

15-294 Rapid Prototyping Technologies: Molecule Exercise and 3D Printer Intro

Dave Touretzky
Computer Science
Carnegie Mellon University



3D Printing vs. Laser Cutter

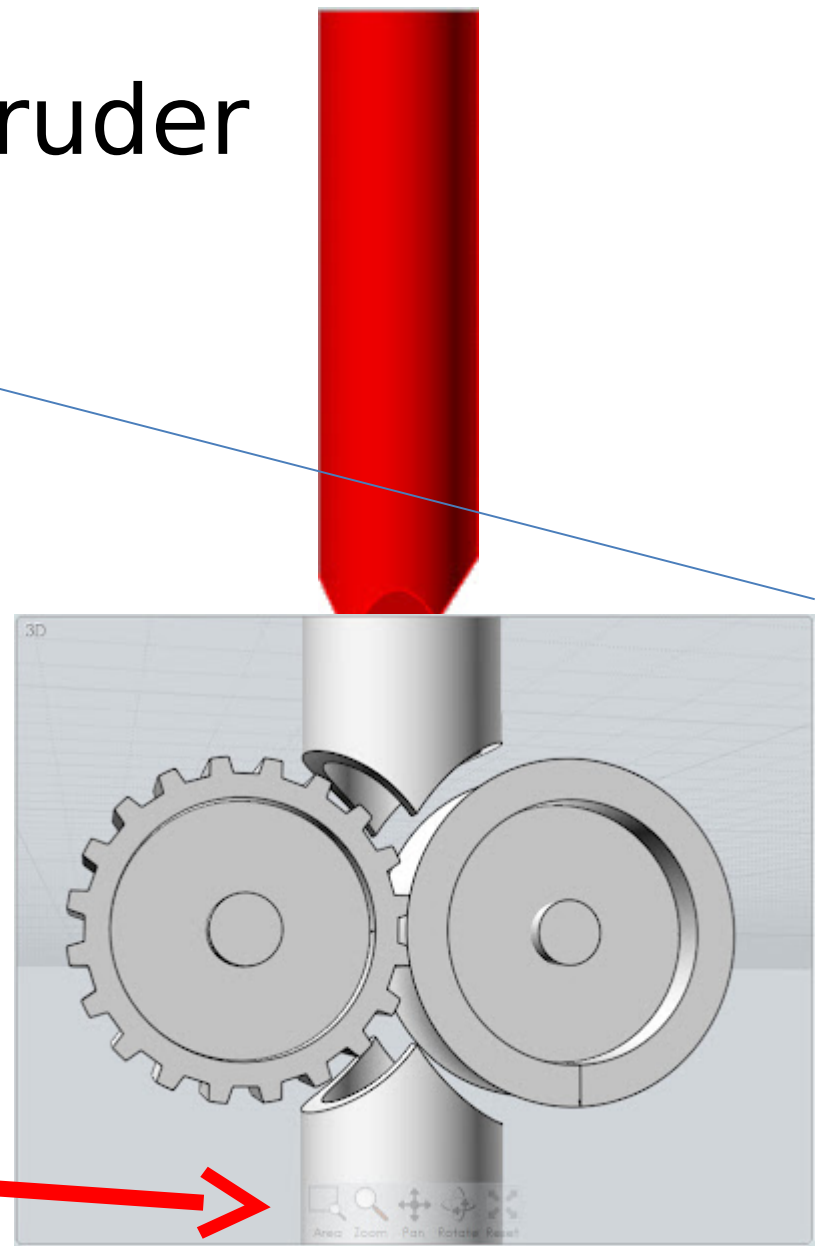
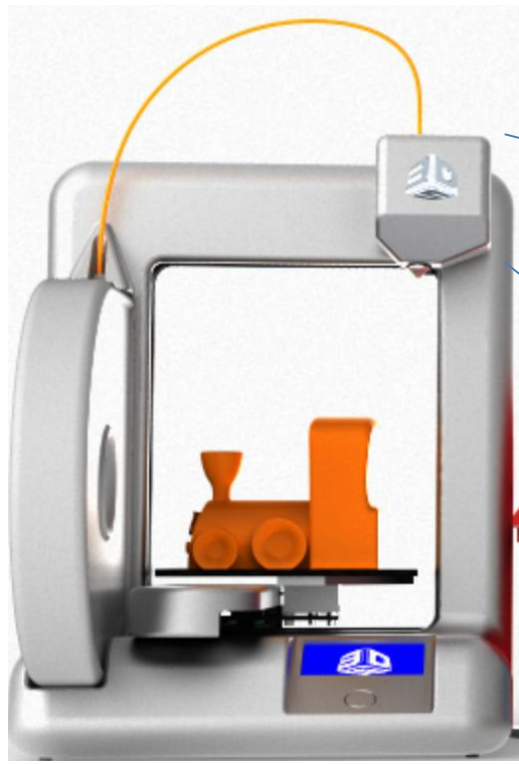
- ✗ Slower
- ✗ Less precise
- ✗ More expensive
- ✗ Limited materials
- ✗ Support material may be required
- ✓ Complex 3D structures!



