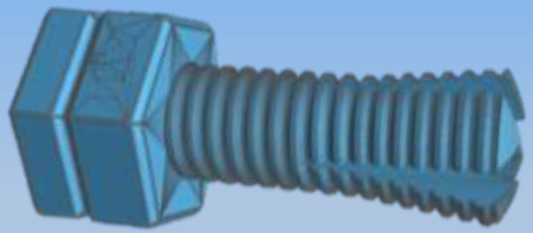
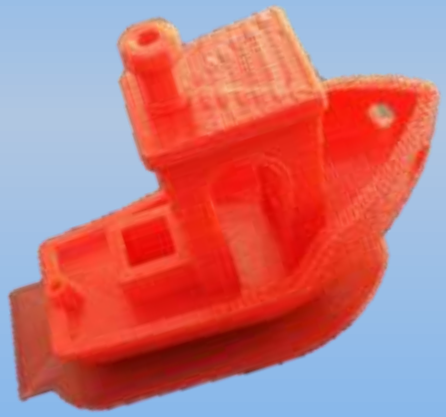
3D PRINTING





Allen Wolff
KC7O

9 January 2018

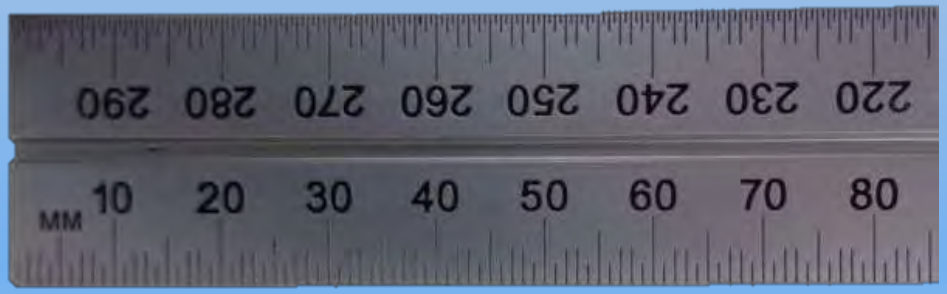
Definitions

- ***Subtractive Manufacturing***
  - ***i.e. machining***
- ***Additive manufacturing***
  - ***A process for making a physical object from a three-dimensional digital model, typically by laying down many successive thin layers of a material***

https://3dprinting.com/what-is-3d-printing/#How-Does-3D-Printing-Work

A Taste of 3D Printing

- ***Limited experience***
  - ***First involvement – June 2016***
- ***Some hints that helped me***
- ***How to get started***
- ***You'll be working and thinking in Metric Units!***



- ***BTW, you will make a lot of scrap***

Get used to it ☺

Basics

- ***Mechanisms***
  - ***Ink Jet printers***
  - ***3D printers***
- ***Software***
  - ***Design***
  - ***Slicing***
- ***Process***
- ***Examples***

Mechanisms

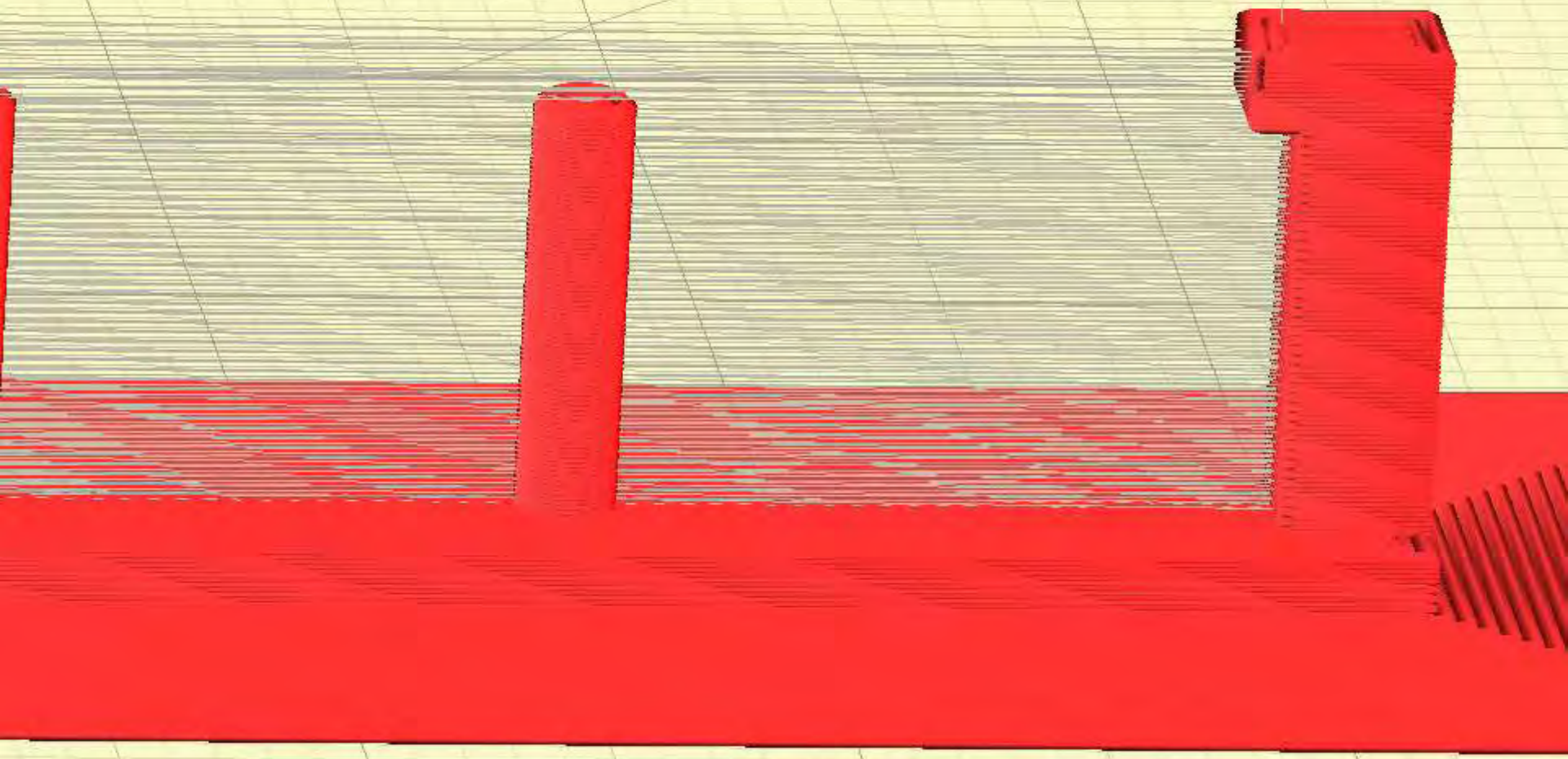
- ***I will concentrate on simple hobby machines***
- ***How they work***

Similarities with Inkjet Printers

http://www.photocopier.org.uk/wp-content/uploads/2011/03/ink-and-ribbon-how-it-works3.png

http://www.bus.umich.edu/KresgePublic/Journals/Gartner/research/90500/90582/90582.html

Tool path
and areas where material is not deposited

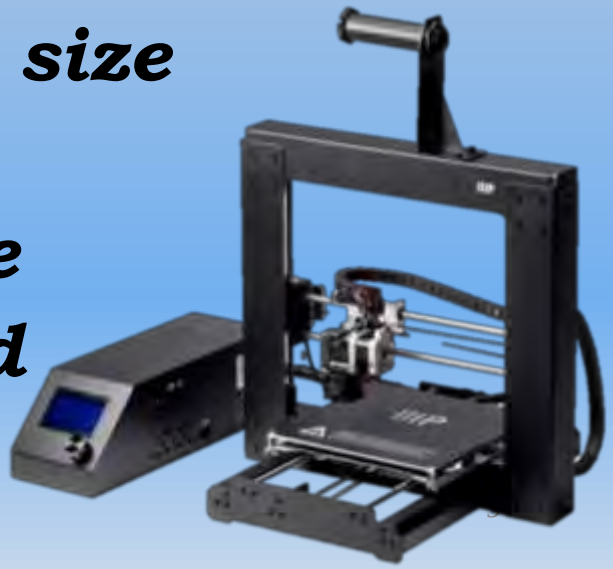


Machines & Costs

- ***Based on size and complexity***
  - ***Single or multiple filaments***
  - ***Many choices available***
  - ***Resolution***
  - ***$$$$$***
- ***Professional to Hobby***

Machines & Costs

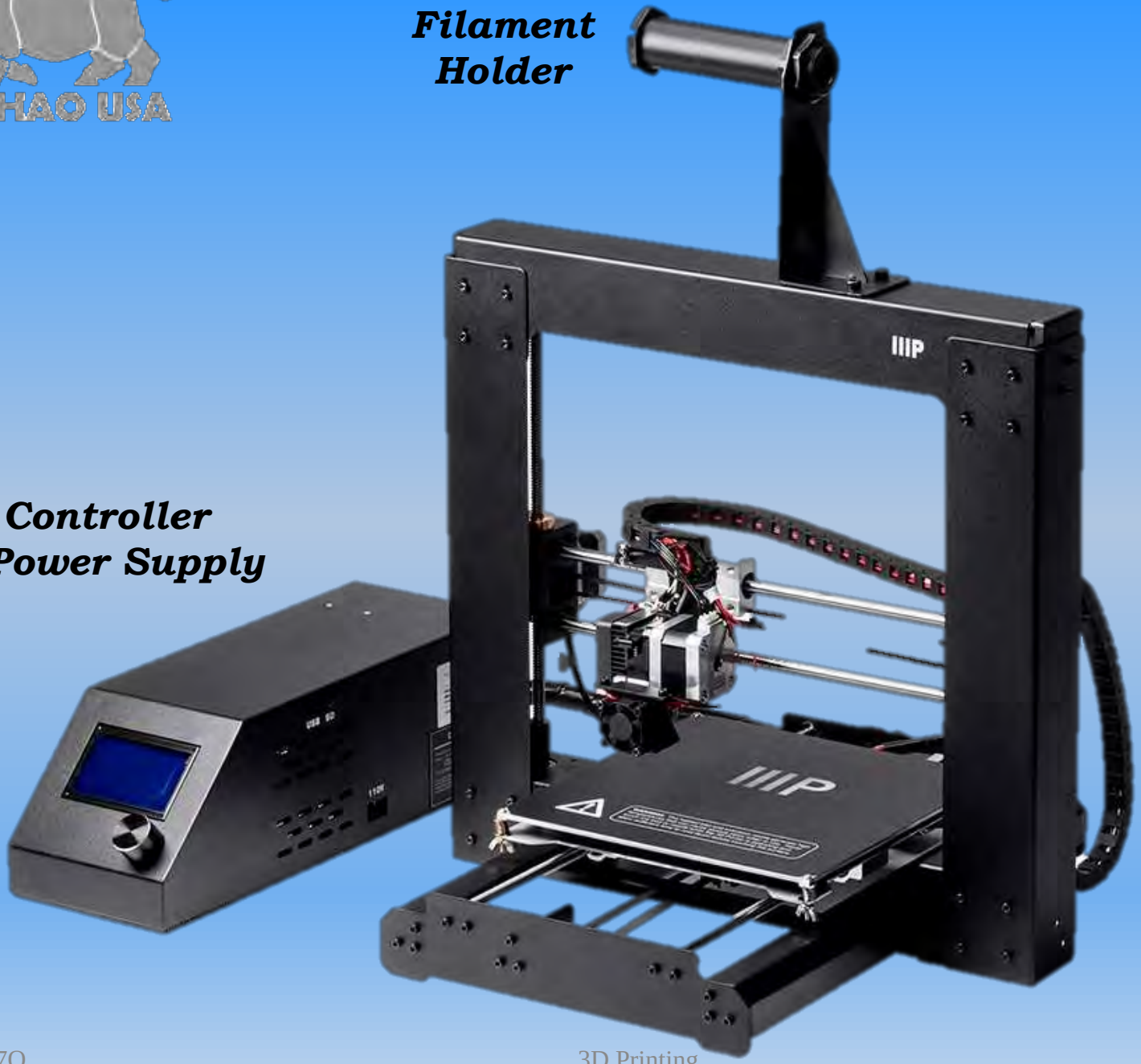
- **Based on complexity**
  - Single or multiple filaments
  - Many choices available
  - Resolution
  - $$$$$
- **Wanhao Duplicator I3**
  - Monoprice Maker Select 3D v2
  - 8” x 8” x 7” high max part size
  - ~ $300 *(7/17)*
  - Easy to upgrade & improve
  - ~250 Watts using µSD card

