

3D Printing

*Prof. Hank Dietz
TCMS, March 14, 2014*

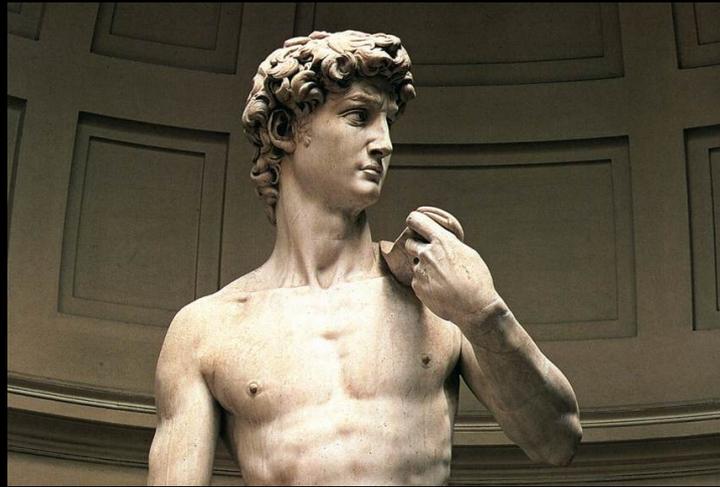


University of Kentucky
Electrical & Computer Engineering

How To Make Stuff

- People used to make things by hand...
but **humans make and use tools**
- Most tools are special purpose;
they only make a particular type of thing
- Using **computer control** we can build
smart, generic, tools –
even tools that can build themselves
(**RepRap**: Replicating Rapid prototyper)

Subtractive Building



"Every block of stone has a statue inside it and it is the task of the sculptor to discover it."

– *Michelangelo*

Subtractive 2D



- **Cutter:** cuts 2D material in any pattern
- **Paper/Craft:** paper moves in Y, knife in X
- **EDM/Laser:** X/Y bed, vaporizes material

Subtractive 3D



- **CNC**: Computer Numerical Control
- **Mill/Router**: part on X/Y bed, bit on Z axis
- **Lathe**: spins the part against a cutter

Additive Building

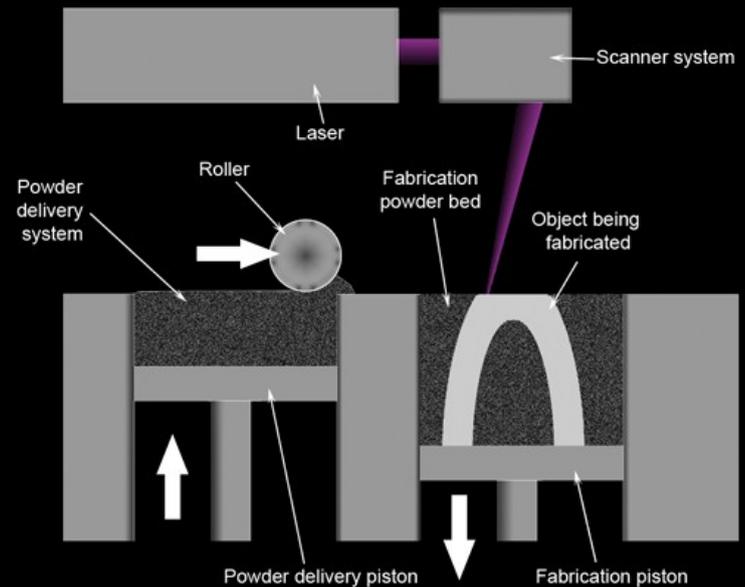
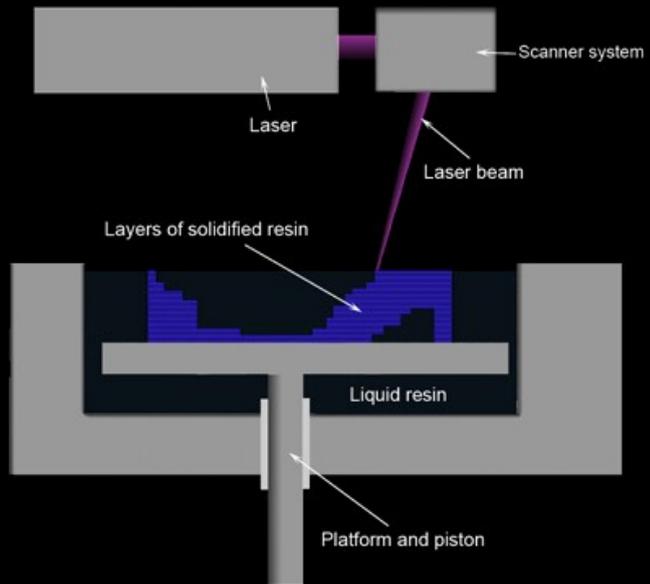