Low Cost 3D Printers

- RepRap: 2005 onward
 - Adrian Bowyer, University of Bath (UK)
 - Goal: open source 3D printer that can replicate itself
 - 4 generations: Darwin, Mendel, Prusa Mendel, Huxley
 - Spawned many start-ups
- Makerbot
 - Evolved from RepRap; initially was open source
 - Cupcake, Thing-o-Matic, Makerbot2, Replicator
- Solidoodle (\$500)
- Zortrax M-200
- Many, many more...

The Cube 2 Extruder

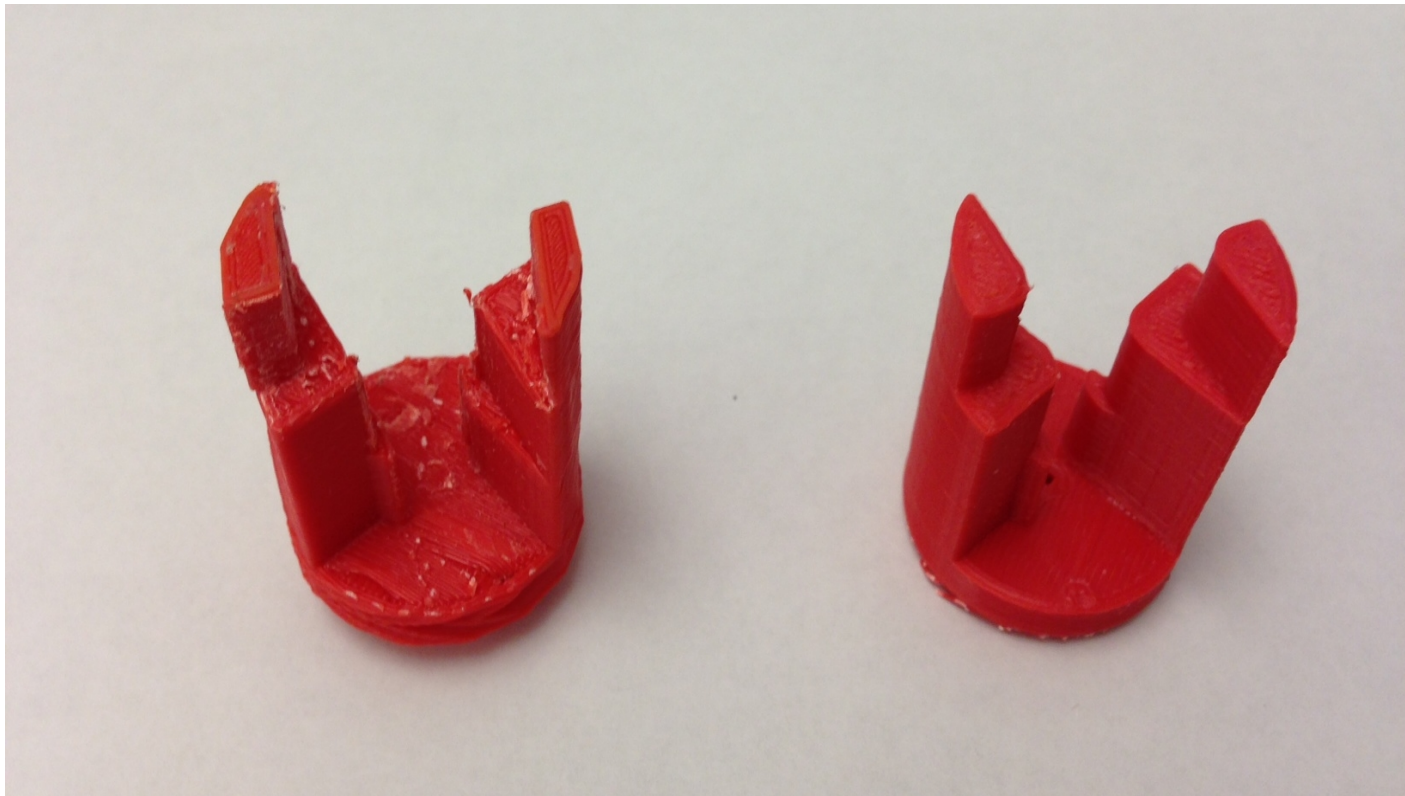


Heated section

Image from cubifyfans.blogspot.com

Coarse vs. Fine STL Triangulation

- Too coarse can lose detail, but too fine can also cause features to be lost.
 - SolidWorks “fine” (under “Options” when you save an STL file) seems to be okay, but don’t go to “custom” and crank up resolution to the max.