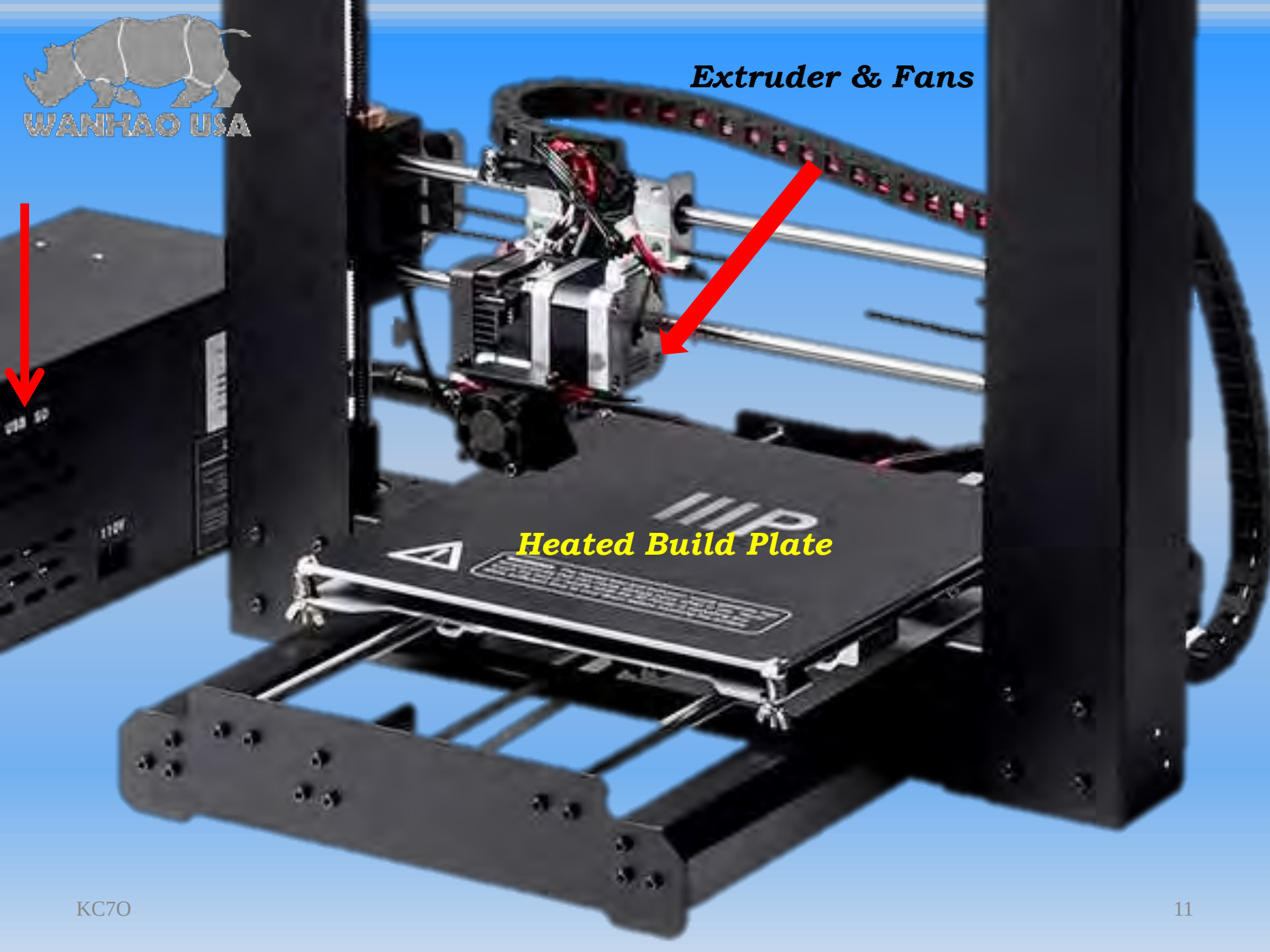


WANHAO USA

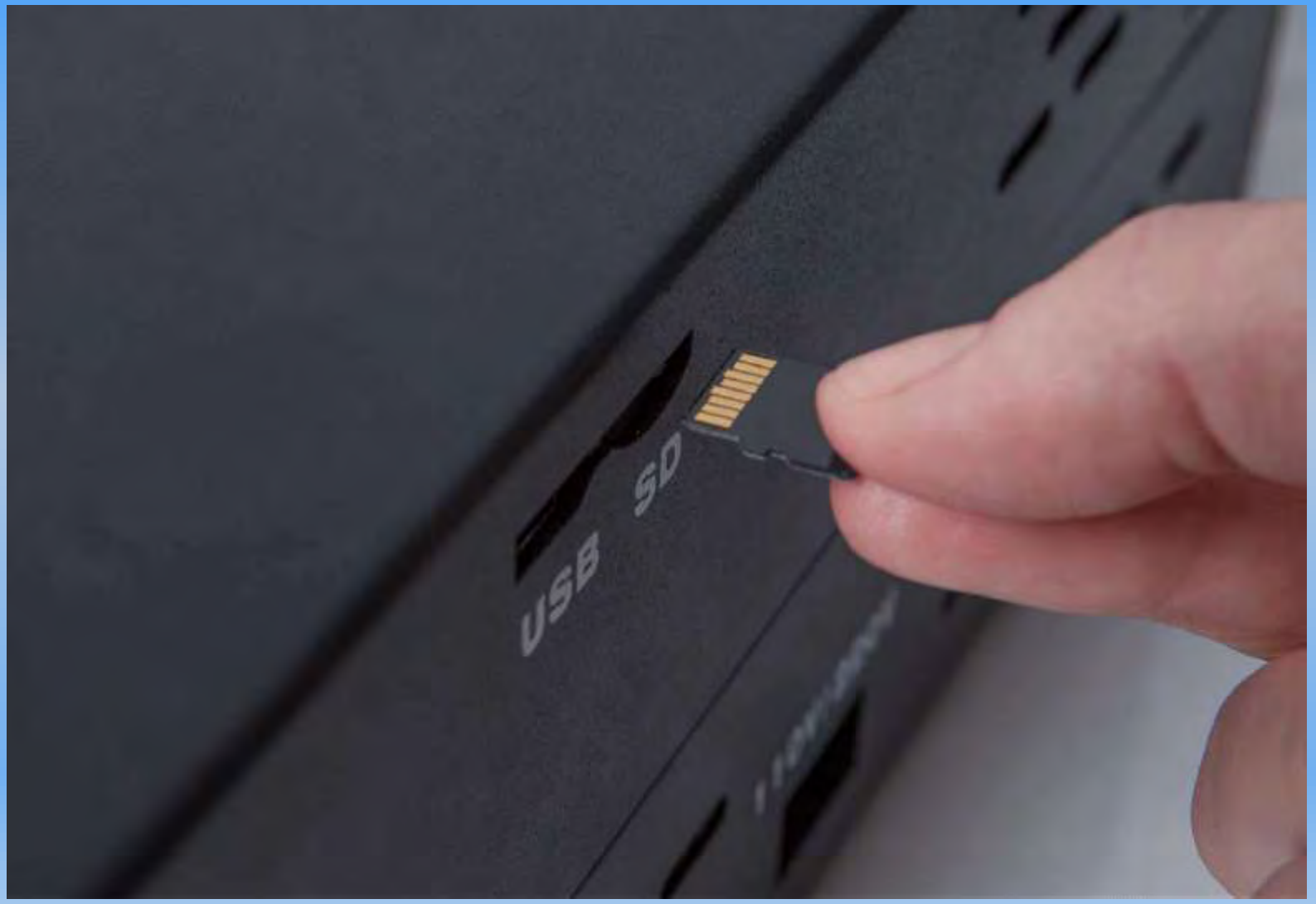
Filament Holder

Controller & Power Supply

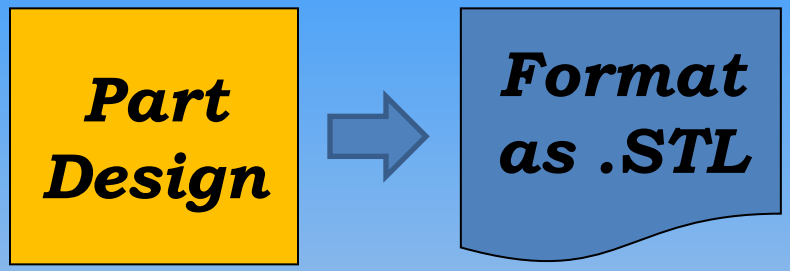



WANHAO USA
Extruder & Fans
Heated Build Plate

WANHAO USA



Process

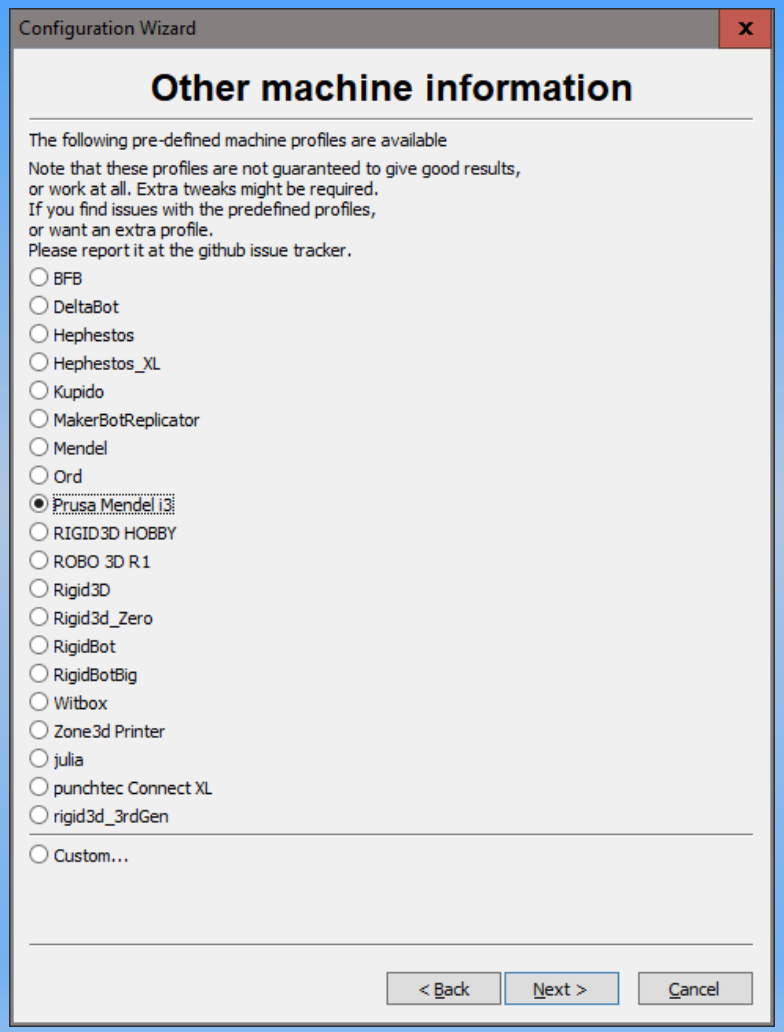


Process

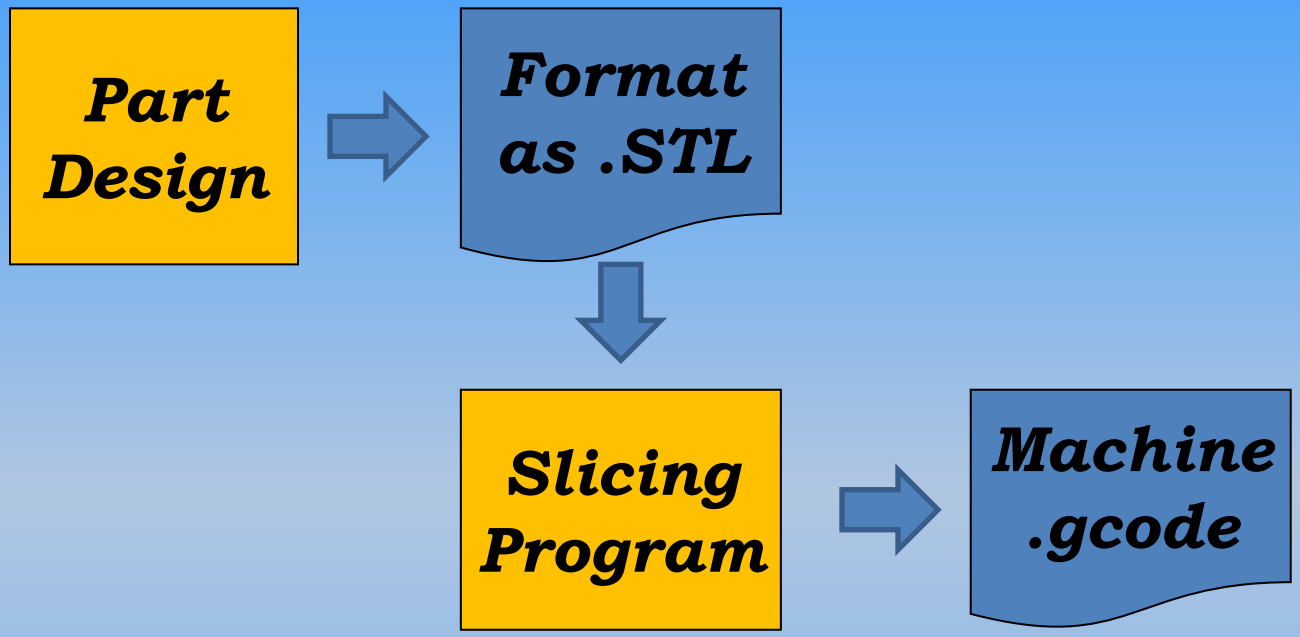
Part Design

Format as .STL

Slicing Program



Process



Process

Part Design

Format as .STL

Slicing Program

Machine .gcode

Machine interface

Machine

Micro SD card or USB cable

Design Software

- **Part design**
  - **Autocad** **$$$$$**
  - **Solid Works** **$$$$$**
  - **SketchUp** **Free**
  - **3dslash** **Free**
  - **123D Design** **Free**
  - **DesignSpark** **Free**
    - **Mechanical**
  - **FreeCAD** **Free**
  - **OpenSCAD** **Free**

Export Formats

- **3D solid formats:**
  - **DWG, DXF, 123DX, SAT, STEP**
- **3D mesh formats:**
  - **STL, VRML, X3D**
- **STL - STereoLithography**
  - **Files are the most common**
  - **This format only describes the surface geometry of the object, and can't store properties like color or texture**
  - **This is generally ok when printing in one color**

Programs

OpenSCAD
design

→ ***xxx.scad*** →

xxx.stl

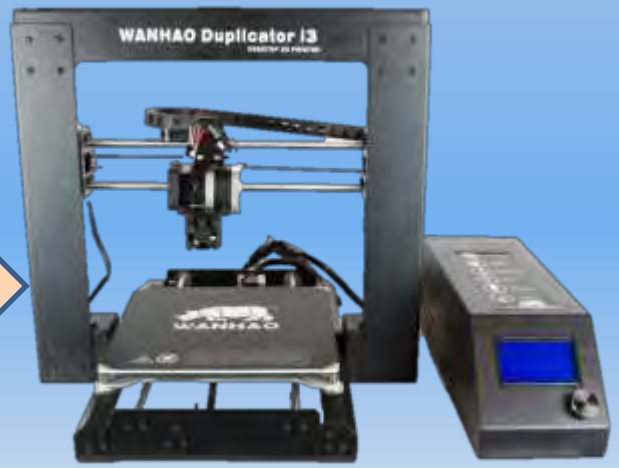
Or From the Internet

Cura
slicing

→ ***x.gcode***

Pronterface
machine interface

→ ***USB*** →



Programs

OpenSCAD
design

→ ***xxx.scad*** →

xxx.stl

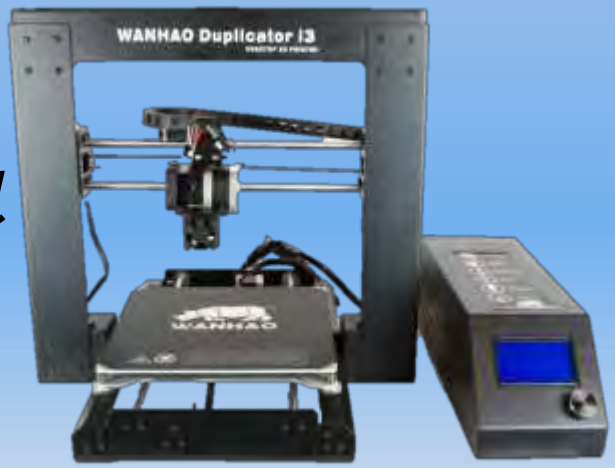
Or From the Internet

Cura
slicing

→ ***x.gcode***

Micro SD card

Recommended



gcode

- ***The line by line code that defines the printers tool path & operation***
- ***Created by slicing program (i.e. Cura)***
- ***Not necessary to know!***
- ***Just for information***
- ***Goes on for ten's of thousands of lines***

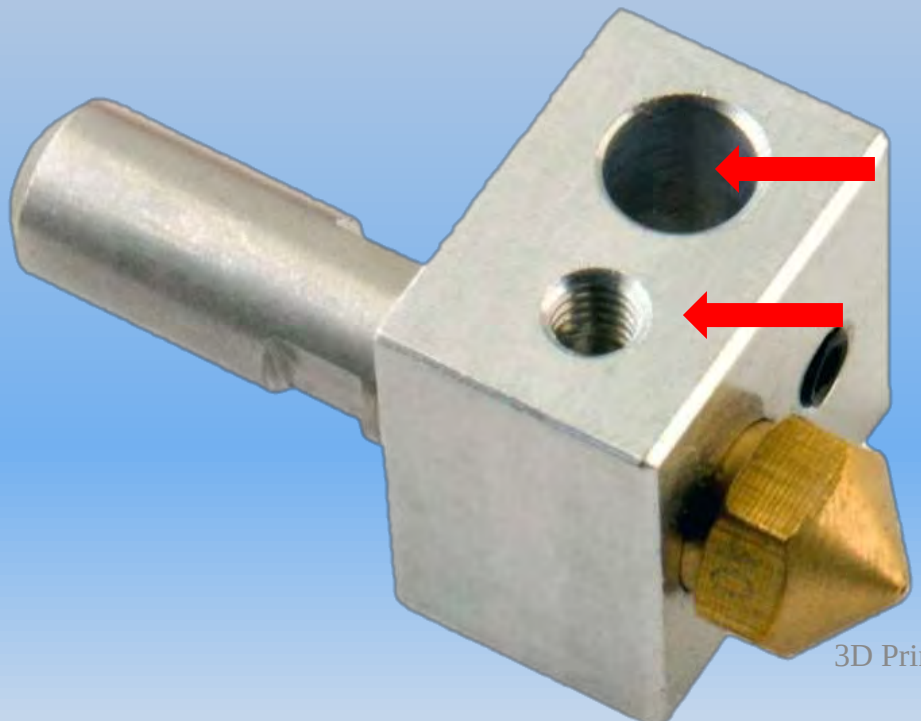
```
M190 S70.000000          Temps
M109 S210.000000
;Sliced at: Thu 23-06-2016 16:06:04
;Basic settings: Layer height: 0.1 Walls: 0.8 Fill: 20
;Print time: 3 hours 25 minutes
;Filament used: 2.38m 18.0g
;Filament cost: None
;M190 S70 ;Uncomment to add your own bed temperature line
;M109 S210 ;Uncomment to add your own temperature line
G21        ;metric values
G90        ;absolute positioning
M82        ;set extruder to absolute mode
M107       ;start with the fan off      Fan off
G28 X0 Y0  ;move X/Y to min endstops     Move to stops
G28 Z0     ;move Z to min endstops
G1 Z15.0 F9000 ;move the platform down 15mm
G92 E0                  ;zero the extruded length
G1 F200 E3              ;extrude 3mm of feed stock
G92 E0                  ;zero the extruded length again
G1 F9000
;Put printing message on LCD screen
M117 Printing...  Print starts

;Layer count: 98
;LAYER:0
M107
G0 F9000 X69.709 Y4.512 Z0.300
;TYPE:SKIRT
G1 F1200 X96.889 Y4.512 E0.51127
G1 X99.362 Y9.927 E0.62325
G1 X115.276 Y44.814 E1.34455
G1 X115.276 Y60.112 E1.63231
G1 X69.537 Y60.112 E2.49269
G1 X69.537 Y36.930 E2.92875
G1 X84.467 Y36.930 E3.20959
G1 X69.709 Y4.512 E3.87961
G0 F9000 X70.330 Y4.912
```

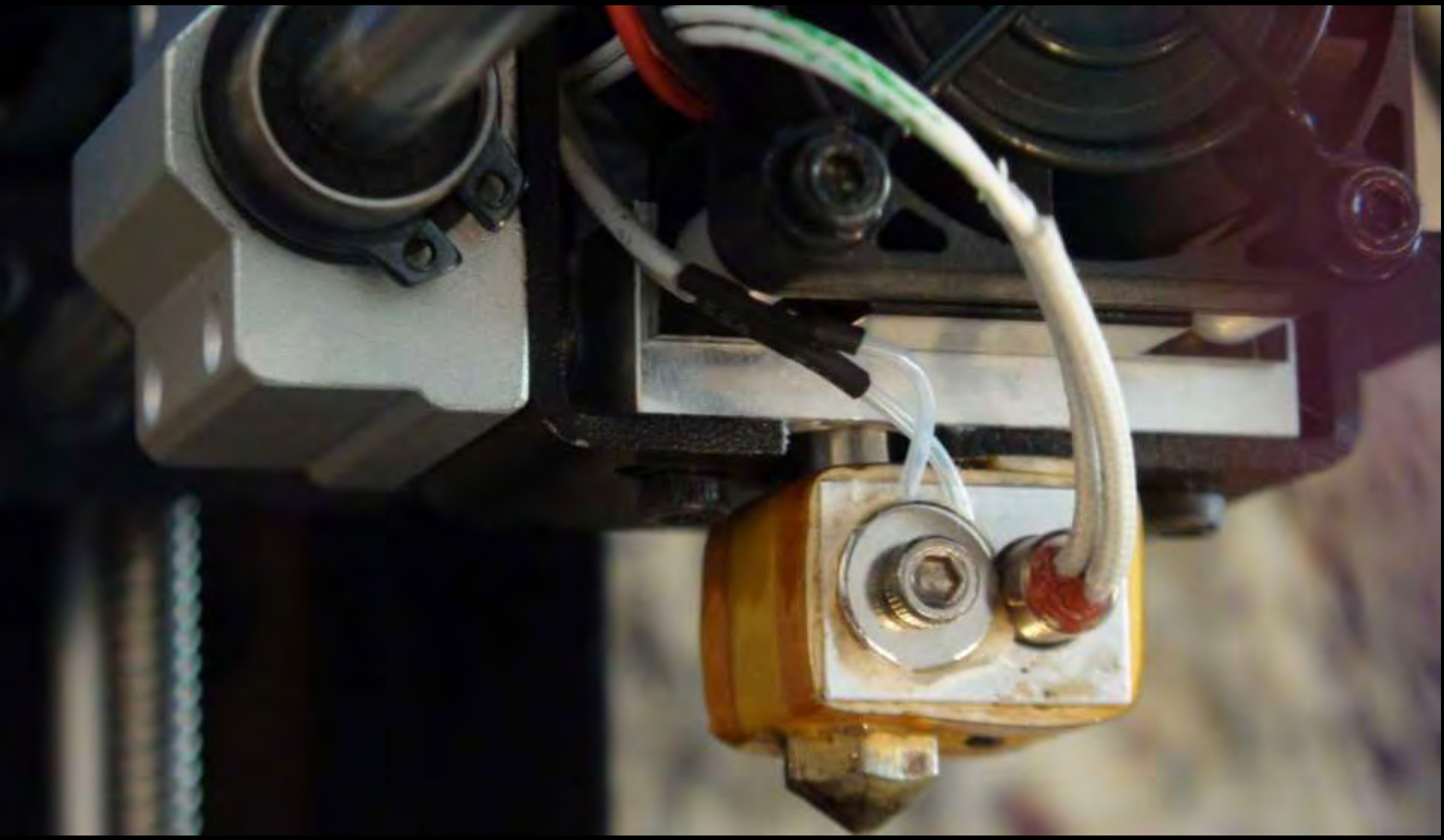
Machine Components

(Wanhao Duplicator I3)

- *0.4 mm nozzle*
  - *0.01575” ~ 5 times a hair diameter*
- *Hot end with nozzle*



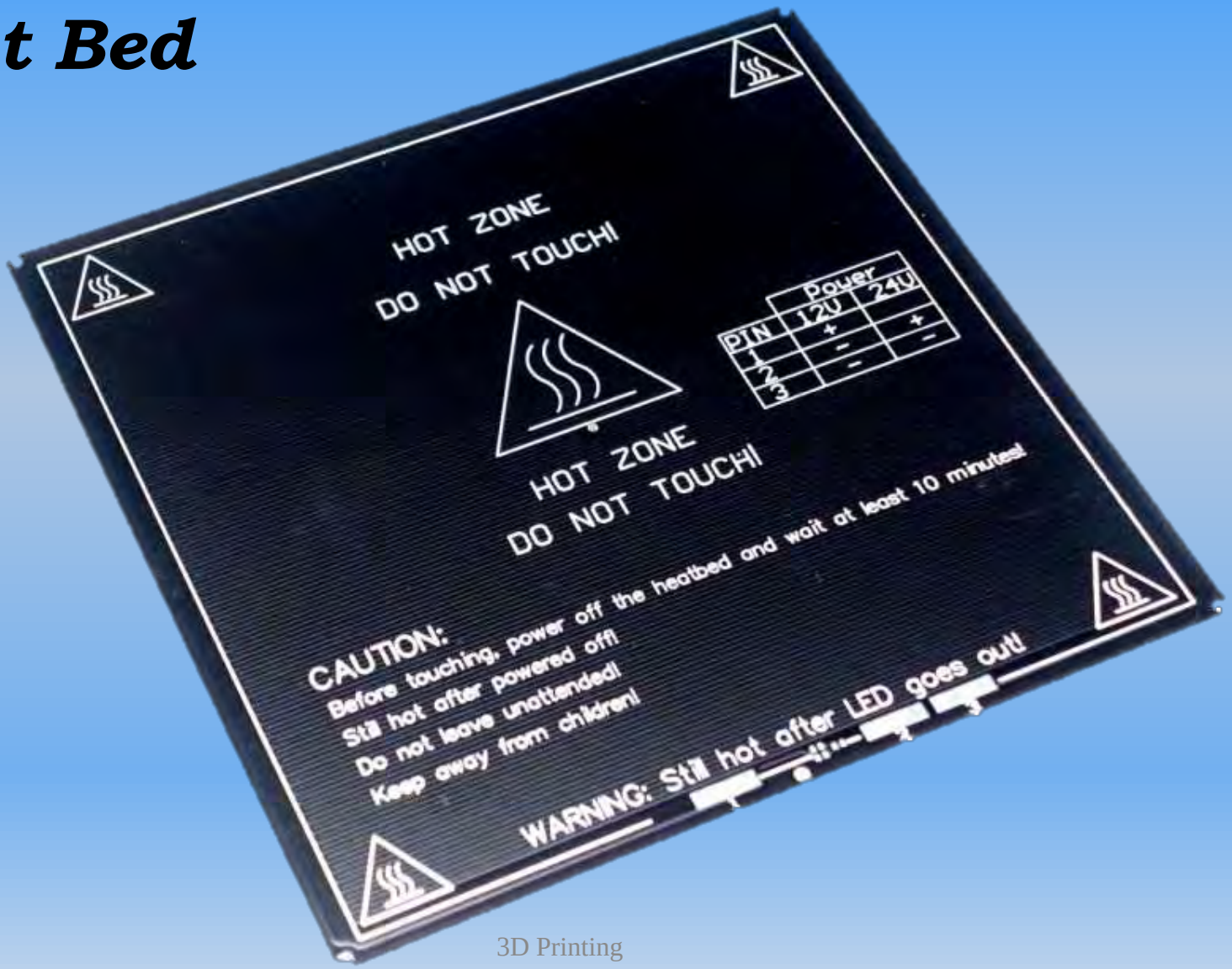
Heater & Thermocouple



Machine Components

(Wanhao Duplicator I3)

- **Hot Bed**



Materials

- ***Usually 1 Kg spools***
  - ***~$25 - $30***
  - ***I use Hatchbox – 1.75 mm***
  - ***~ 330 meters or 1080 feet***
- ***Available in multiple colors and materials***

HATCHBOX
3D PRINTER FILAMENT
PLA

Materials

- Come in 1 Kg spools
  - ~$25 - $30
  - I use Hatchbox – 1.75 mm
  - ~ 330 meters or 1080 feet
- Comes in multiple colors
- Types
  - PLA
  - ABS
  - Wood
  - Nylon
- Quality of the filament is critical

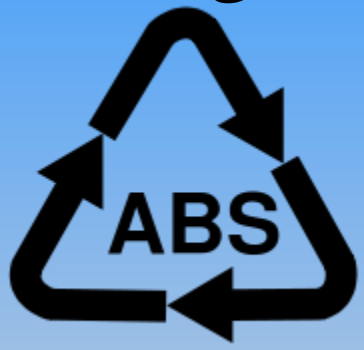
Common Materials

- ***PLA - Polylactic acid***
  - ***Easy to Print***
  - ***Biodegradable & Nontoxic***
  - ***Porous (clear coat to water proof)***
  - ***Should be kept dry (as with all filaments)***
    - ***I use Home Depot Buckets & covers with desiccant***
    - ***The filaments come with desiccant packs***

http://www.wikiwand.com/en/Polylactic_acid

Common Materials

- ABS - Acrylonitrile Butadiene Styrene
  - Durable, Impact Resistant
  - Warpage
  - Smells
  - Inhalation issues
    - Heating may release vapors which may be irritating



- Wood
  - Wood fibers in PLA
- Nylon
  - Strong, Flexible, Durable
  - Harder to work with

PLA - Polylactic acid	Easy to Print, Biodegradable
ABS - Acrylonitrile Butadiene Styrene	Durable, Impact Resistant
PETG (XT, N-Vent)	Flexible, Durable
nGen	Like PETG, but Easier to Print, Heat Resistant, Transparent
Flexible, TPE, TPU	Extremely Flexible, Rubber-Like
TPC	Extremely Flexible, Rubber-Like, Chemical-/ Heat-/ UV Resistant
HIPS	Disolvable, Biodegradable
PVA	Disolvable, Water Soluble, Biodegradable, Oil Resistant
Wood PLA	Wood Finish
Nylon	Strong, Flexible, Durable
PET (CEP)	Strong, Flexible, Durable, Recyclable
Carbon Fiber PLA	Rigid, Stronger Than Pure PLA
Metal PLA	Metal Finish
PC Polycarbonate	Strongest, Flexible, Durable, Transparent, Heat Resistant
Conductive PLA	Conductive
ASA	Rigid, Durable, Weather Resistant
PP	Flexible, Chemical Resistance
PETT (T-Glase)	Strong, Flexible, Transparent, Clear
POM, Acetal	Strong, Rigid, Low Friction, Resilient
Glow-In-The-Dark PLA	Luminous, Flourescent
Wax (MOLDLAY)	Melts Away
PMMA, Acrylic	Rigid, Durable, Transparent, Clear, Impact Resistant
PC/ABS	Rigid, Durable, Impact Resistant, Resilient, Deflecting Heat
Cleaning	Cleaning
Magnetic Iron PLA	Magnetic
Sandstone (LAYBRICK)	Sandstone Finish
Color Changing PLA	Changes Color

Temperatures Based on Materials

- PLA (recommended initially)
  - Hot End – Extrusion/Nozzle
    - 210°C (180°C - 210°C) => (356°F - 410°F)
  - Hot Bed
    - Not heated or 70°C
    - Experimentation
- ABS
  - Hot End – Extrusion/Nozzle
    - 230°C (210°C - 240°C) => (410°F - 464°F)
  - Hot Bed
    - 70°C (55°C - 85°C) => (131°F - 185°F)
    - Experimentation

YOUR CREATIVITY, OUR TOOLS.