“The whole is greater than the sum of its parts.”
– Aristotle

Additive 3D Building

- Material is deposited, not taken away
- Only works with specific materials
 - powders or paper
 - curable photopolymer liquid resin
 - extrudable materials (mostly plastics)
- No need to get tool around material; can build things with internal structure
- Simpler “clamping” of the part

3D With Lasers



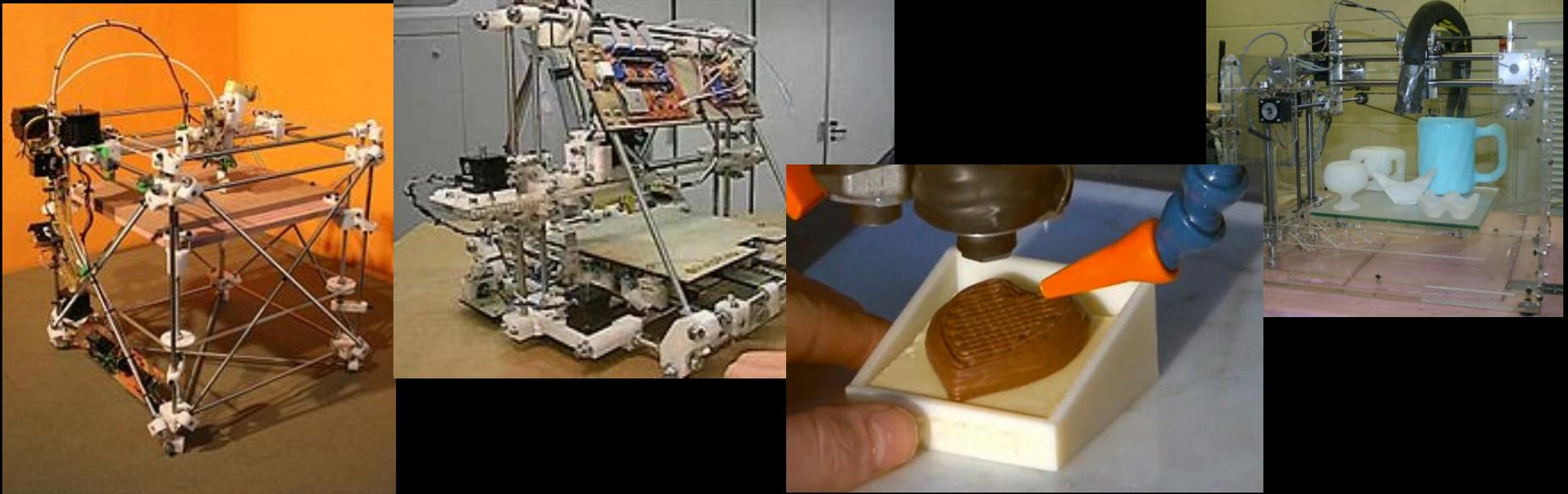
- SLA: Stereolithography of photopolymer
- SLS: Selective Laser Sintering of powder
- SLM: Selective Laser Melting of powder

3D With Glue



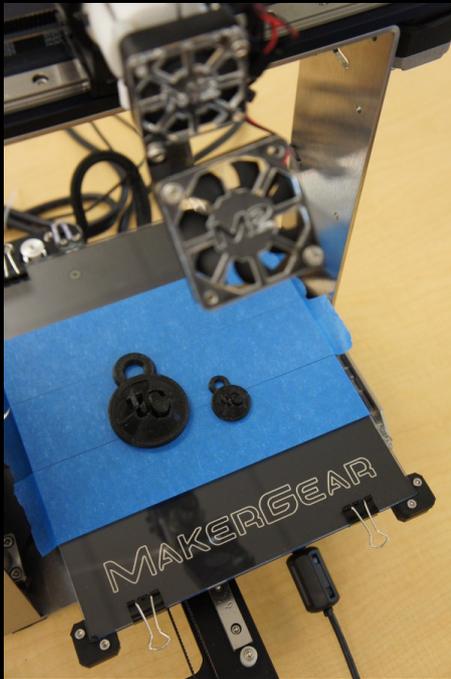
- Layers of paper: printed with glue & cut
- Layers of powder: printed with glue
- Can also be printed in full color

3D Extrusion (RepRaps)



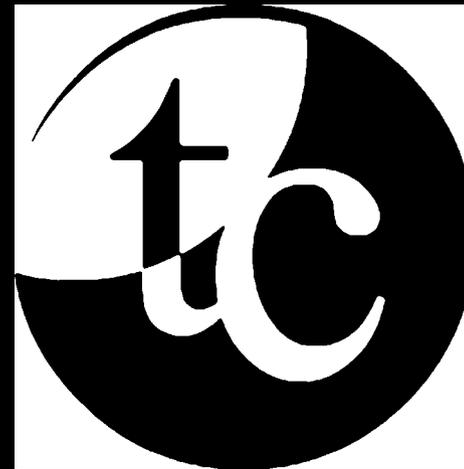
- **FDM**: Fused Deposition Modeling
- **FFF**: Fused Filament Fabrication
- Typically ABS or PLA plastic filament...
but chocolate, water, etc. can be extruded