Changing the Amount of Infill

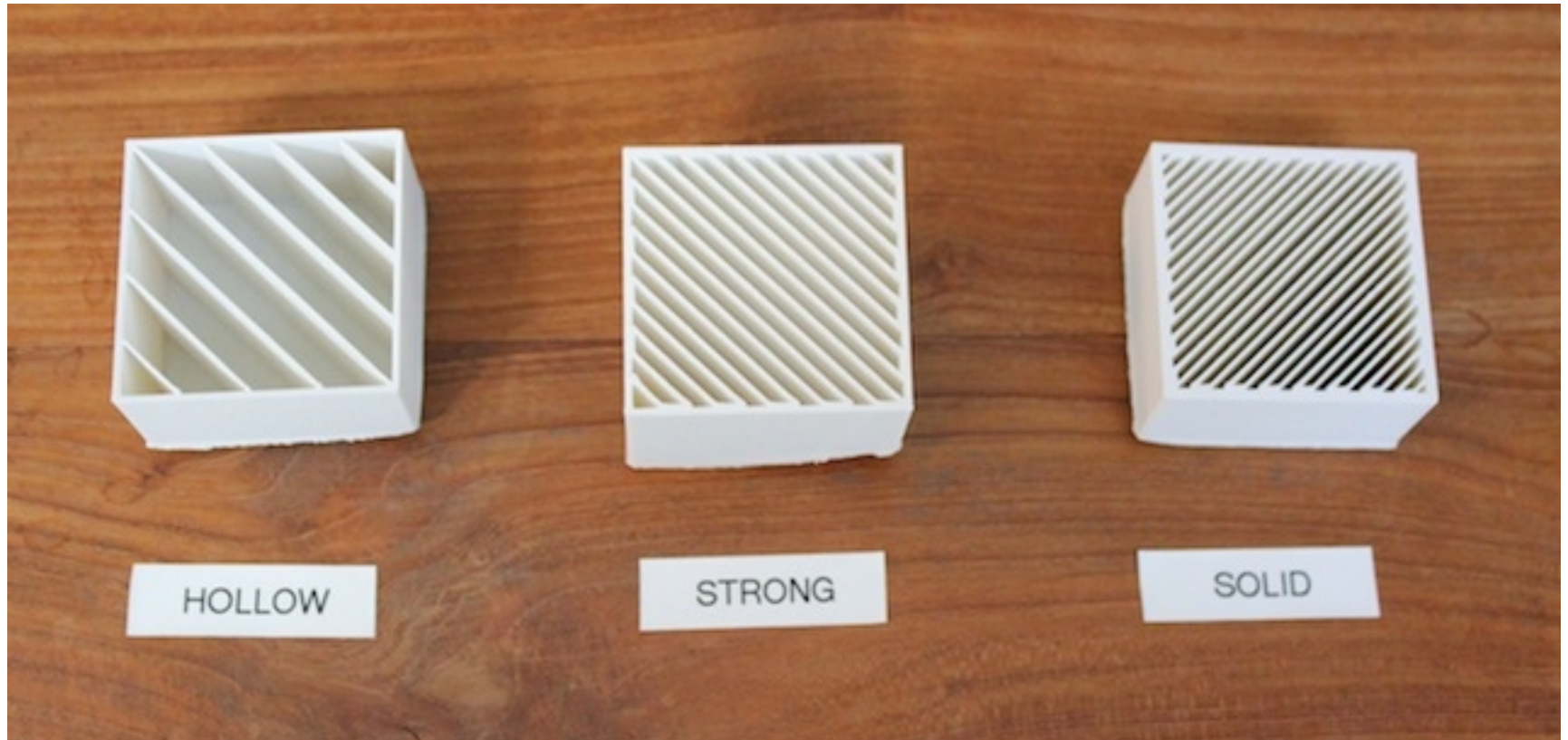


Image from cubify.com

Stratasys Printer Array



skylab.ideate.cmu.edu

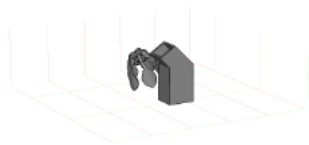


- Start Order
- Saved Parts
- Your Orders
- Factory Status

Assem1.STL

257488

X:59.80mm Y:71.29mm Z:69.38mm



Model Volume
20073 mm³

Units
Milimeters

Resolution
Fast .010in

Material
ABS-M30

Density
Sparse

Color
Any

Quantity
1



Print time est: 4 hrs 40 mins Quality score: 81 Support vol: 38720.4mm ³	Print time est: 6 hrs 14 mins Quality score: 81 Support vol: 77881.8mm ³	Print time est: 4 hrs 50 mins Quality score: 74 Support vol: 38224.9mm ³

Print time est: 4 hrs 27 mins Quality score: 74 Support vol: 30442.3mm ³	Print time est: 3 hrs 24 mins Quality score: 76 Support vol: 7827.44mm ³	Print time est: 4 hrs 24 mins Quality score: 76 Support vol: 22216.3mm ³