Bed Adhesion

None – no additional material

Brim

Raft

Determine by experimentation

Bed Adhesion

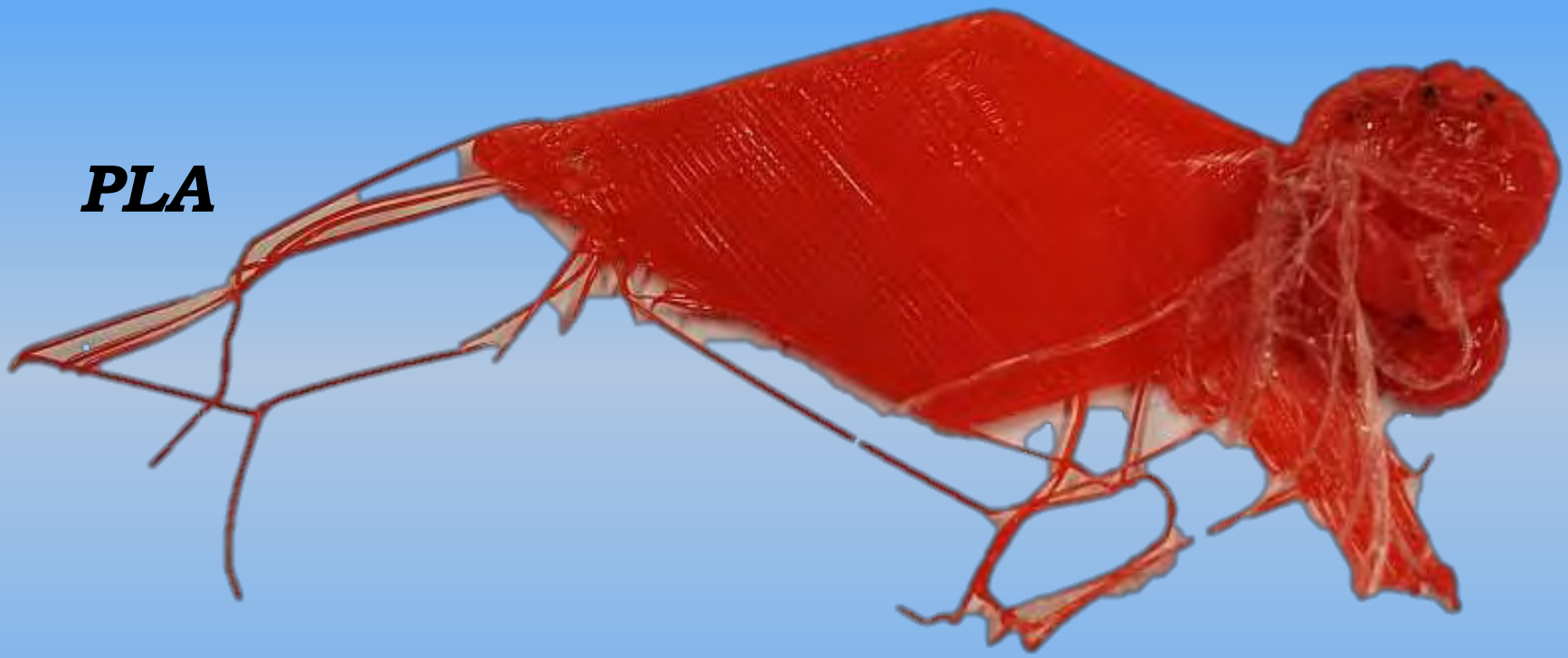
Sometimes too much!

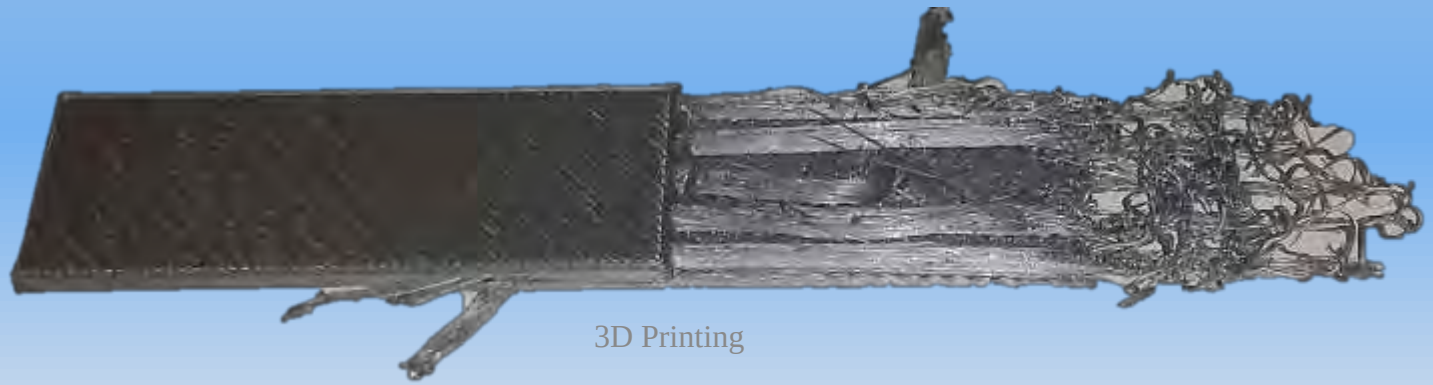
ABS

Bed Adhesion

Sometimes breaks loose!

PLA





Printer Adjustments

- ***Printer bed must be level***
- ***Extruder should be one to two paper thickness away from bed across the build area – depending on the bed***
- ***Prints always start from "Home"***
  - ***X=0, Y=0, Z=0***
  - ***Front left***
- ***Bed temperatures critical for each material & type of bed material***

Part Adherence to Bed

- ***Methods:***
  - ***Print on Blue painters tape***
  - ***Adhesives to hold part – glue stick***
  - ***Acqua-Net hair spray***
  - ***Mylar tape***
  - ***Borosilicate Glass Beds***
  - ✓ ***– print plates***

Part Removal

- ***Scraper***

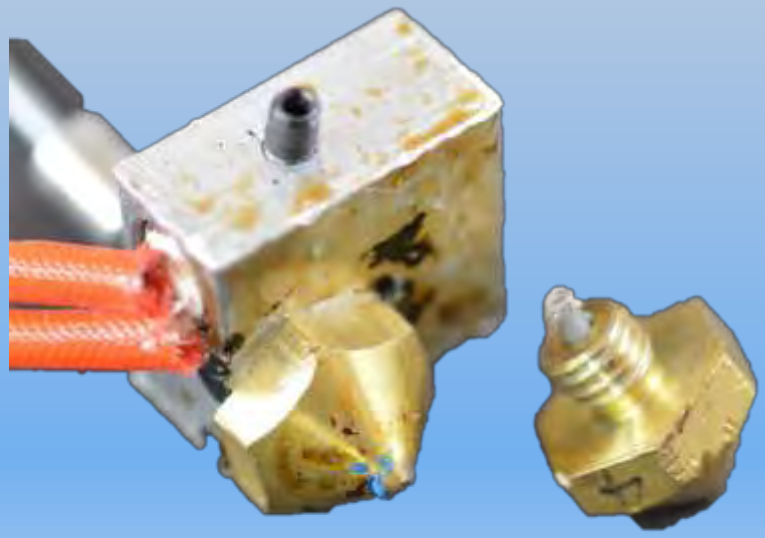
- ***Care not to harm the print surface***
- ***Another reason to use a replaceable surface on the bed***

Cleaning

- ***91% Isopropyl Alcohol and a clean rag***
- ***70% pads ok too***

Problems

- *Clogged nozzle*
- *Models not adhering*
- *Warping*
  - *Bed temperature adjustment*
  - *Head to bed alignment*



Shrinkage

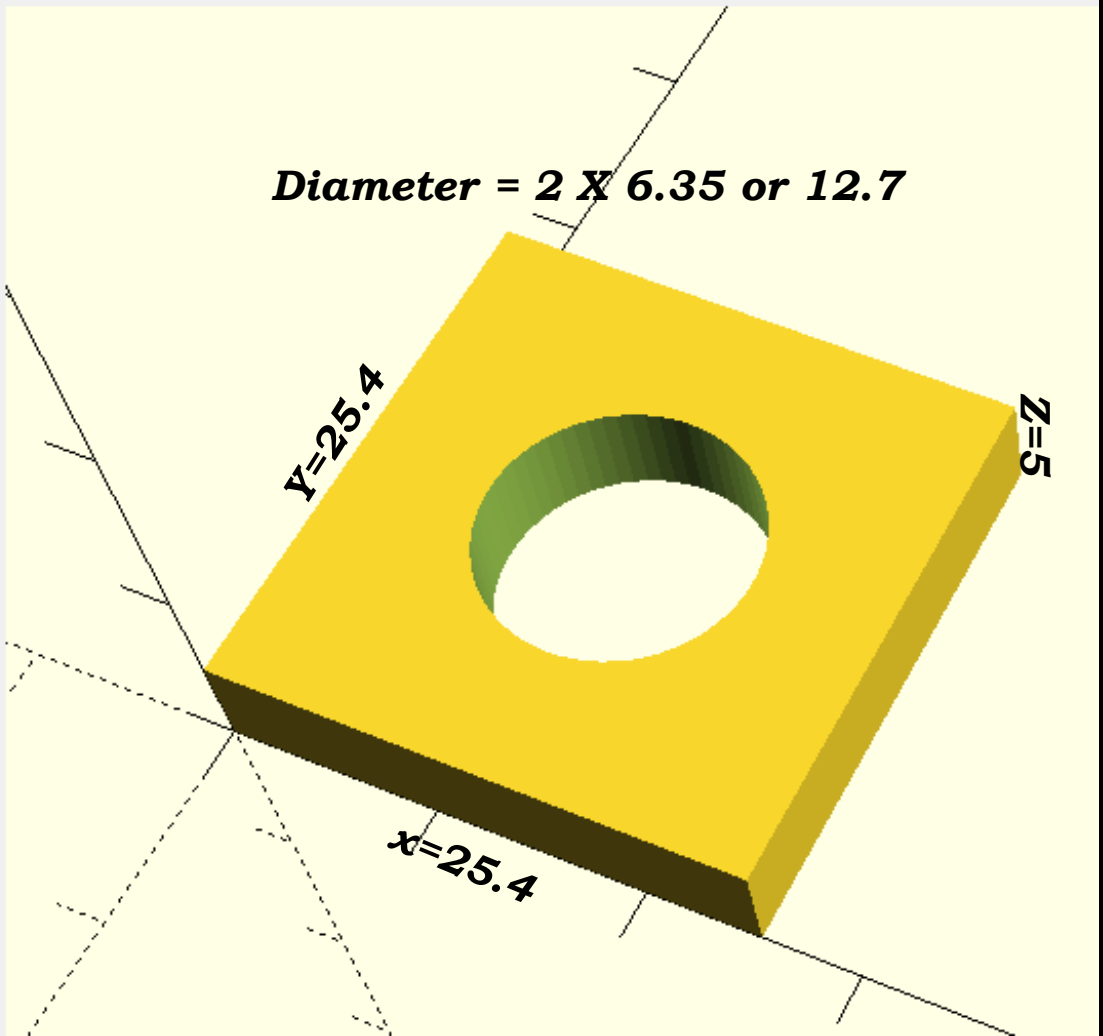
Test_Cube_Shrinkage.scad - OpenSCAD

File Edit Design View Help

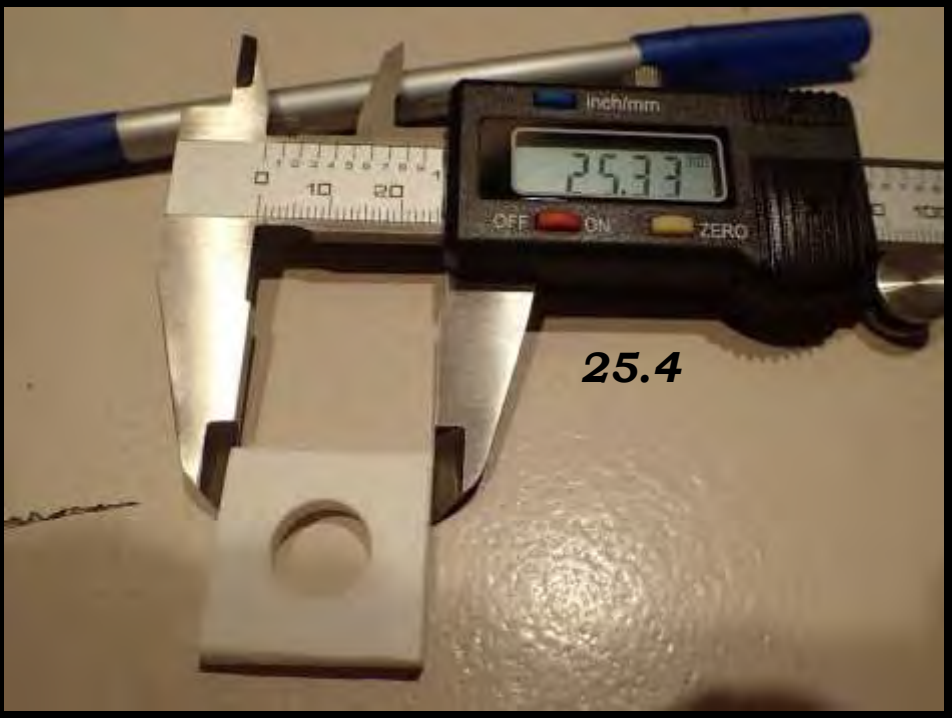
Editor

```
1  // 1 inch block - shrinkage
2  //KC7O - 20Sept2017
3  $fn=63;
4  difference(){
5  cube([25.4,25.4,5]);
6
7  translate([12.7,12.7,0])
8      cylinder(10,6.35,6.35);
9  }
```

OpenSCAD



Shrinkage



25.4

25.4

12.7

Design

- ***OpenSCAD (free download)***

OpenSCAD

The Programmers Solid 3D CAD Modeller

Donate

Flattr 965

Donate 0

home | about | news | downloads | documentation | gallery | community | github

Recent News

14 Jul 2016

OpenSCAD Customizer

The topic of this year's Google Summer of Code project is...

3 Mar 2016

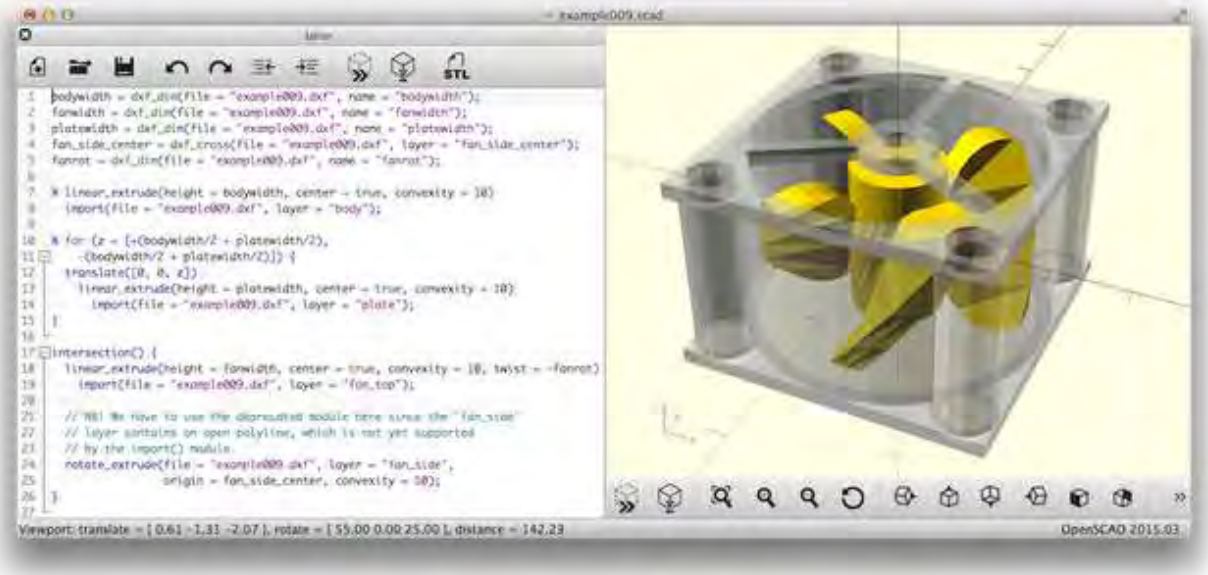
Google Summer of Code 2016

OpenSCAD, in collaboration with

10 Mar 2015

OpenSCAD is a software for creating solid 3D CAD objects.

It is free software and available for Linux/UNIX, MS Windows and Mac OS X.



