 – 410
ABS	110 – 115	230 - 239	225 - 235	437 - 455

Common Tools

How Many ‘x’ Can I Print?

- Matter is neither created nor destroyed
- A standard spool of filament is 1kg (2.2 pounds)
- Ukulele weighs about 425g (0.425kg) so it took just under half a spool of filament.
- A cookie cutter weighs < 10g
  - 1000g / 10 = 100 so you can print about 100 cookie cutters from a single 1kg (1000g) spool of filament.

Questions! (3D Printing Resources)

- **Models**
  - www.thingiverse.com
- **Modeling Software**
  - www.tinkercad.com
  - www.meshmixer.com
  - www.123dapp.com
  - www.blender.org (open source)
- **3D Slicing / Printing software**
  - www.replicat.org (ReplicatorG)
  - www.repetier.com (Repetier)
  - www.slic3r.org (open source)
  - www.kisslicer.com (single printhead free)