Est. Cost (\$ 4 ea.) \$ 4

Comments

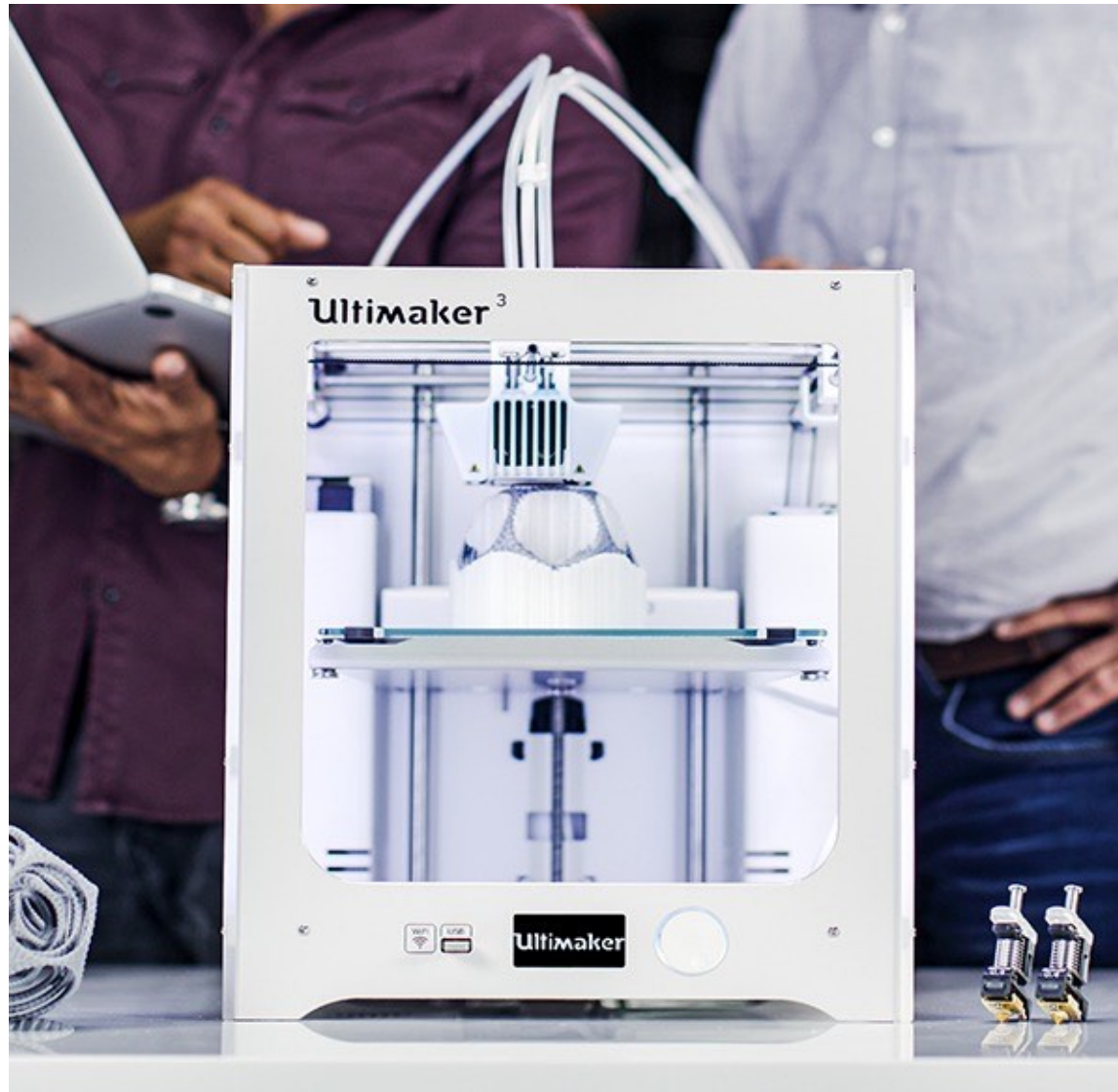
ORDER

SAVE FOR LATER

Zortrax M200



Ultimaker 3

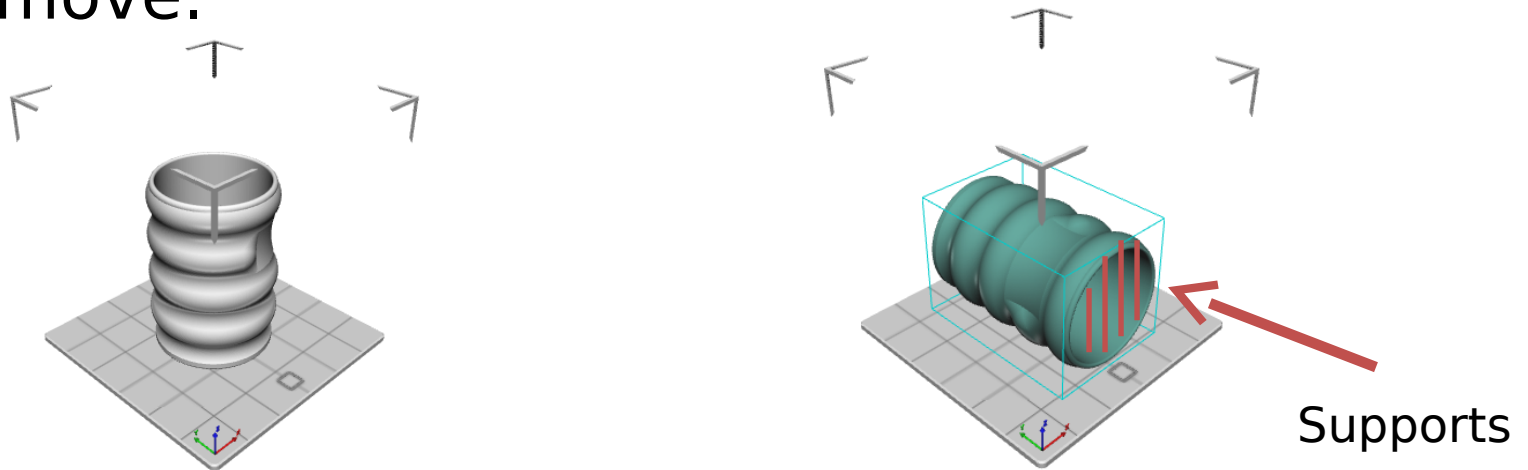


The NvPro



Part Orientation

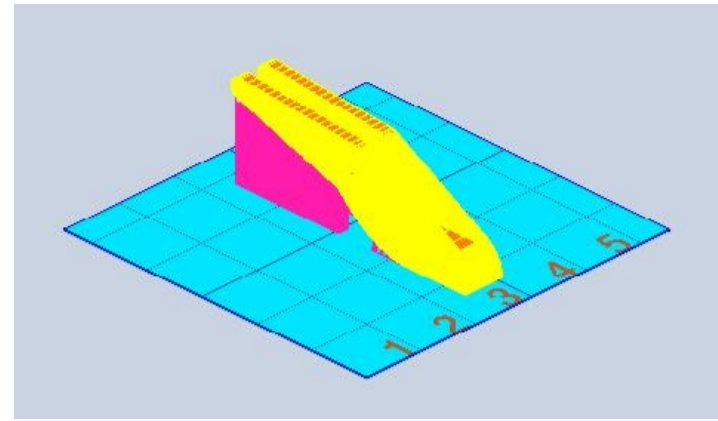
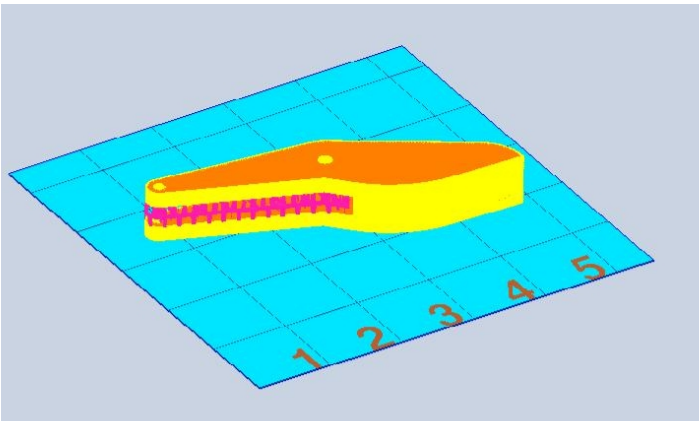
- Choose your part orientation to avoid the need for supports if possible.