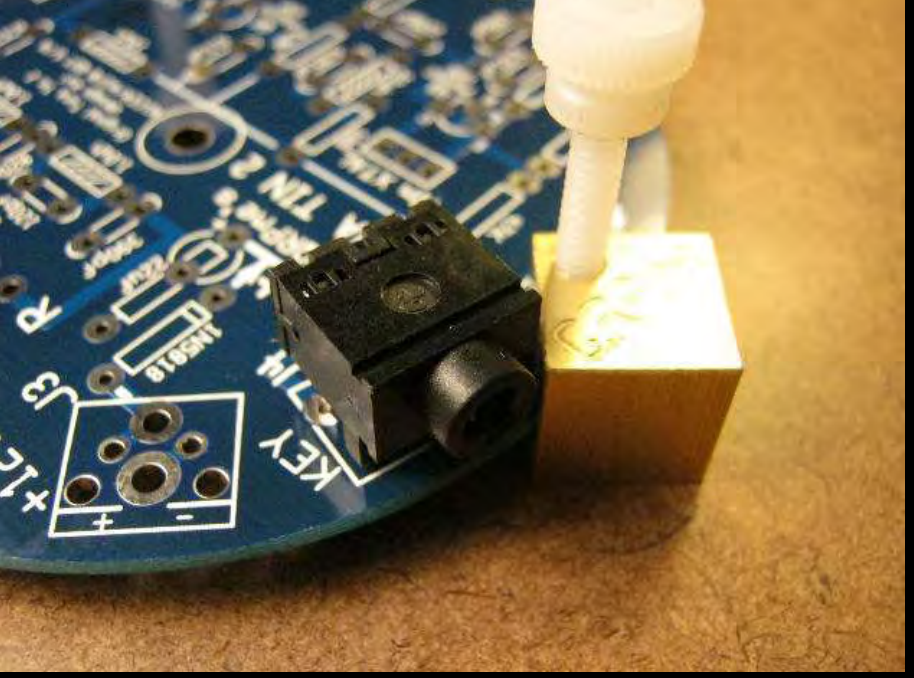
Download OpenSCAD

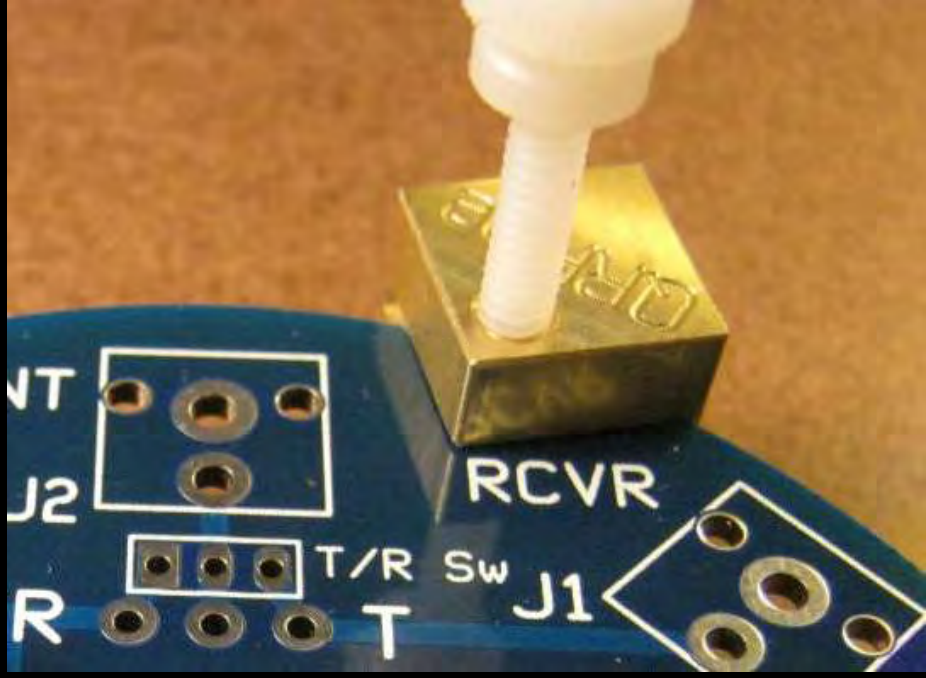
OpenSCAD 2015.03-2 Windows

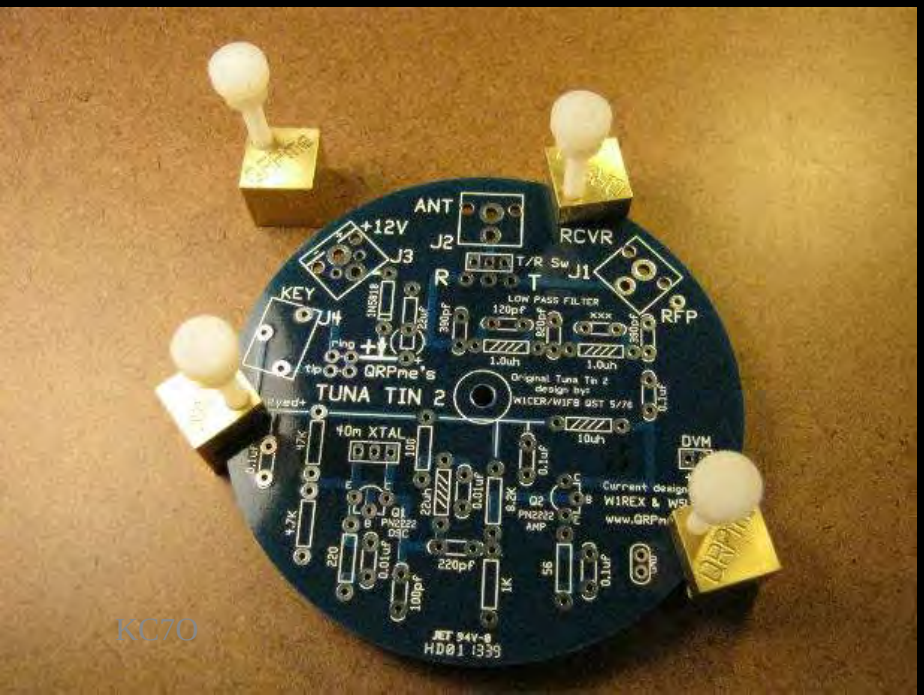
Other OSs and Versions

Example

- ***Appeared in CQ Magazine***
  - ***October 2016 – PC Board Build Supports***
  - ***"A Brass Set" from QRPme.com***
  - ***Issue – they are brass so you can't power and test your project – potential shorts***


KEY


J2
RCVR
T/R Sw
J1
R
T


ANT
+12V
J2
RCVR
J3
T/R Sw
J1
R
T
KEY
J4
LOW PASS FILTER
RFP
QRPme's
TUNA TIN 2
40m XTAL
DVM
Q1
Q2
220pF
100pF
1K
56
0.1uF
0.01uF
22uh
10uh
1.0uh
HD01 1339

A Better Idea!

Design It & Print It!

The process from idea to part

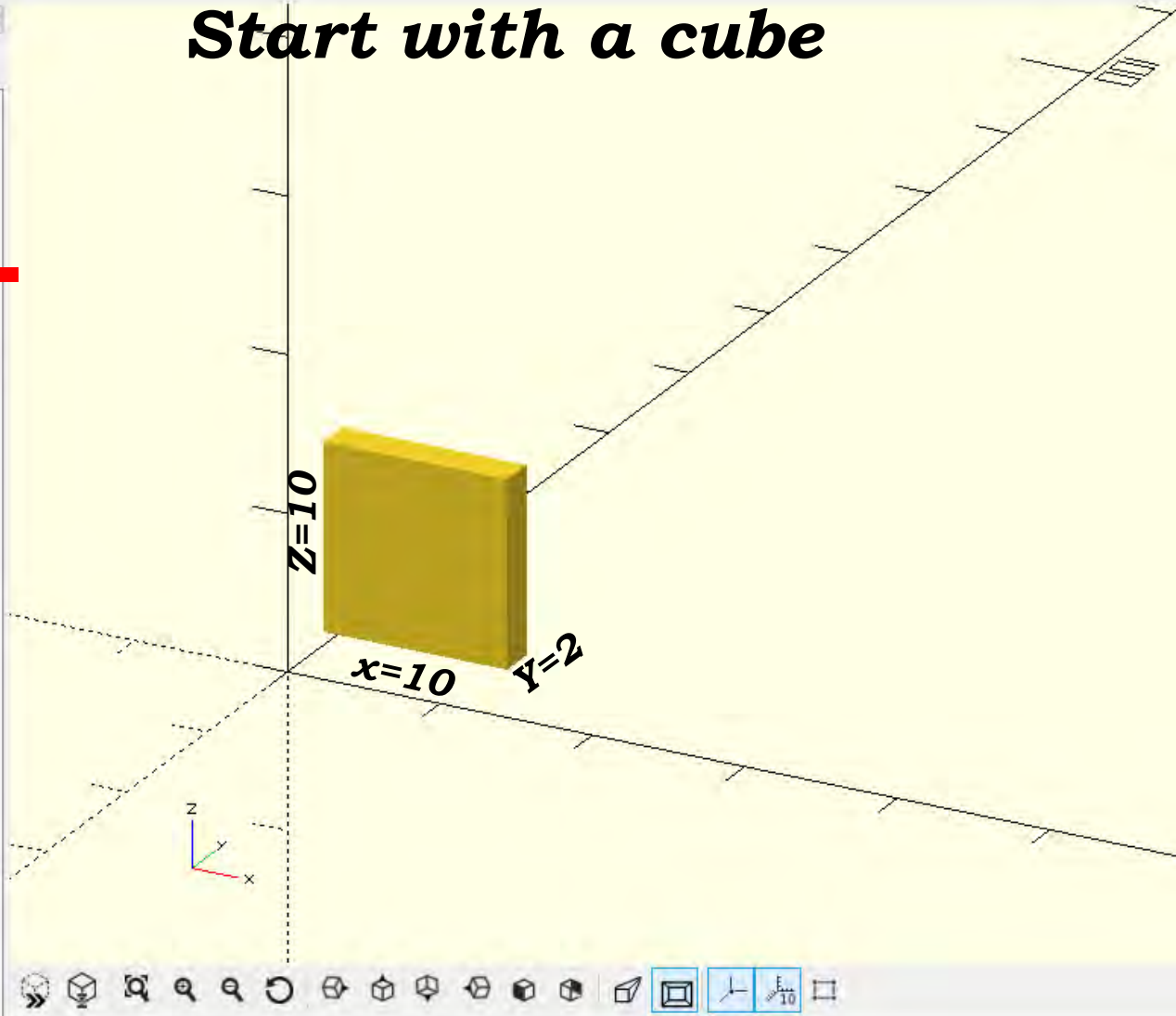
#8_feet-for presentation.scad* - OpenSCAD

File Edit Design View Help

Editor

```
1
2  $fn=30;
3  rotate([0,90,0])
4 scale([1.2,1.2,1.2]){
5 translate([-12.5,0,2]){
6  //difference(){
7  cube ([10,2,10]);
8  //rotate([90,0,0])
9  //translate([5,5,-7])
10     //cylinder(10,2,2);
11
12 //}
13
14 }
15 }
```

Start with a cube



OpenSCAD

Console

```
Geometries in cache: 5
Geometry cache size in bytes: 7184
CGAL Polyhedrons in cache: 0
CGAL cache size in bytes: 0
Compiling design (CSG Products normalization)...
Normalized CSG tree has 1 elements
Compile and preview finished.
Total rendering time: 0 hours, 0 minutes, 0 seconds
```

Viewport: translate = [37.43 7.93 16.30], rotate = [66.90 0.00 27.80], distance = 140.00

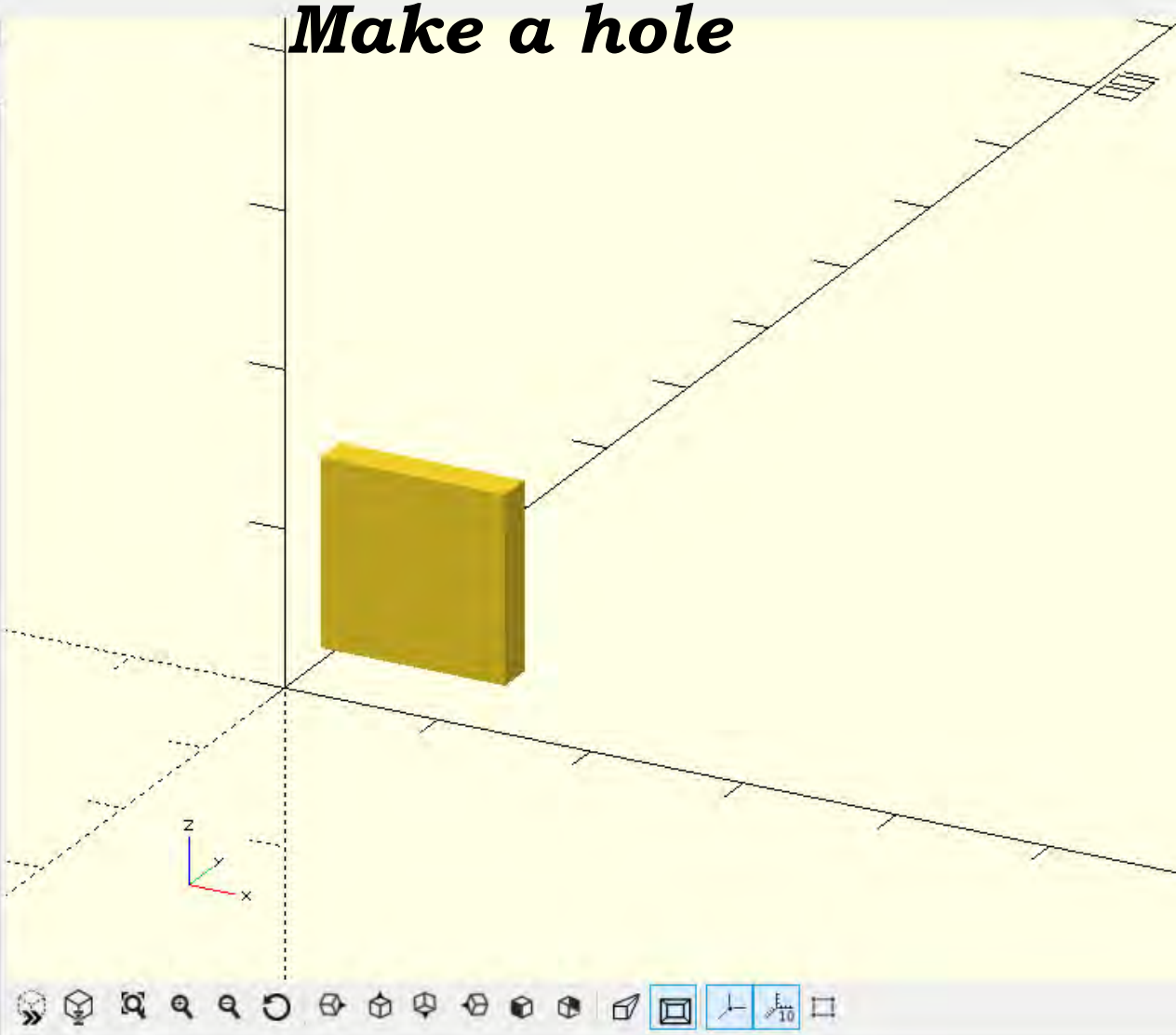
Make a hole

#8_feet-for presentation.scad* - OpenSCAD

File Edit Design View Help

Editor

```
1
2  $fn=30;
3  rotate([0,90,0])
4 scale([1.2,1.2,1.2]){
5 translate([-12.5,0,2]){
6  //difference(){
7  cube ([10,2,10]);
8  //rotate([90,0,0])
9  //translate([5,5,-7])
10     //cylinder(10,2,2);
11
12 //}
13
14 }
15 }
```



Console

```
Geometries in cache: 5
Geometry cache size in bytes: 7184
CGAL Polyhedrons in cache: 0
CGAL cache size in bytes: 0
Compiling design (CSG Products normalization)...
Normalized CSG tree has 1 elements
Compile and preview finished.
Total rendering time: 0 hours, 0 minutes, 0 seconds
```

Viewport: translate = [37.43 7.93 16.30], rotate = [66.90 0.00 27.80], distance = 140.00

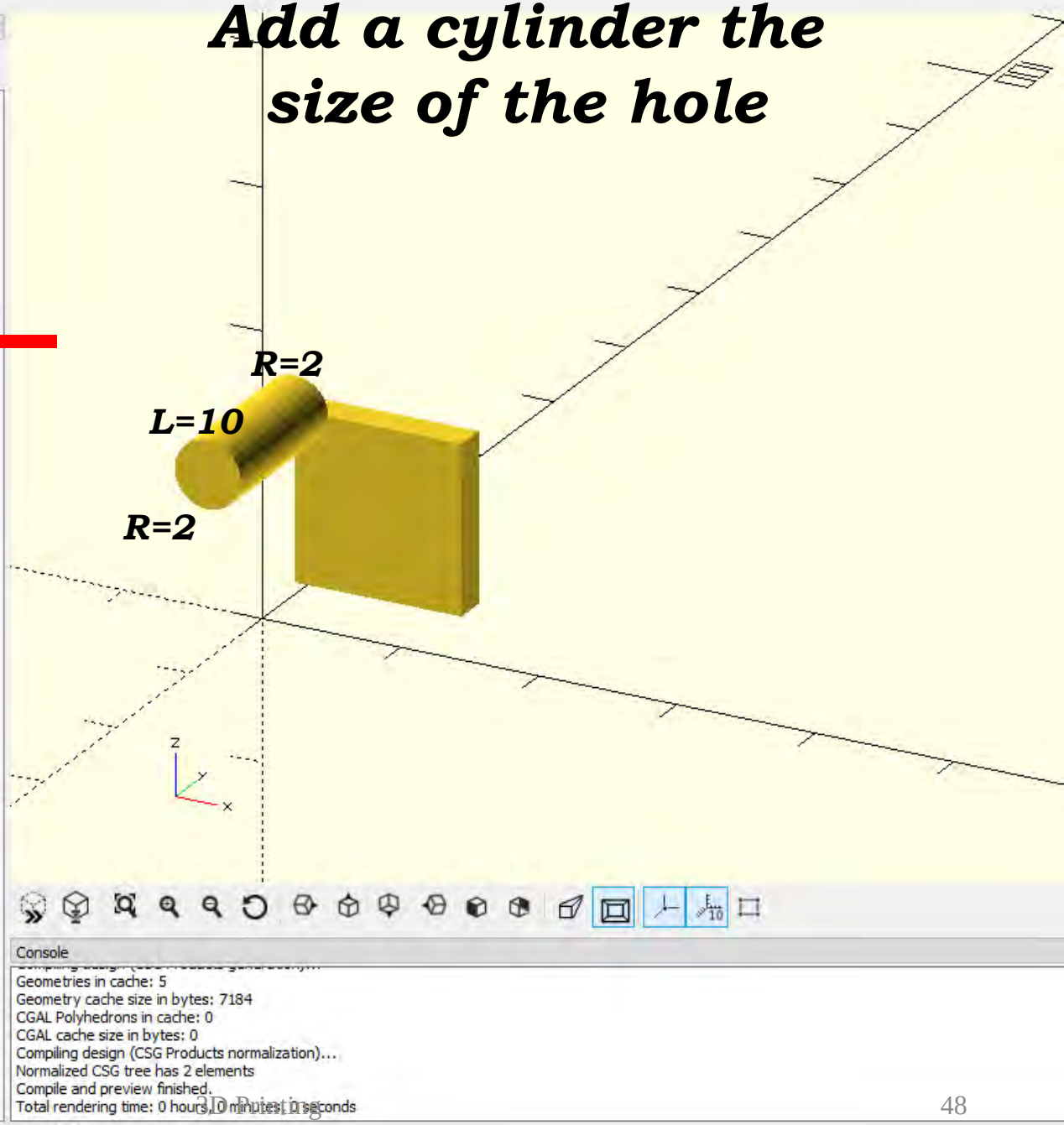
Add a cylinder the size of the hole

#8_feet-for presentation.scad* - OpenSCAD

File Edit Design View Help

Editor

```
1
2  $fn=30;
3  rotate([0,90,0])
4 scale([1.2,1.2,1.2]){
5 translate([-12.5,0,2]){
6  //difference(){
7  cube ([10,2,10]);
8  rotate([90,0,0])
9  //translate([5,5,-7])
10     cylinder(10,2,2);
11
12 //}
13
14 }
15 }
```



Console

```
Geometries in cache: 5
Geometry cache size in bytes: 7184
CGAL Polyhedrons in cache: 0
CGAL cache size in bytes: 0
Compiling design (CSG Products normalization)...
Normalized CSG tree has 2 elements
Compile and preview finished.
Total rendering time: 0 hours, 0 minutes, 0 seconds
```

Viewport: translate = [37.43 7.93 16.30], rotate = [66.90 0.00 27.80], distance = 140.00