Our 3D Printer



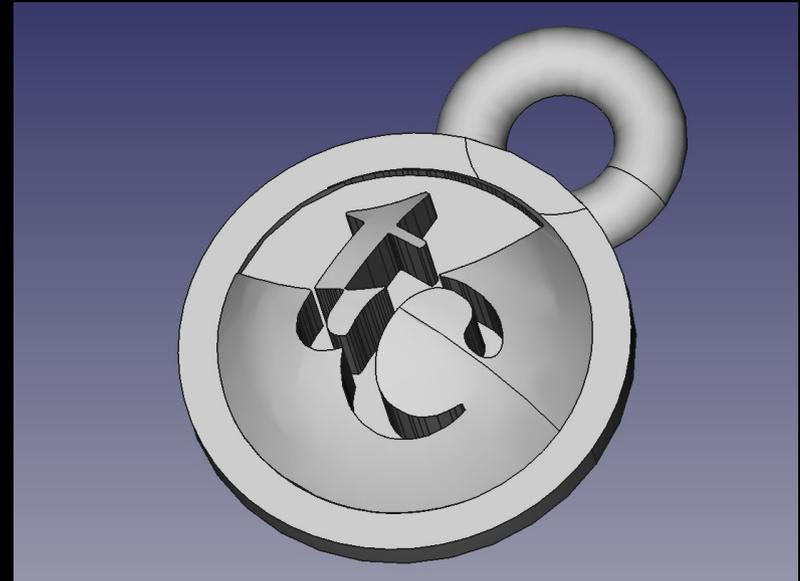
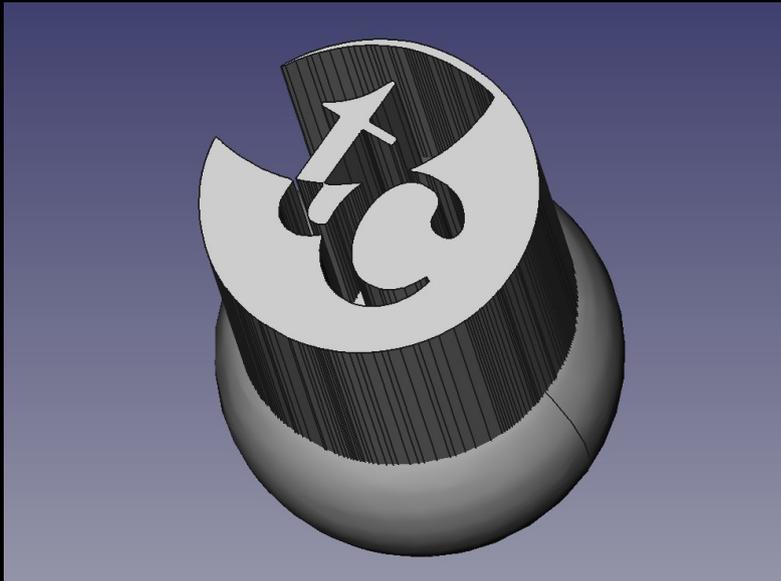
- It's a **MakerGear M2**, cost about \$1700
- We extrude 1.75mm diameter PLA filament to make **0.25mm** tall “threads”
- PLA extrudes around 180° – 225° C
- No clamping; **extrusion bonds to hot bed**

How I Made The TC Medal



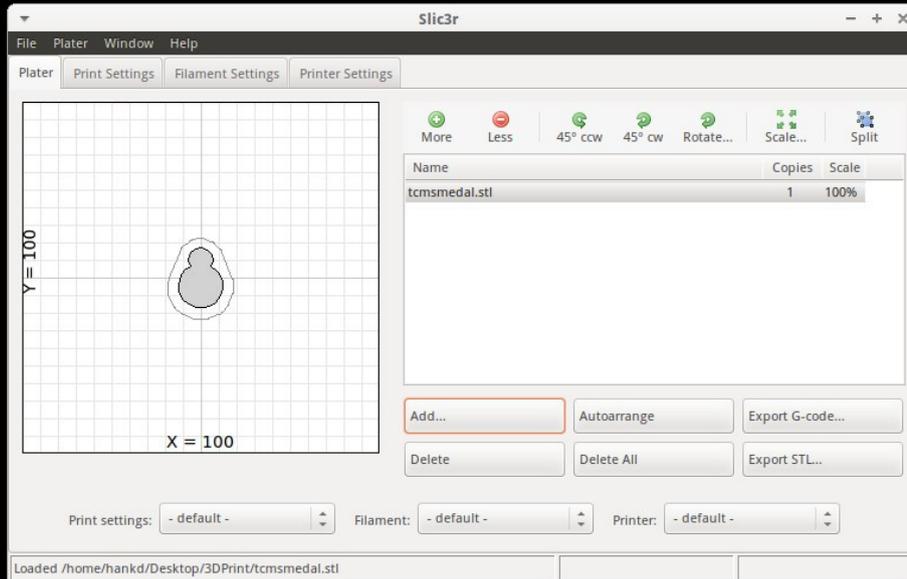
- Start with Tates Creek logo (from WWW)
- Use `gimp` (an image editor) to simplify it
- Use `inkscape` to convert it to **DXF** vectors