- Don't put supports where they will be difficult to remove.



- Remember: supports leave a rough surface.

Part Orientation

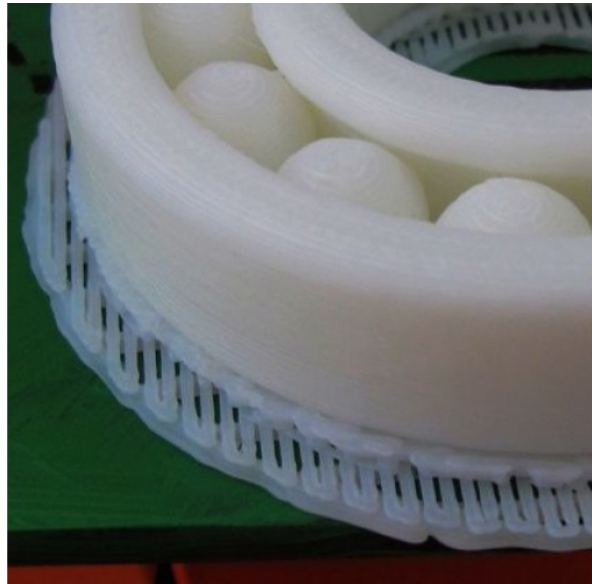
- Sometimes the use of support material is unavoidable.
- Don't put supports where they will be difficult to remove.