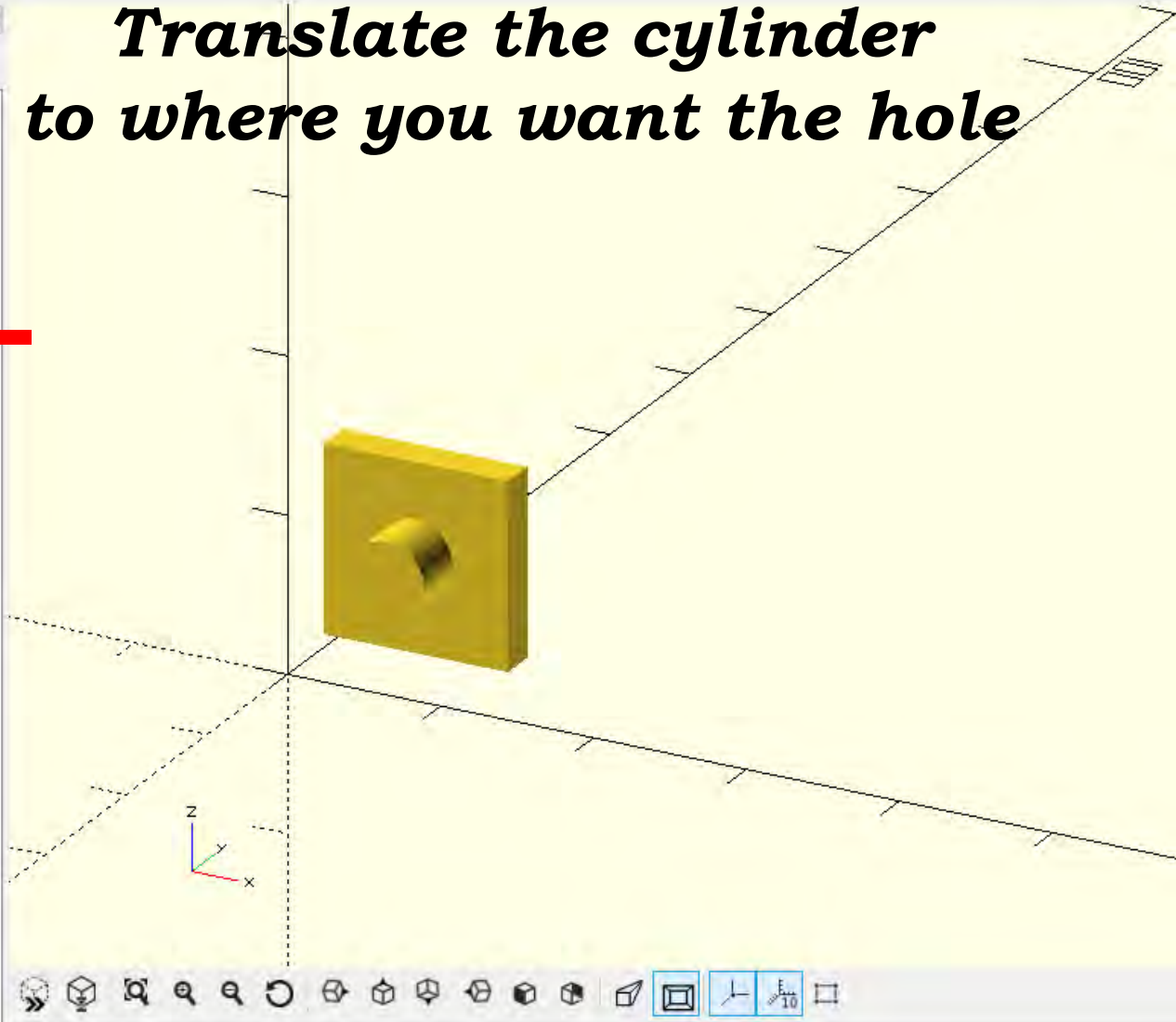
Translate the cylinder to where you want the hole

#8_feet-for presentation.scad* - OpenSCAD

File Edit Design View Help

Editor

```
1
2  $fn=30;
3  rotate([0,90,0])
4 scale([1.2,1.2,1.2]){
5 translate([-12.5,0,2]){
6  //difference(){
7  cube ([10,2,10]);
8  rotate([90,0,0])
9  translate([5,5,-7])
10     cylinder(10,2,2);
11
12 //}
13
14 }
15 }
```



Console

```
Geometries in cache: 5
Geometry cache size in bytes: 7184
CGAL Polyhedrons in cache: 0
CGAL cache size in bytes: 0
Compiling design (CSG Products normalization)...
Normalized CSG tree has 2 elements
Compile and preview finished.
Total rendering time: 0 hours, 0 minutes, 0 seconds
```

Viewport: translate = [37.43 7.93 16.30], rotate = [66.90 0.00 27.80], distance = 140.00

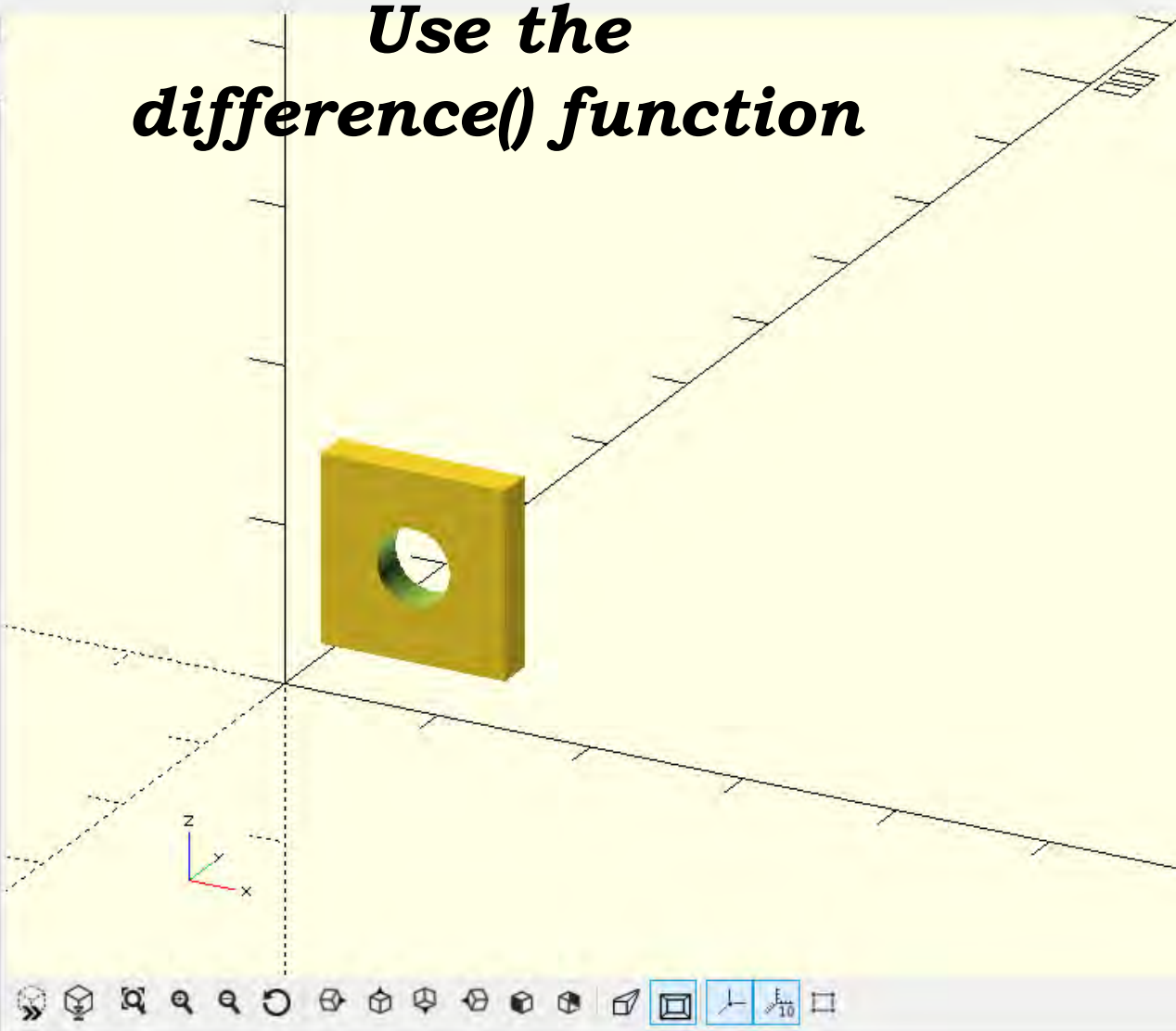
Use the difference() function

#8_feet-for presentation.scad* - OpenSCAD

File Edit Design View Help

Editor

```
1
2  $fn=30;
3  rotate([0,90,0])
4 scale([1.2,1.2,1.2]){
5 translate([-12.5,0,2]){
6 difference(){
7  cube ([10,2,10]);
8  rotate([90,0,0])
9  translate([5,5,-7])
10     cylinder(10,2,2);
11
12 }
13
14 }
15 }
```



Console

```
Geometries in cache: 5
Geometry cache size in bytes: 7184
CGAL Polyhedrons in cache: 0
CGAL cache size in bytes: 0
Compiling design (CSG Products normalization)...
Normalized CSG tree has 2 elements
Compile and preview finished.
Total rendering time: 0 hours, 0 minutes, 0 seconds
```

Viewport: translate = [37.43 7.93 16.30], rotate = [66.90 0.00 27.80], distance = 140.00

#8_feet.scad - OpenSCAD

File Edit Design View Help

Editor

```
1  //PC Board Feet
2  //Use #8 nylon nut and 3/4" screw
3  //A. Wolff
4  //Original idea from "A Brass
       Set" qrpme.com
5  //70% fill, 0.2 layer
6  //210 & 70 deg C - raft
7  $fn=30;
8  scale([1.2,1.2,1.2]){
9  difference(){
10 cube ([10,2,10]);
11 rotate([90,0,0])
12 translate([5,5,-7])
13 cylinder(10,2,2);
14 }
15 difference(){
16 translate([0,5,0])
17     cube ([10,2,10]);
18 rotate([90,0,0])
19 translate([5,5,-7])
20 cylinder(10,2,2);
21 }
22 translate([8.5,0,-2])
23 cube ([4,12,14]);
24 translate([0,10,-2])
25 cube ([12.5,4,14]);
26 translate([0,0,-2])
27 cube ([10.5,7,2]);
28 translate([0,0,10])
29 cube ([10.5,7,2]);
30 }
```

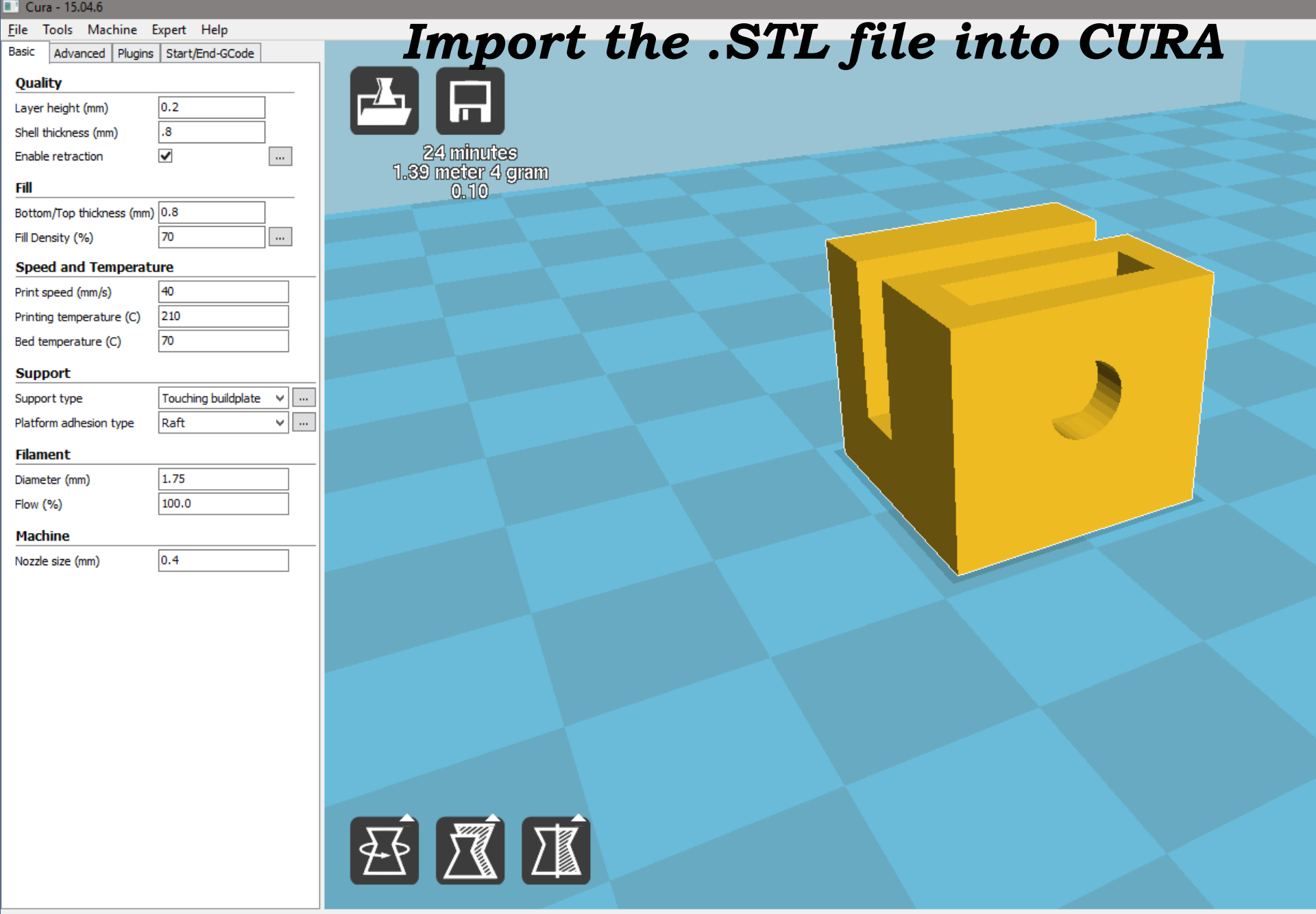
Once completed and rendered
Export as a .STL file

Console

```
Compiling design (CSG Tree generation)...
Compiling design (CSG Products generation)...
Geometries in cache: 5
Geometry cache size in bytes: 7184
CGAL Polyhedrons in cache: 0
CGAL cache size in bytes: 0
Compiling design (CSG Products normalization)...
Normalized CSG tree has 8 elements
```

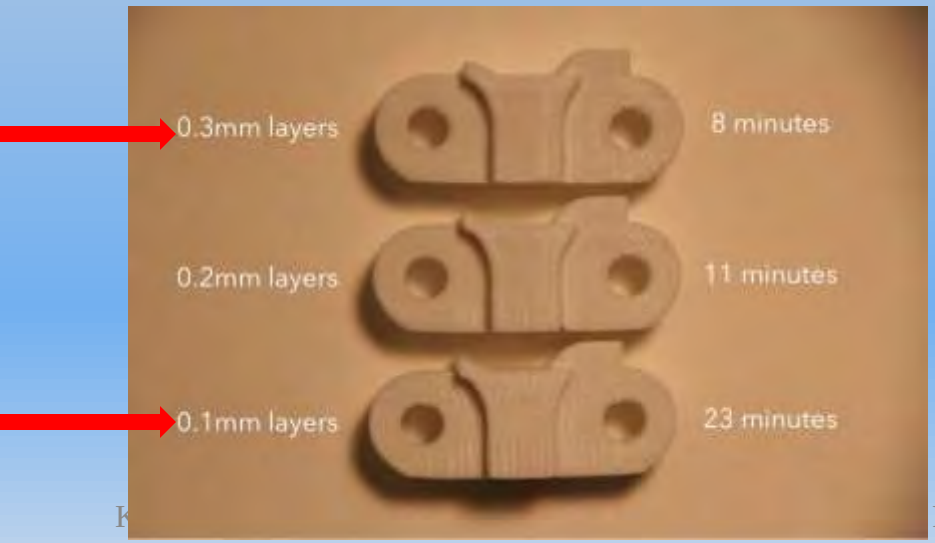
Viewport: translate = [9.19 9.21 6.38], rotate = [55.00 0.00 25.00], distance = 74.40

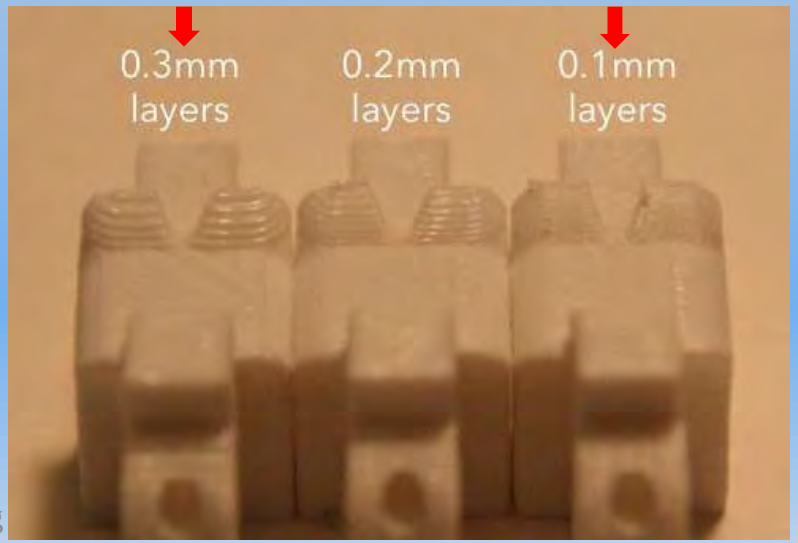
Import the .STL file into CURA



Settings

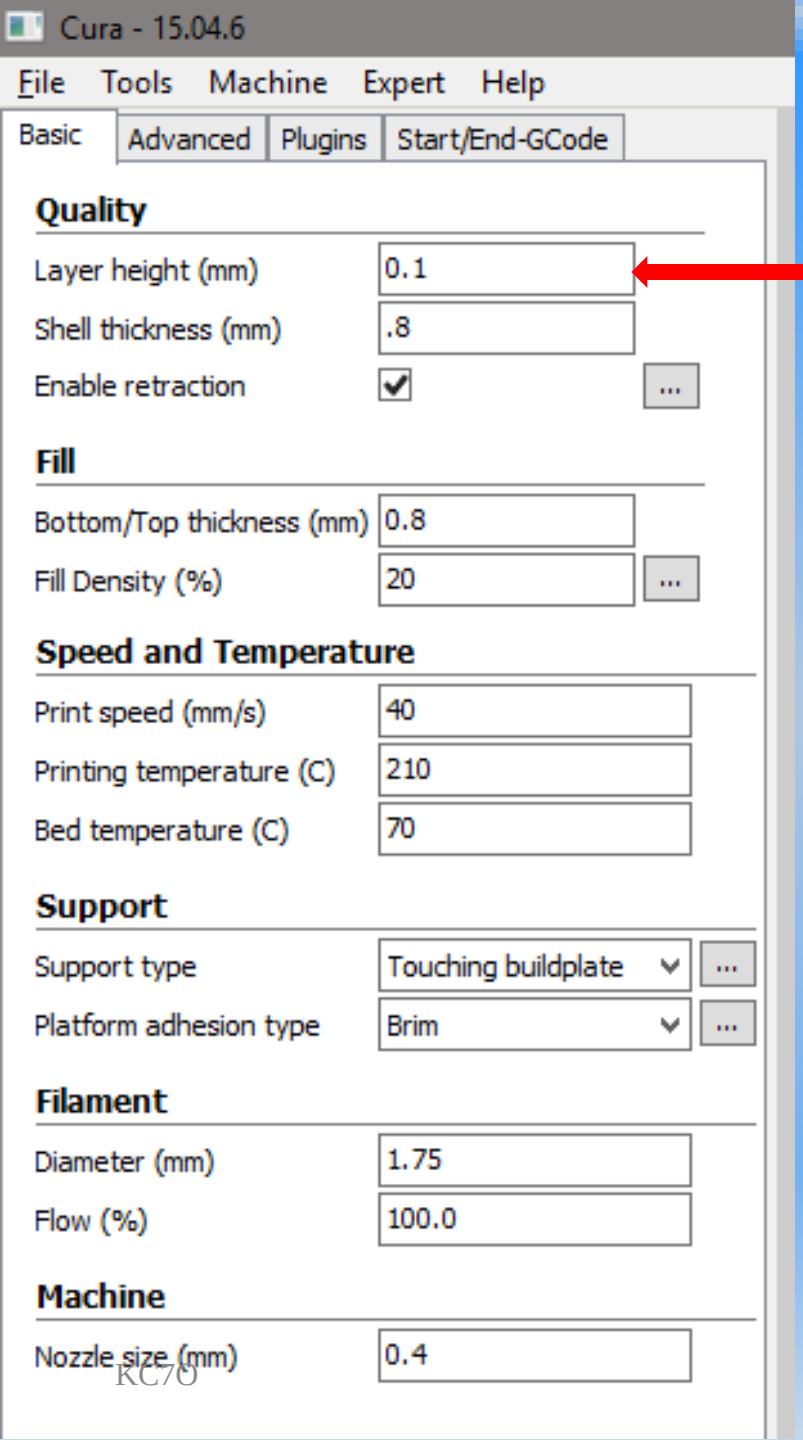
- ***Layer Height***
  - ***How thick the slices are***
    - ***0.1 mm = "high" resolution***
    - ***0.3 mm = "low" resolution***
    - ***Thicker the layer the shorter the time***
    - ***The smaller the layer the less stepping***
    - ***Strength relationship layer height vs % infill***