How I Made The TC Medal



- Load the 2D **DXF** into `freecad`
- Extrude it and intersect it with a sphere
- Add other shapes to the design, save **STL**

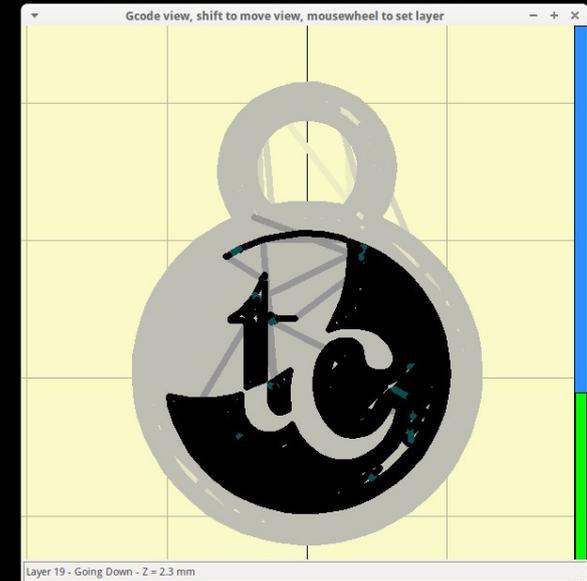
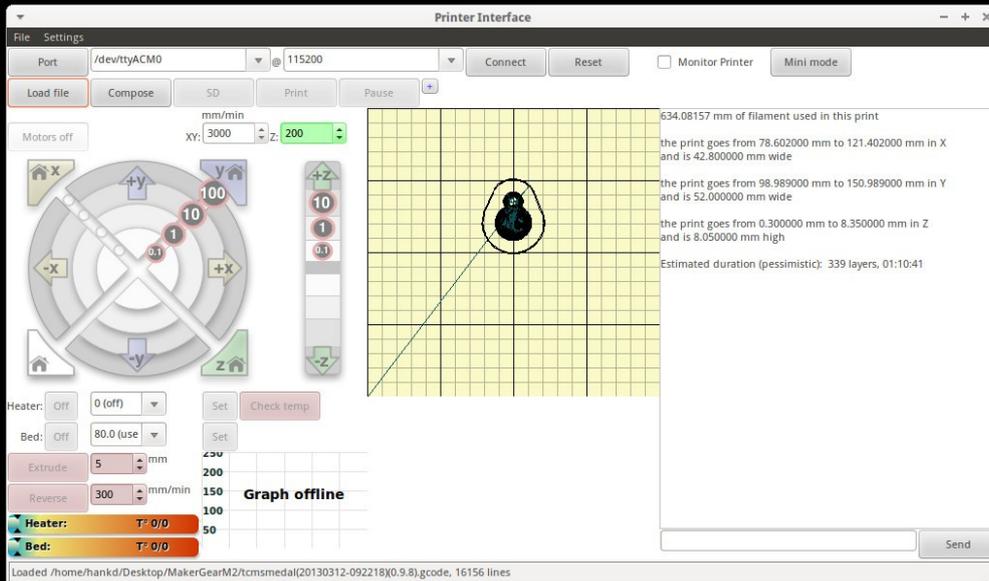
How I Made The TC Medal



```
G1 X90.062 Y143.899 E2.97592
G1 X89.502 Y143.229 E3.05532
G1 X88.872 Y142.279 E3.15897
G1 X88.262 Y141.249 E3.26782
G1 X87.812 Y140.339 E3.36013
G1 X82.282 Y126.599 E4.70690
G1 X81.972 Y125.579 E4.80383
G1 X81.432 Y123.169 E5.02841
G1 X81.332 Y122.429 E5.09631
G1 X81.242 Y119.949 E5.32196
G1 X81.252 Y119.199 E5.39016
```

- The **STL** model is triangles on surfaces
- “Slice” the solid model using `slic3r`
- Output is **gcode** – lines in X,Y,Z,E

How I Made The TC Medal



- Print **gcode** using **pronterface**
- **Wait for it...**
- Finished part comes off the cooled bed