- Remember: supports leave a rough surface.

Use of a Raft

- Why use a raft?
 - Stable base of support for tall, skinny parts.
 - Prevents warping of big smooth parts (like cases) by reducing surface contact with heated bed (1st gen. Cubes only).
- Why avoid a raft?
 - Ruins the part finish (get out your sandpaper).
 - Takes more time and more plastic to print.





Dashboard



Upload

Approve

Queue

Library

Support

Dave Touretzky
RAPID PROTOTYPING TECH - ...

Ethanol-2016.STL

GENERAL

TRANSFORMS

ADVANCED

Quality

Fast

Standard

Strength

Infill: 5%

Copies



1



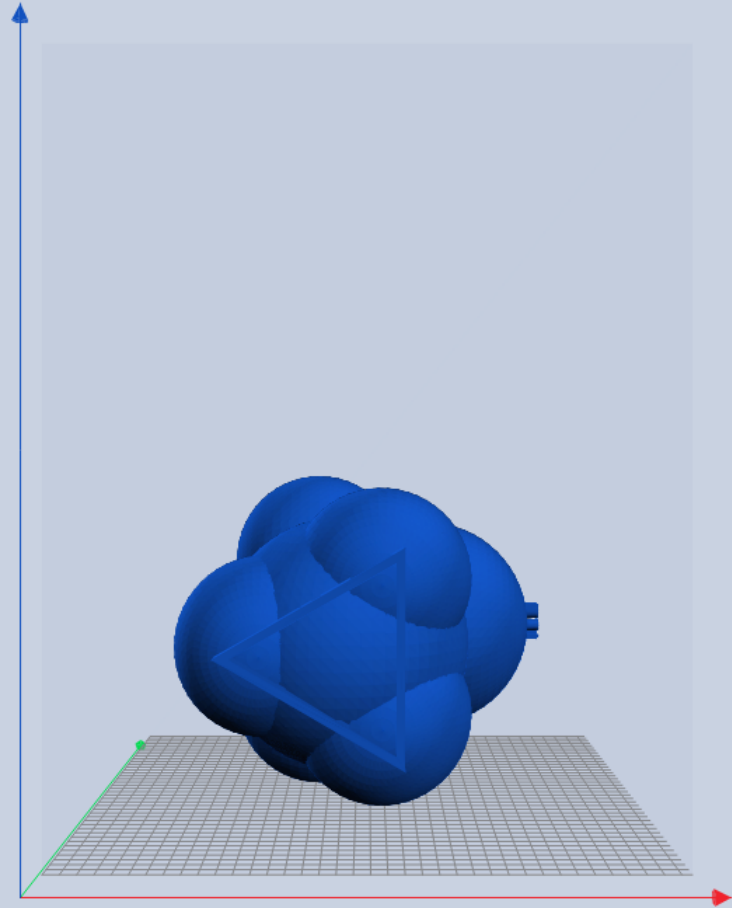
x: 131mm

y: 127mm

z: 113mm

mm

in





Dashboard



Upload

Approve

Queue

Library

Support



Dave Touretzky
RAPID PROTOTYPING TECH - ...