K Printing

http://enablingthefuture.org/2014/11/13/tech-talk-thursday-intro-to-3d-printing/



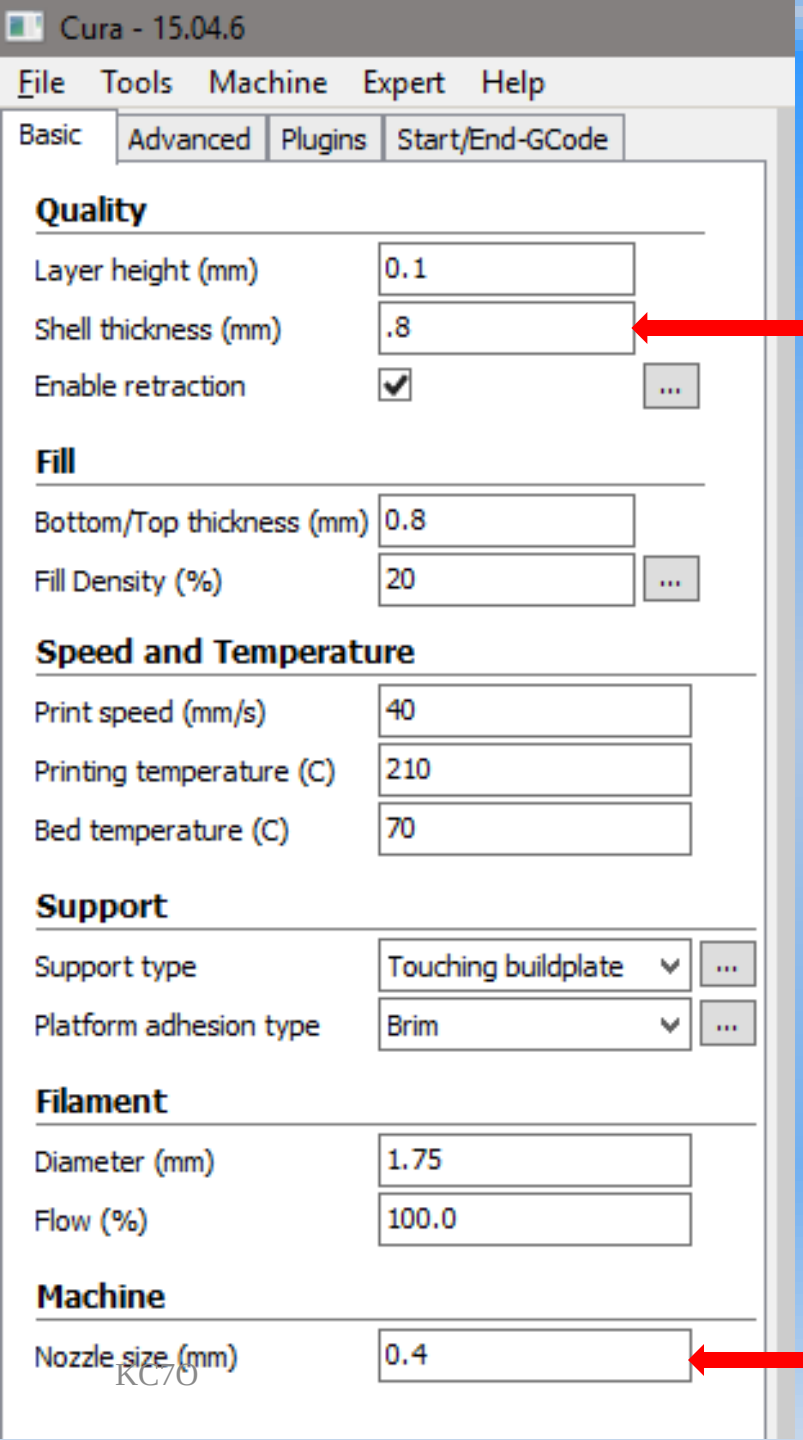
Fine resolution

Half the layer height double the print time

Settings

- ***Number of Shells***
  - ***Solid surface thickness***
    - ***Times the diameter of the nozzle***
    - ***Strength***

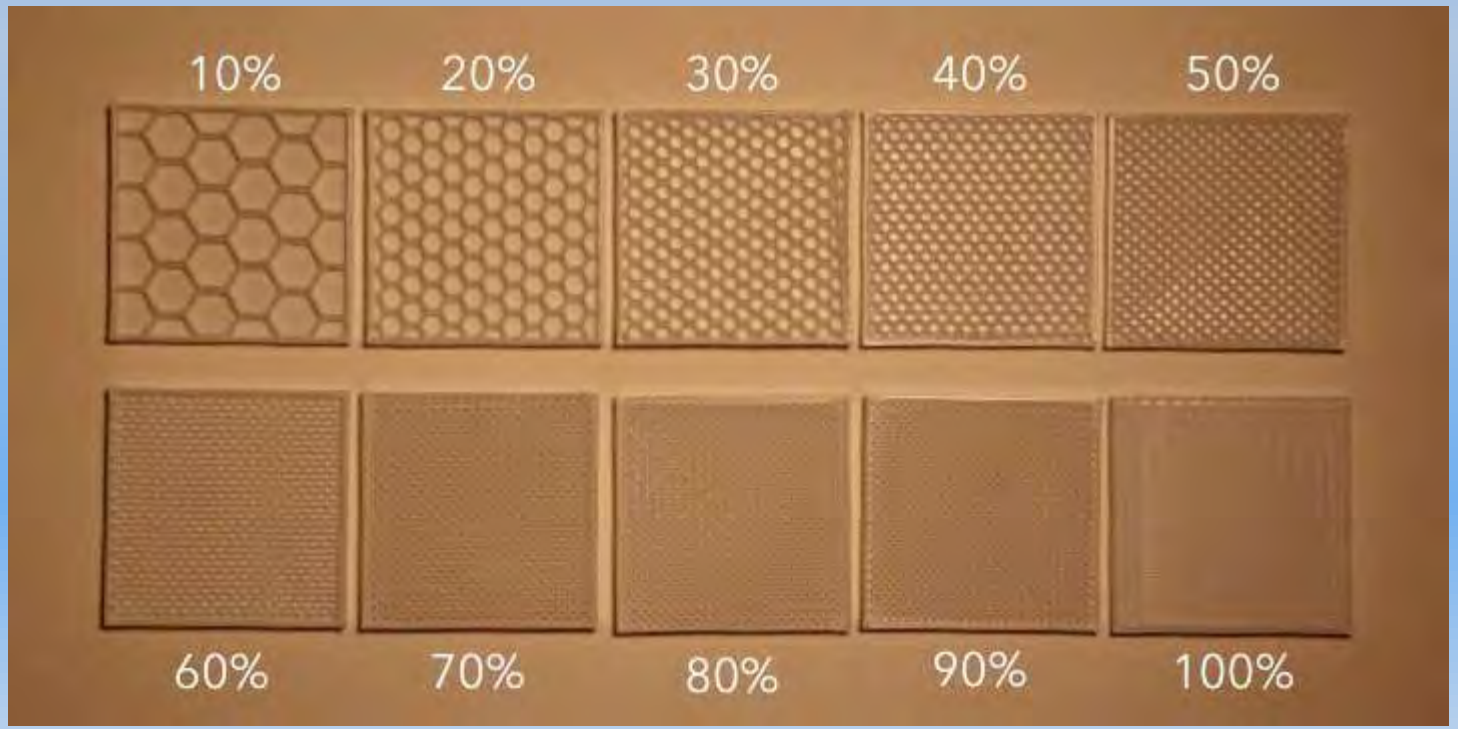
http://enablingthefuture.org/2014/11/13/tech-talk-thursday-intro-to-3d-printing/


Cura - 15.04.6
File Tools Machine Expert Help
Basic Advanced Plugins Start/End-GCode
Quality
Layer height (mm) 0.1
Shell thickness (mm) .8
Enable retraction
Fill
Bottom/Top thickness (mm) 0.8
Fill Density (%) 20
Speed and Temperature
Print speed (mm/s) 40
Printing temperature (C) 210
Bed temperature (C) 70
Support
Support type Touching buildplate
Platform adhesion type Brim
Filament
Diameter (mm) 1.75
Flow (%) 100.0
Machine
Nozzle size (mm) 0.4

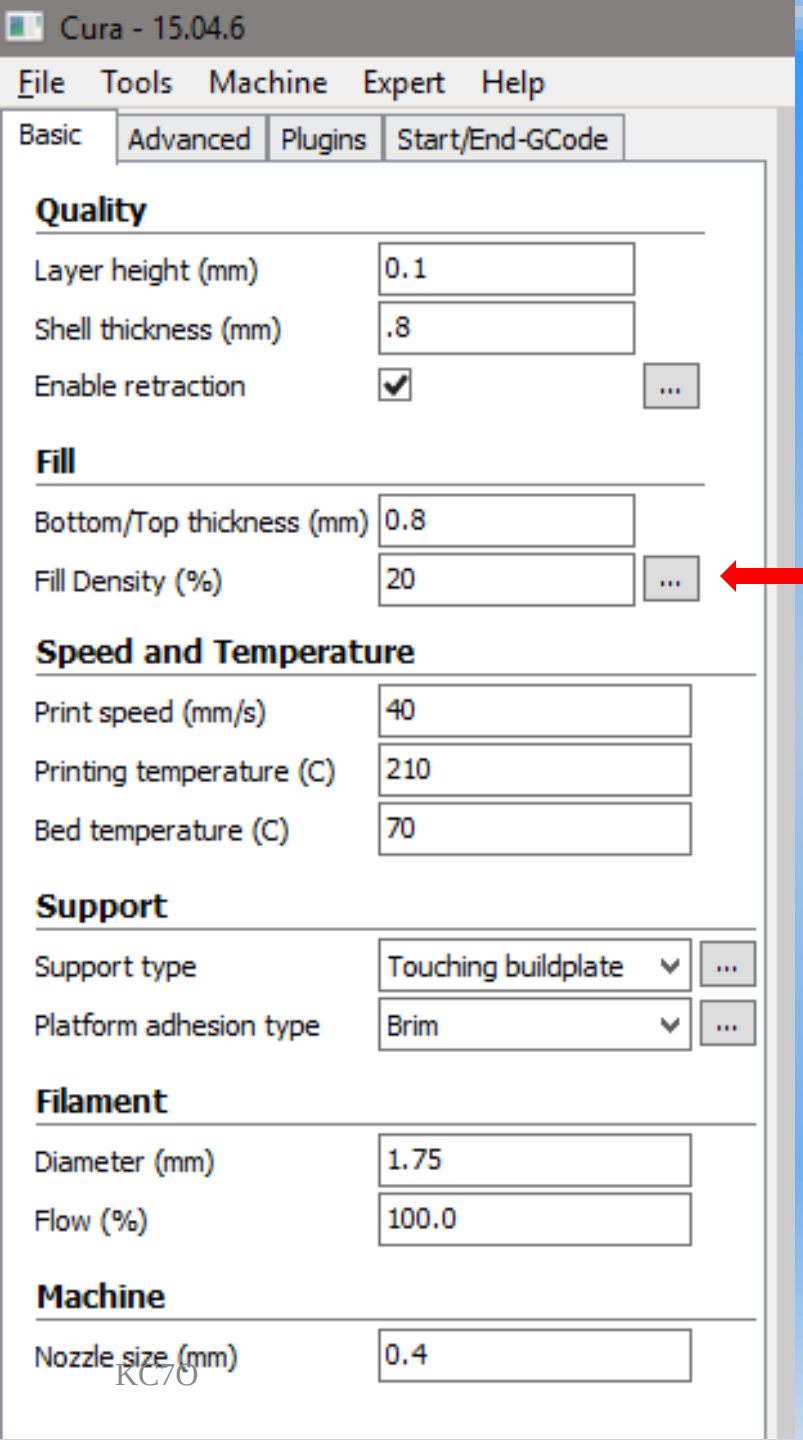
Two Shells

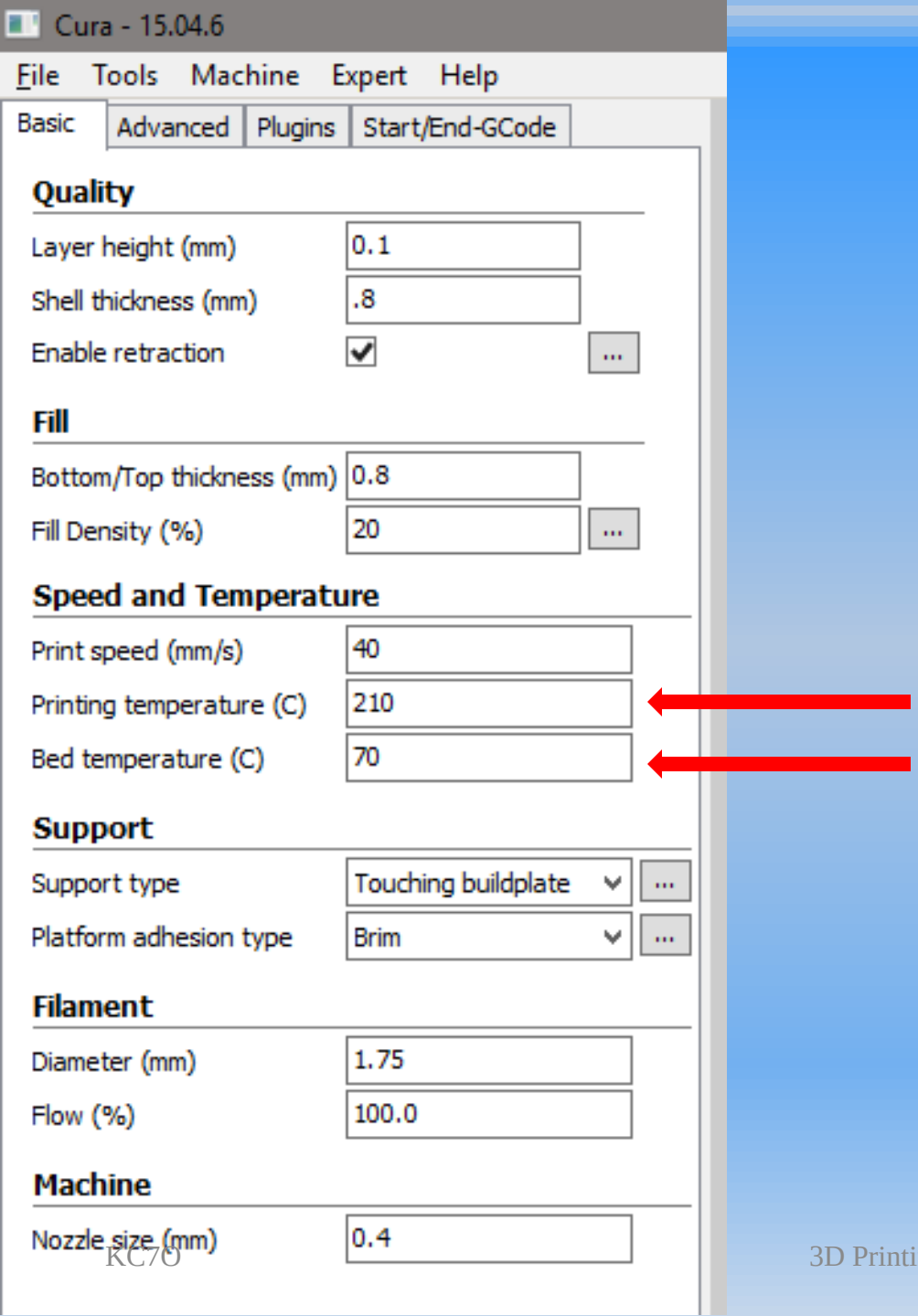
CURA Settings

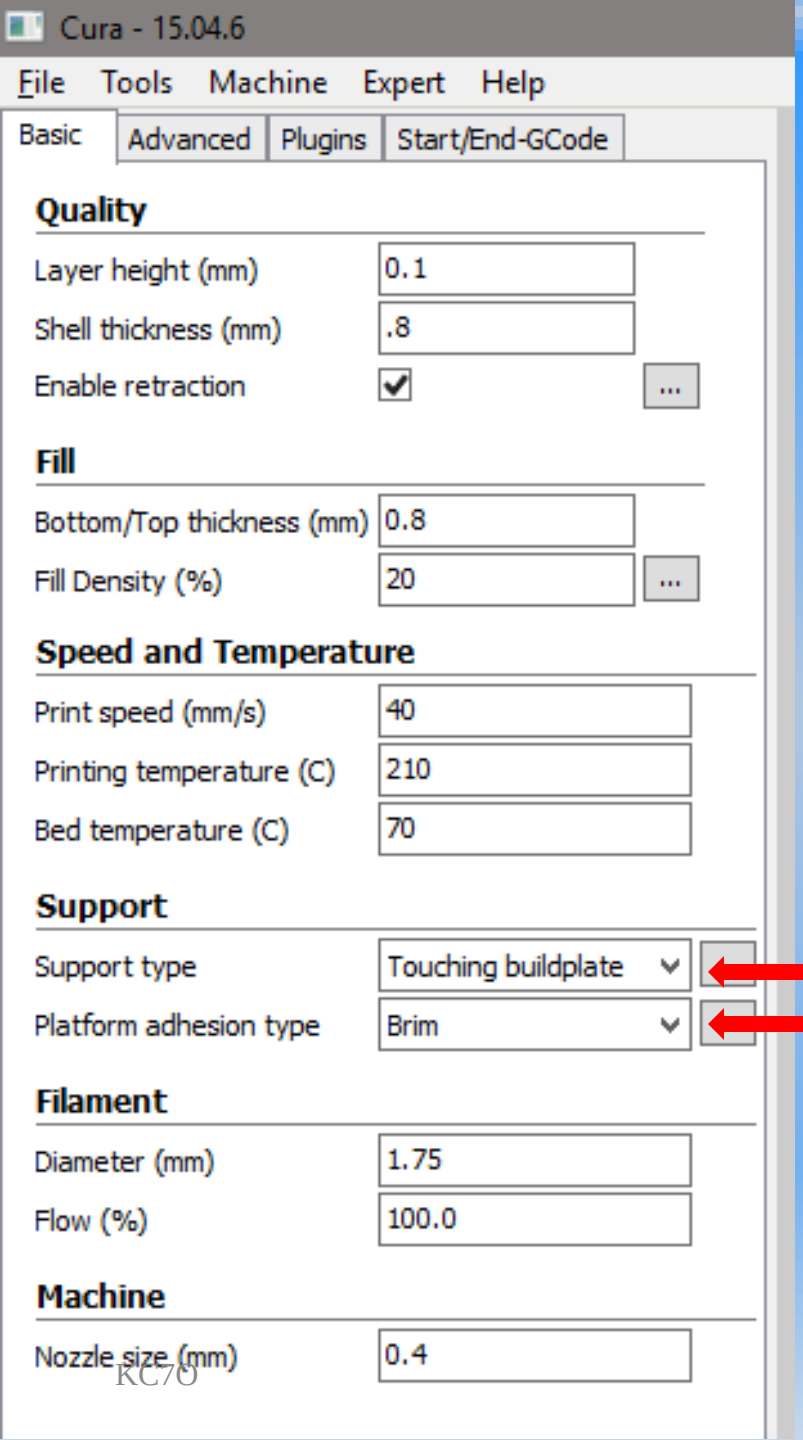
- ***Infill Percentage***
  - ***Interior not completely solid***
    - ***Saves time***
    - ***Saves material***
    - ***Sacrifices strength***



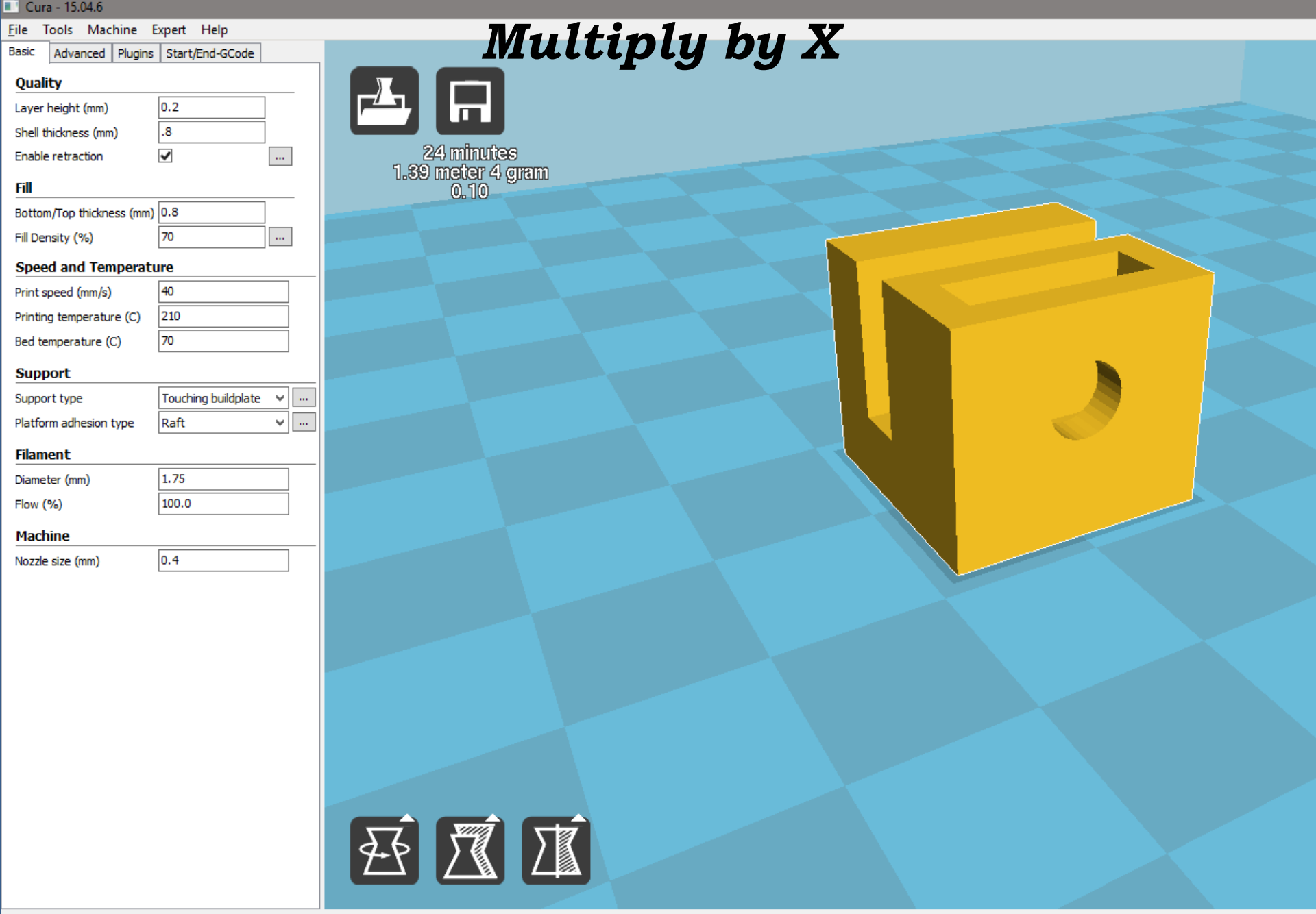
http://enablingthefuture.org/2014/11/13/tech-talk-thursday-intro-to-3d-printing/

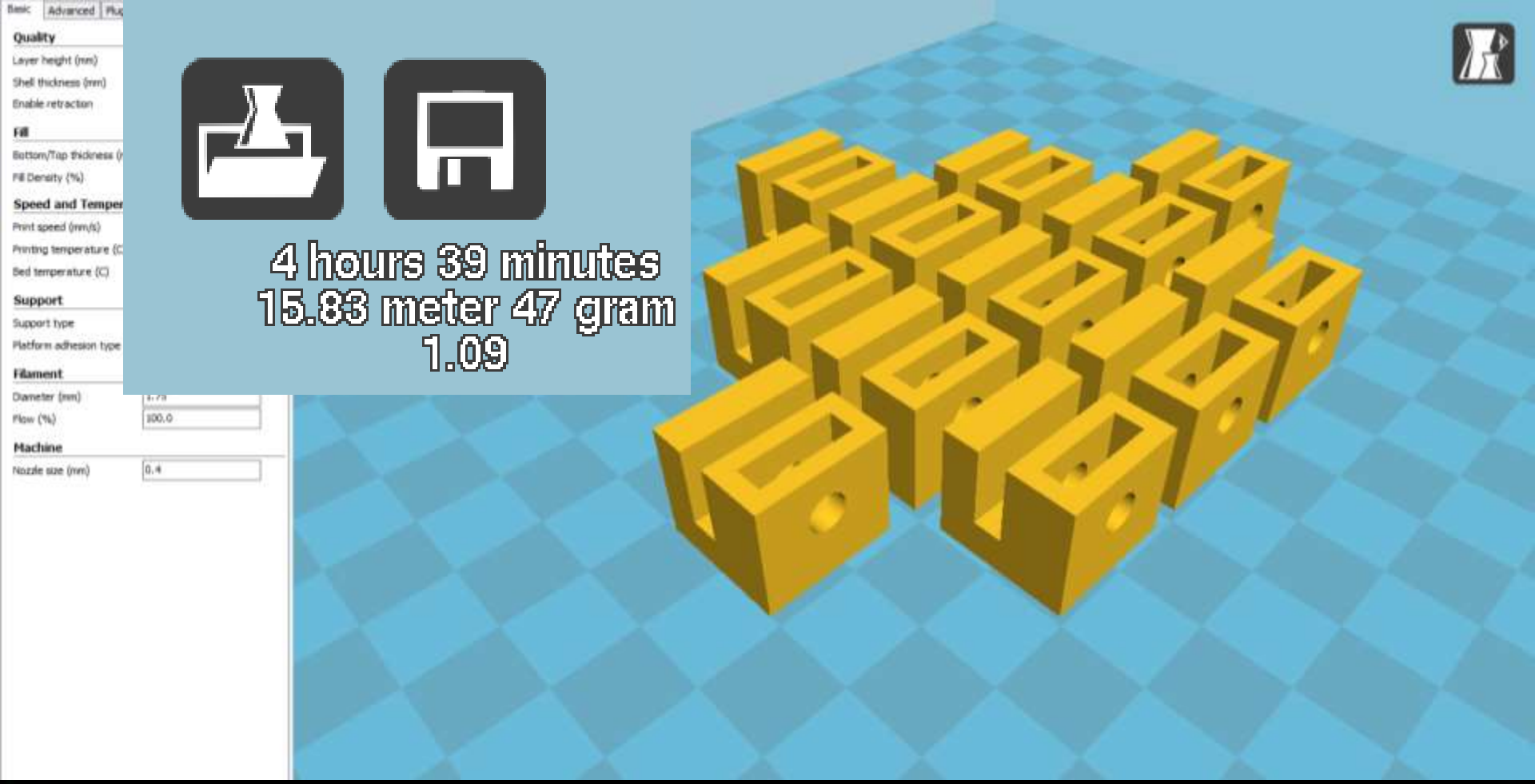

Cura - 15.04.6
File Tools Machine Expert Help
Basic Advanced Plugins Start/End-GCode
Quality
Layer height (mm) 0.1
Shell thickness (mm) .8
Enable retraction ...
Fill
Bottom/Top thickness (mm) 0.8
Fill Density (%) 20 ...
Speed and Temperature
Print speed (mm/s) 40
Printing temperature (C) 210
Bed temperature (C) 70
Support
Support type Touching buildplate ...
Platform adhesion type Brim ...
Filament
Diameter (mm) 1.75
Flow (%) 100.0
Machine
Nozzle size (mm) 0.4


Cura - 15.04.6
File Tools Machine Expert Help
Basic Advanced Plugins Start/End-GCode
Quality
Layer height (mm) 0.1
Shell thickness (mm) .8
Enable retraction ...
Fill
Bottom/Top thickness (mm) 0.8
Fill Density (%) 20 ...
Speed and Temperature
Print speed (mm/s) 40
Printing temperature (C) 210
Bed temperature (C) 70
Support
Support type Touching buildplate ...
Platform adhesion type Brim ...
Filament
Diameter (mm) 1.75
Flow (%) 100.0
Machine
Nozzle size (mm) 0.4



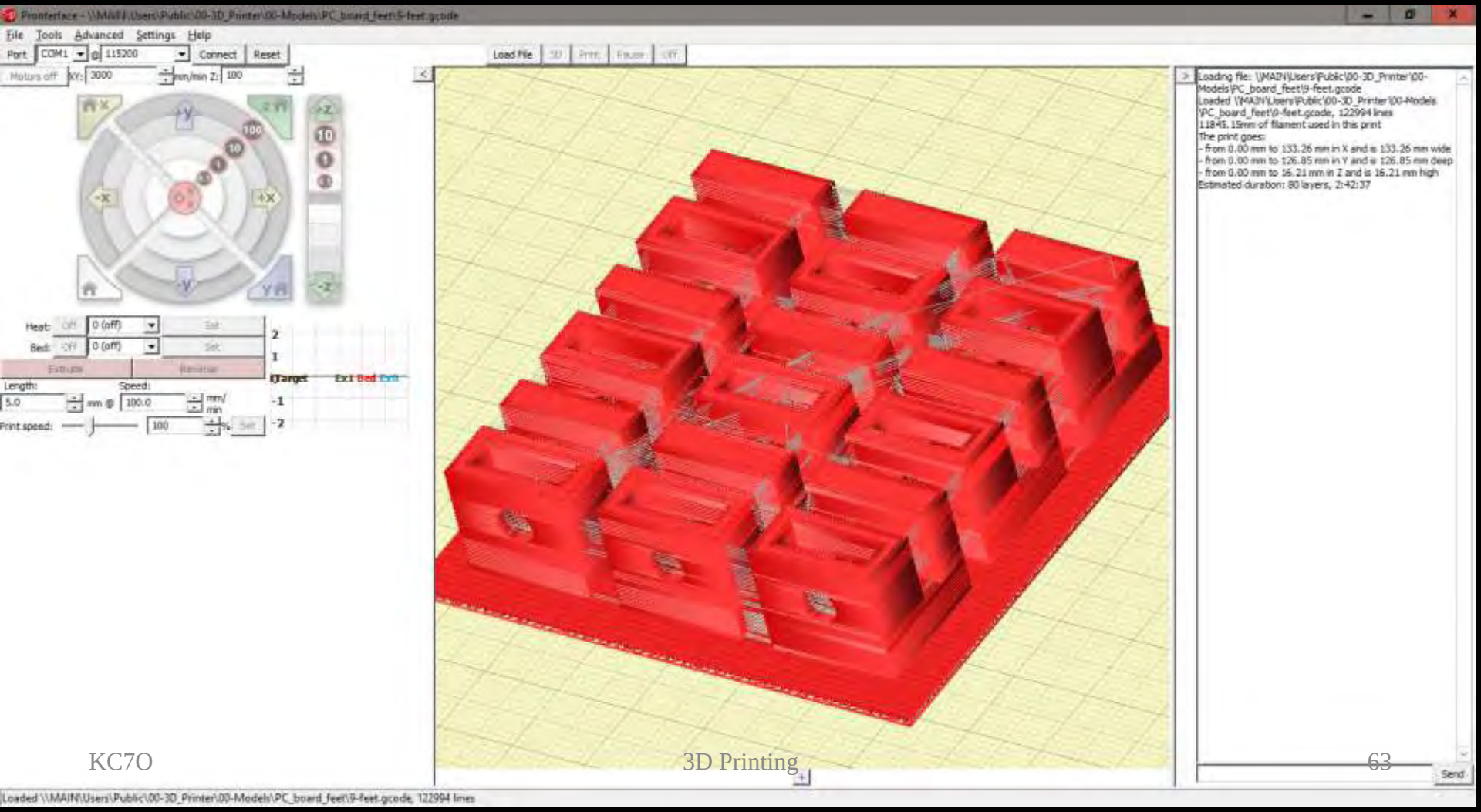
None
Brim
Raft

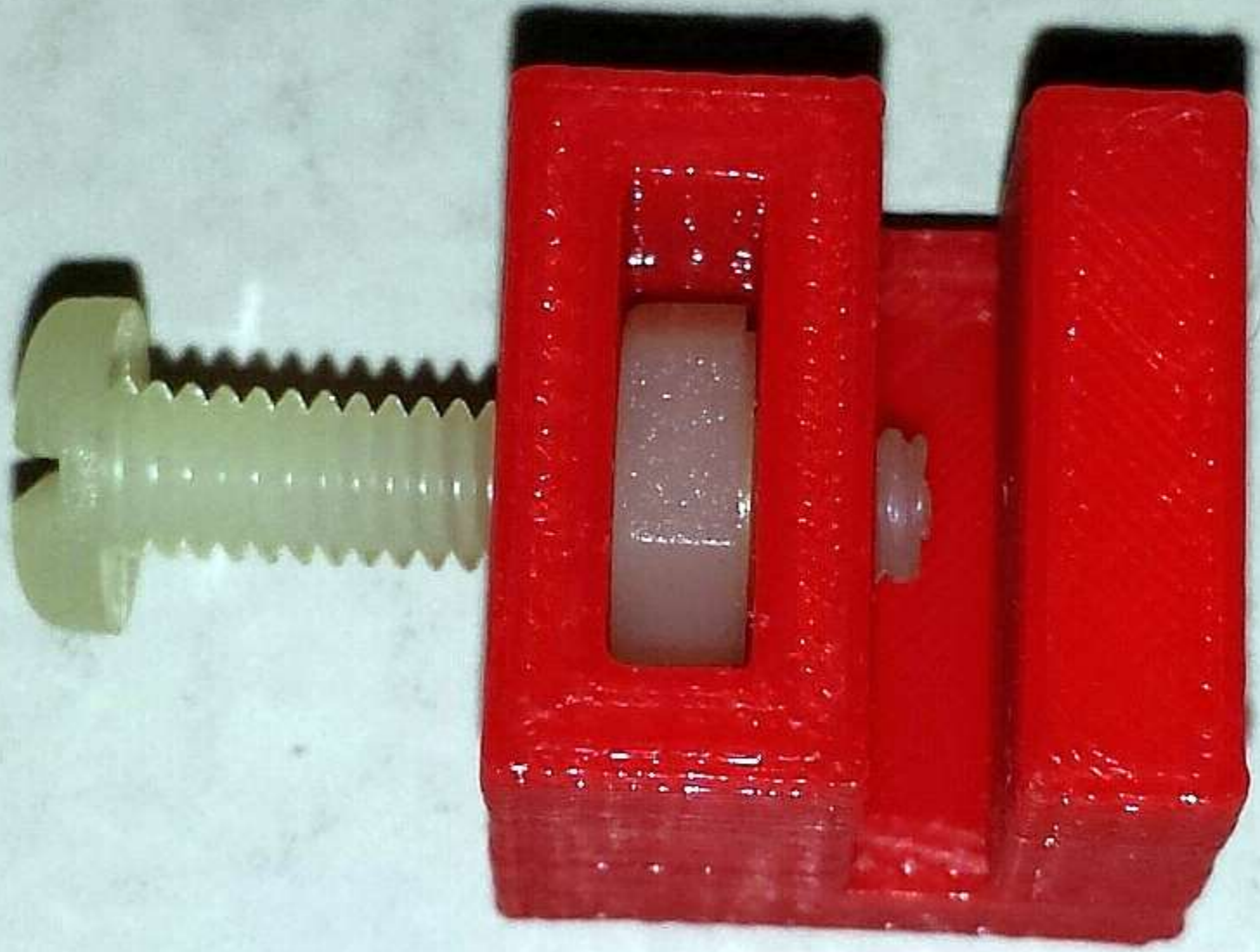

Cura - 15.04.6
File Tools Machine Expert Help
Multiply by X
Basic Advanced Plugins Start/End-GCode
Quality
Layer height (mm) 0.2
Shell thickness (mm) .8
Enable retraction
Fill
Bottom/Top thickness (mm) 0.8
Fill Density (%) 70
Speed and Temperature
Print speed (mm/s) 40
Printing temperature (C) 210
Bed temperature (C) 70
Support
Support type Touching buildplate
Platform adhesion type Raft
Filament
Diameter (mm) 1.75
Flow (%) 100.0
Machine
Nozzle size (mm) 0.4
24 minutes
1.39 meter 4 gram
0.10