Ethanol-2016.STL

GENERAL

TRANSFORMS

ADVANCED

Units



mm

in

Scale

Lock Scaling Ratio

All

100%

Rotate



X

Y

Z

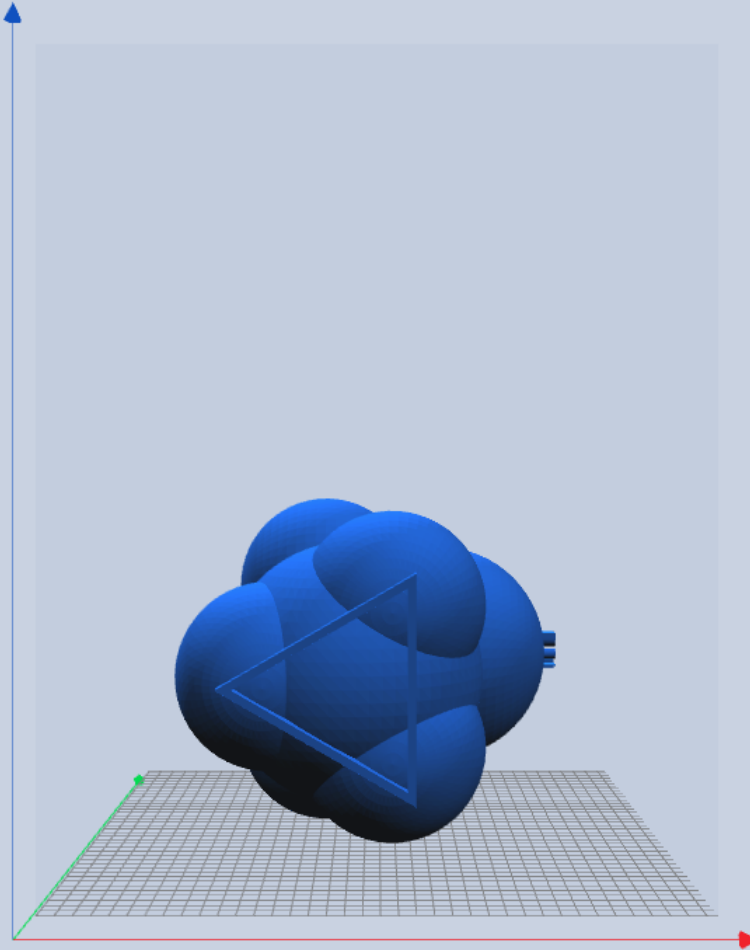
0°

0°

0°

X: 131mm Y: 127mm Z: 113mm

mm in



Ethanol-2016.STL

GENERAL TRANSFORMS ADVANCED

Units i

mm in

Scale Lock Scaling Ratio ON

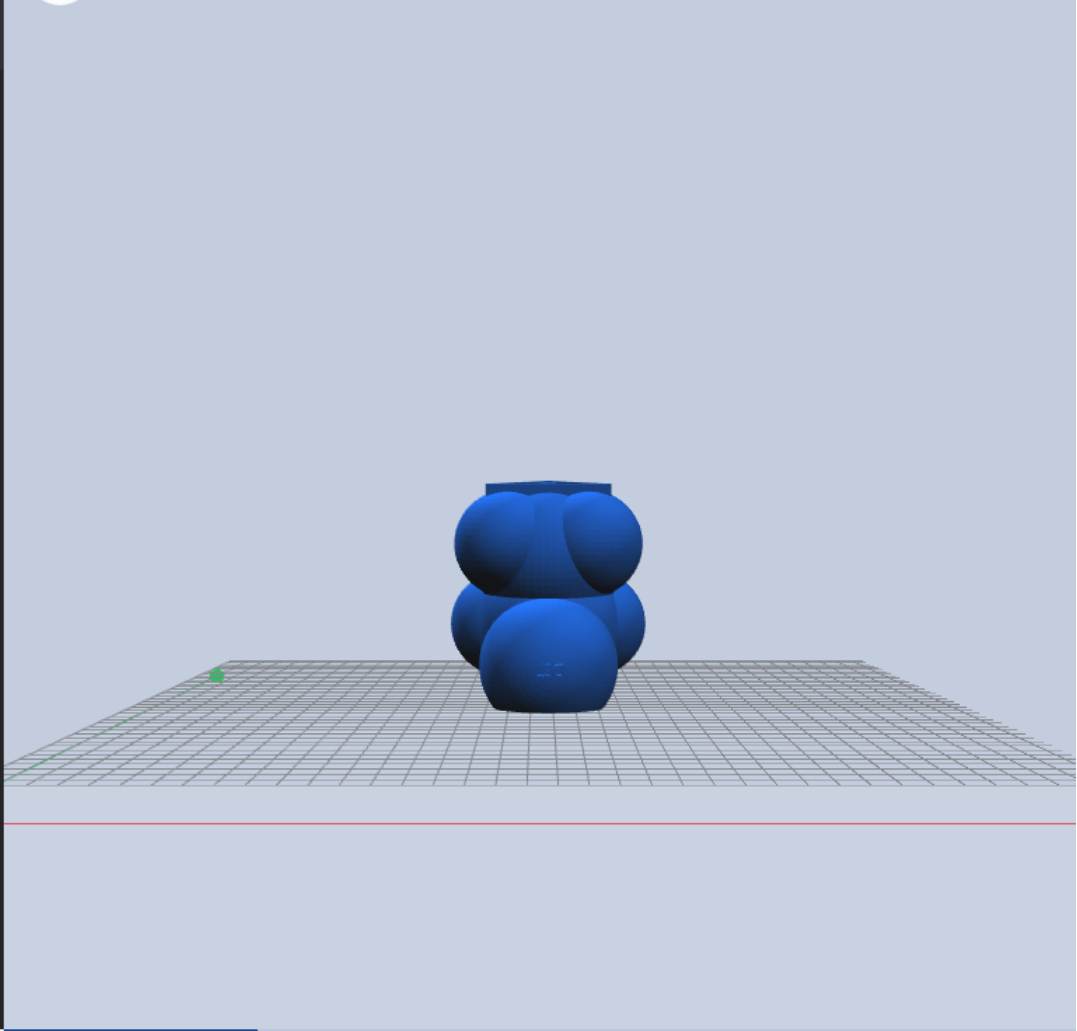
All 40%

Rotate i

X 273° Y 90° Z 0°



X: 45mm Y: 51mm Z: 52mm mm in



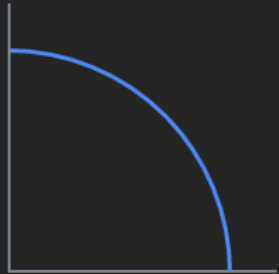
Ethanol-2016.STL


GENERAL TRANSFORMS **ADVANCED**

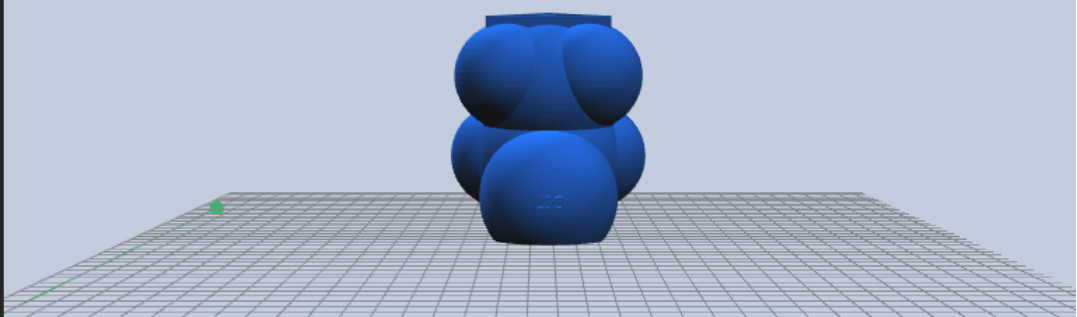
Support Material ON

Support Angle

Support Pattern



 X: 45mm Y: 51mm Z: 52mm **mm** in

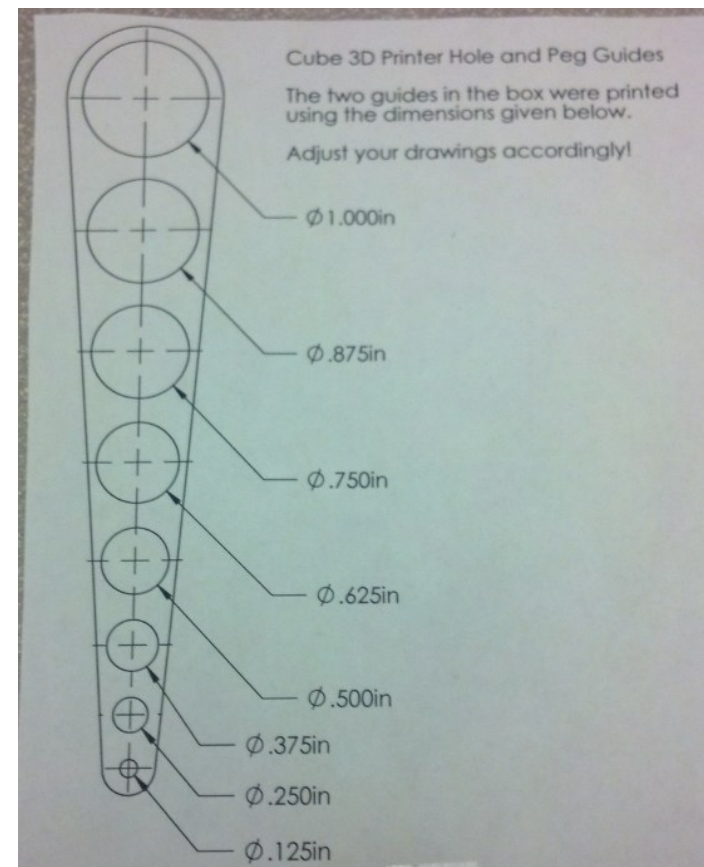


Post-Processing Steps

- Snap off any supports or raft.
 - Cutting tools are on the table next to the printers.
- Use a hot knife to remove stray material and retouch plastic that turned white.
- Sanding or filing might also be helpful.
- Machining? Painting? Gluing? Fake fur?
 - It's up to you!

Test Object (Mike Taylor)

- Compare requested size vs. actual.



Design Rules

- Shafts will be slightly **thicker** than intended.
- Holes will be **narrower** than intended.
- Do you want a 2.5 mm hole? On a 1st generation Cube:
 - Use 3.0 mm for a horizontal hole.
 - Use 3.7 mm for a vertical hole.
- Minimum widths for walls?

When Things Go Wrong



Alternative Printing Choices

- Objet printer in Larry Hayhurst's shop.
 - Finer resolution, smoother finish.
 - Can print dissolvable support material.
 - Pay by the cubic centimeter.
- Stereolithography facility at Pitt.
- Shapeways
 - High end 3D printing service; many materials. e.g., ceramics.
 - Library of models and applications.
 - 8 day turn-around; fast shipping.