Save as a .gcode

Load .gcode into Pronterface and connect to printer Can also use a memory card

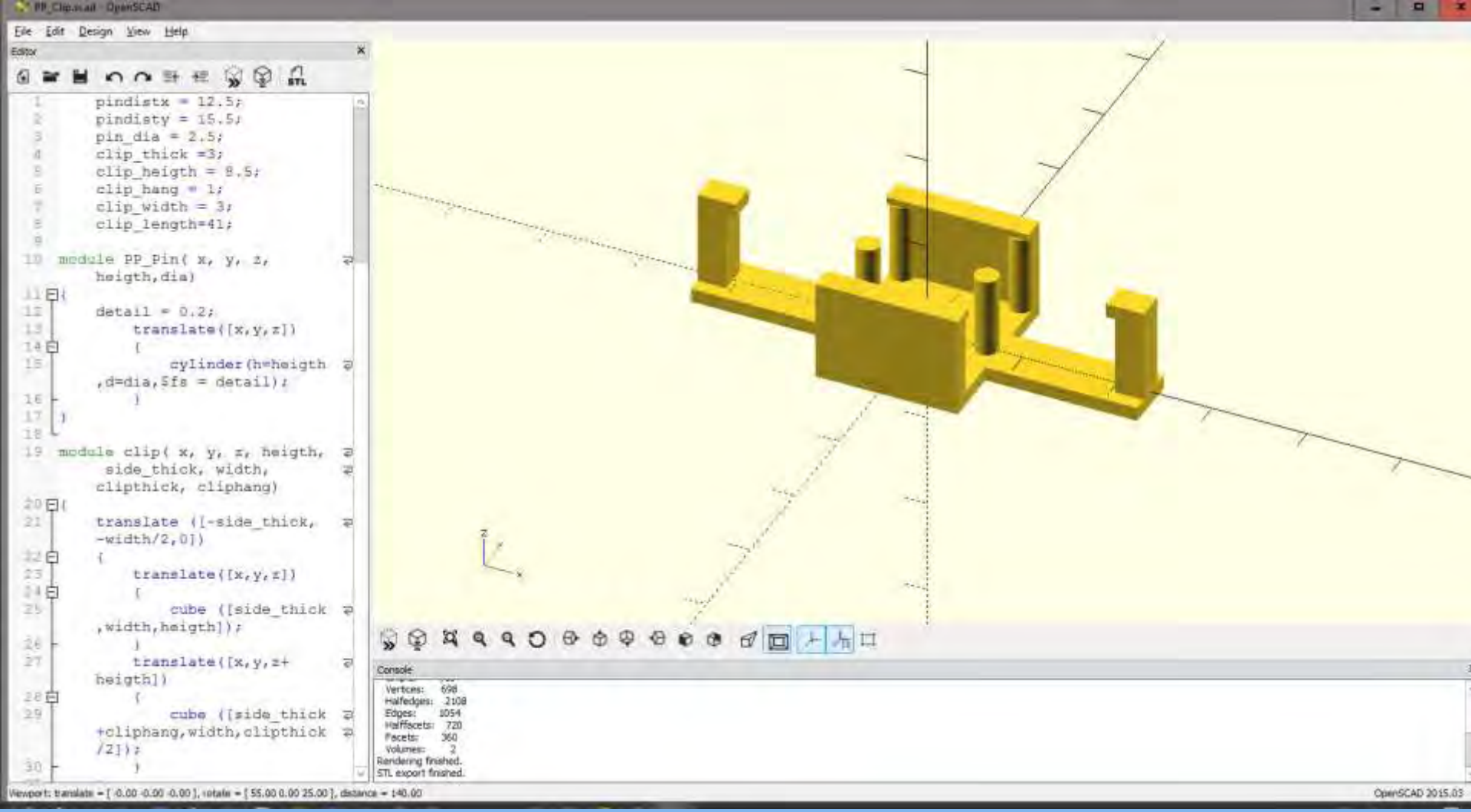




#8 nylon nut and screw

Can put power to the circuit because it's insulated from the feet

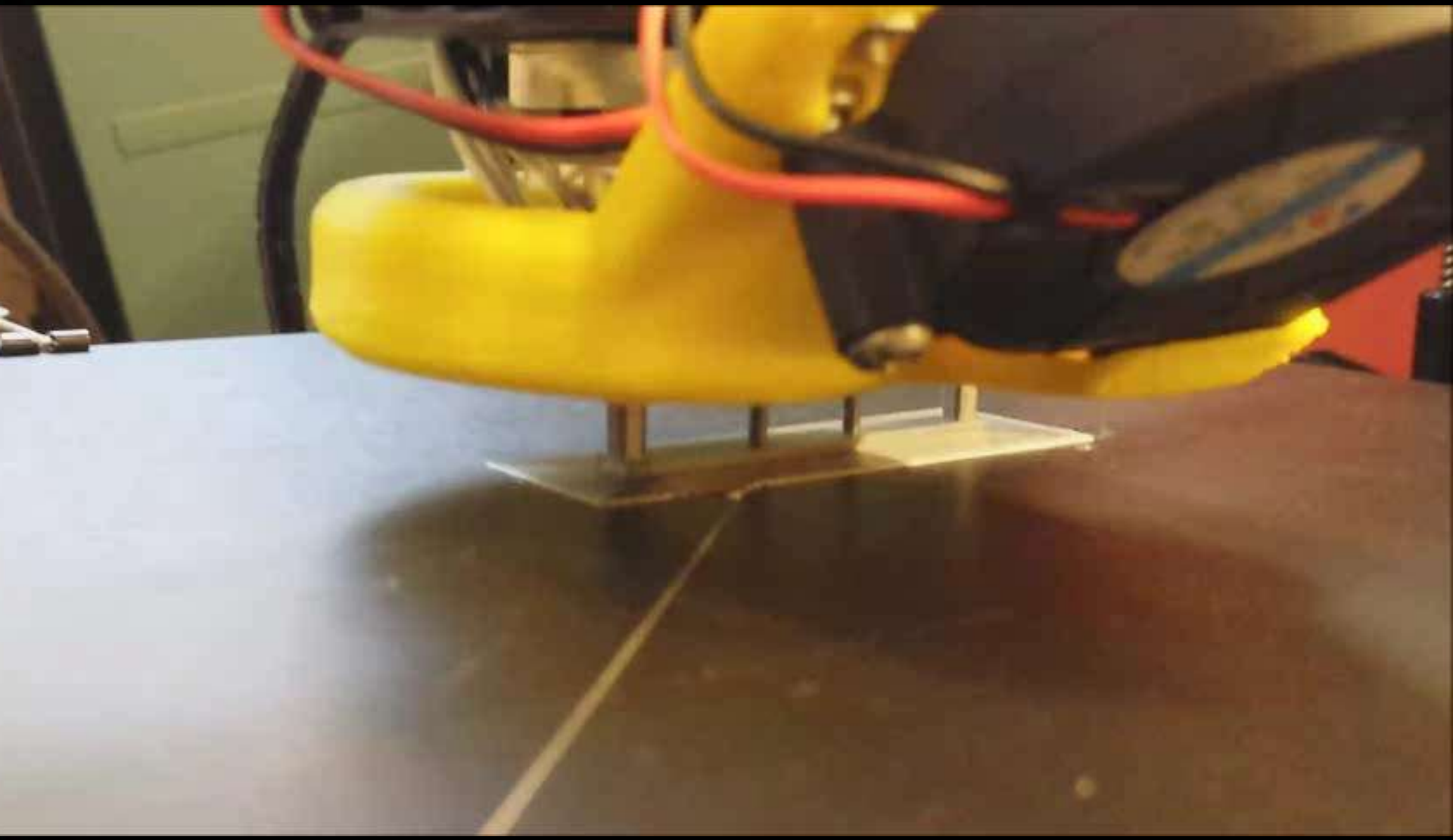
Other Ham Projects

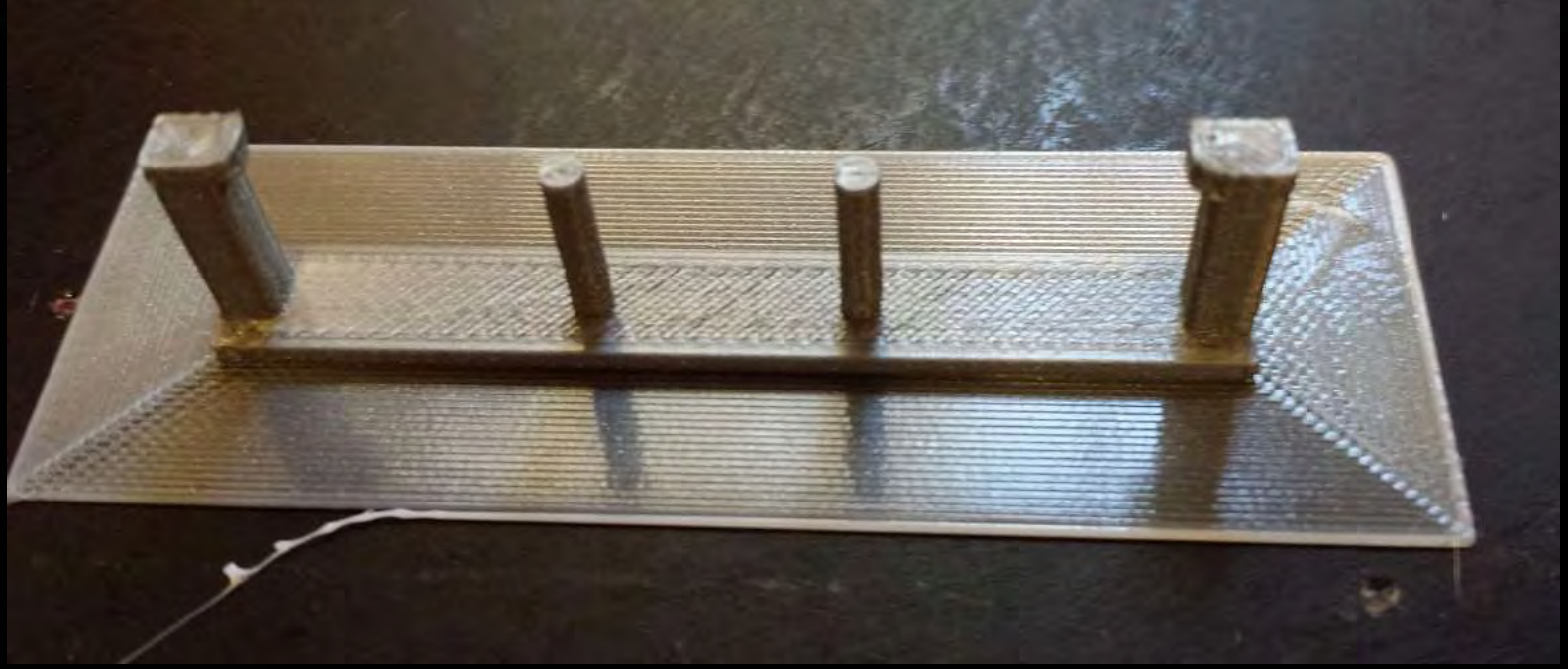


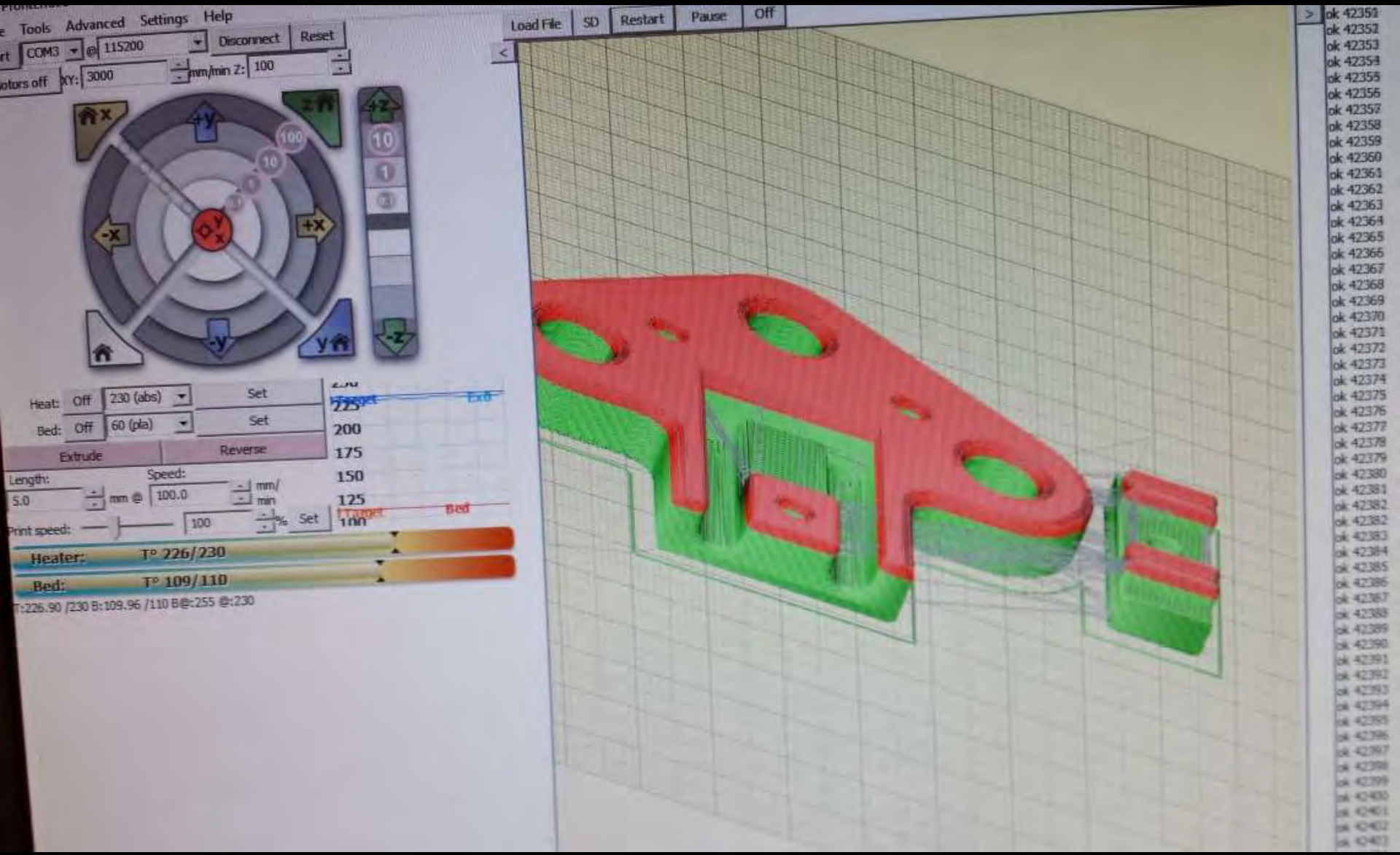
PowerPole Clip by metrux

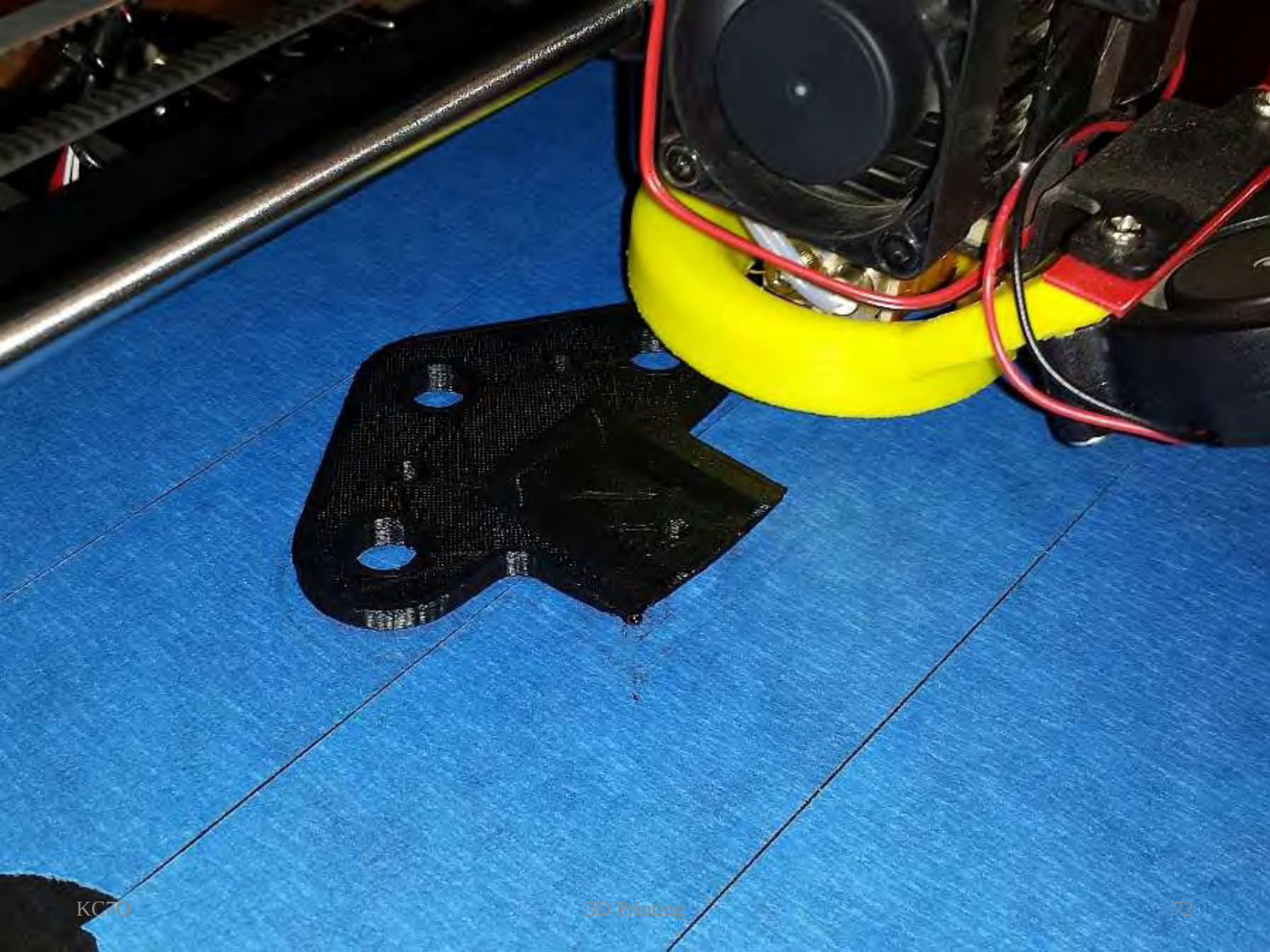
KC7O

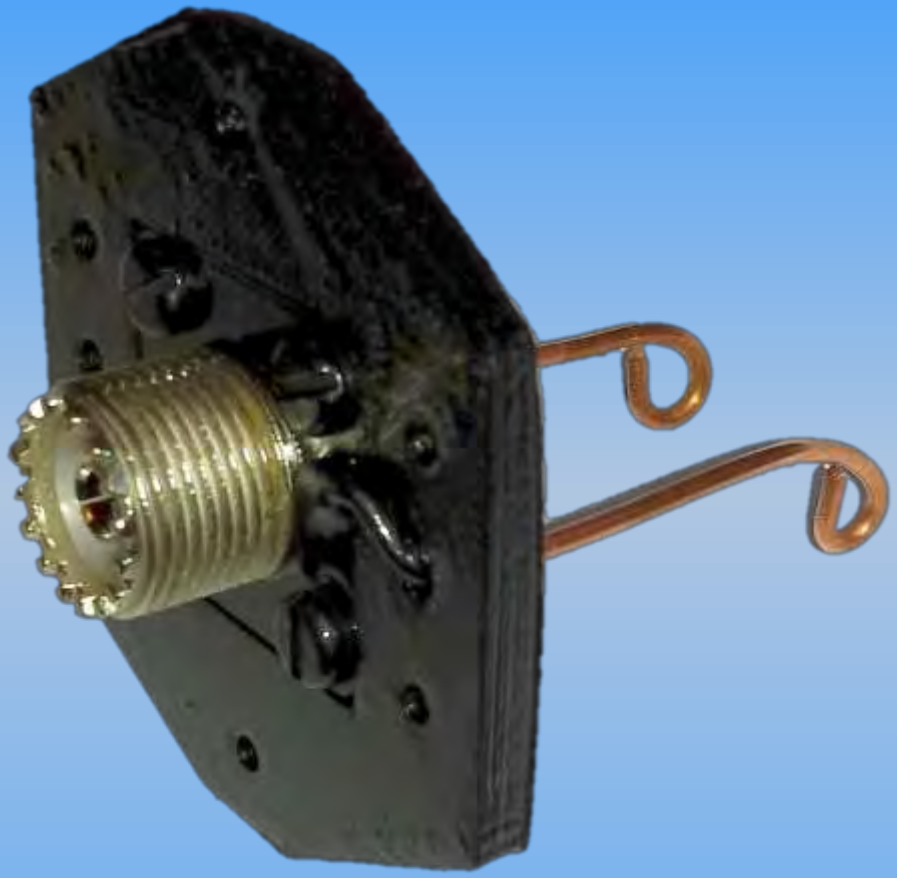
Published on November 22, 2012

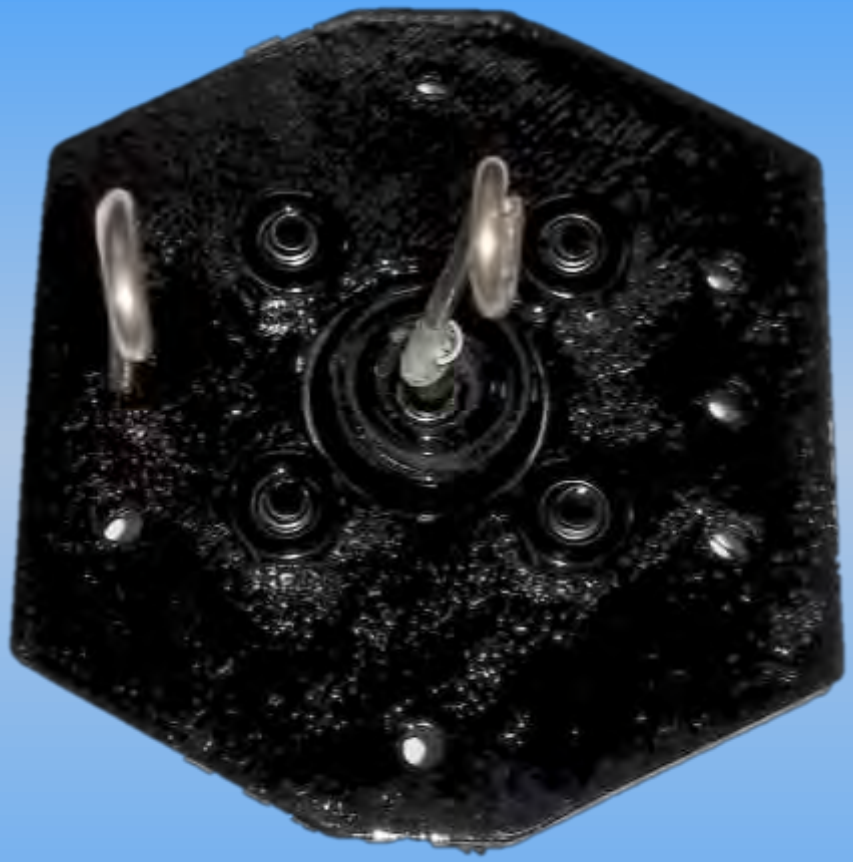





Tools Advanced Settings Help
COM3 @ 115200 Disconnect Reset
Motors off XY: 3000 mm/min Z: 100
Heat: Off 230 (abs) Set
Bed: Off 60 (pla) Set
Extrude Reverse
Length: Speed:
5.0 mm @ 100.0 mm/min
Print speed: 100 % Set
Heater: T° 226/230
Bed: T° 109/110
T:226.90 /230 B:109.96 /110 B@:255 @:230
Load File SD Restart Pause Off
225
200
175
150
125
100
Target
Bed



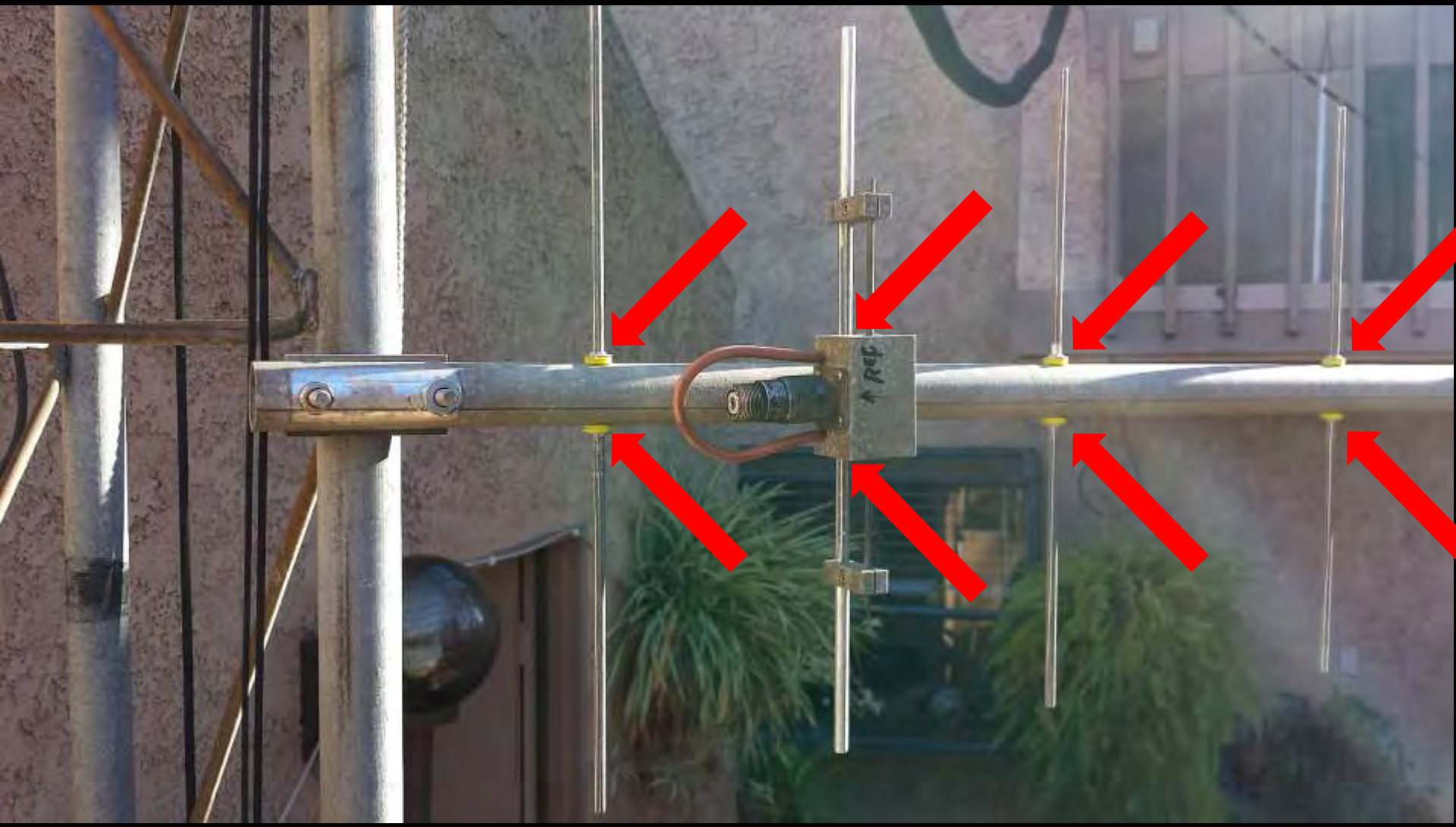




by Sterminato

by Akimitsu

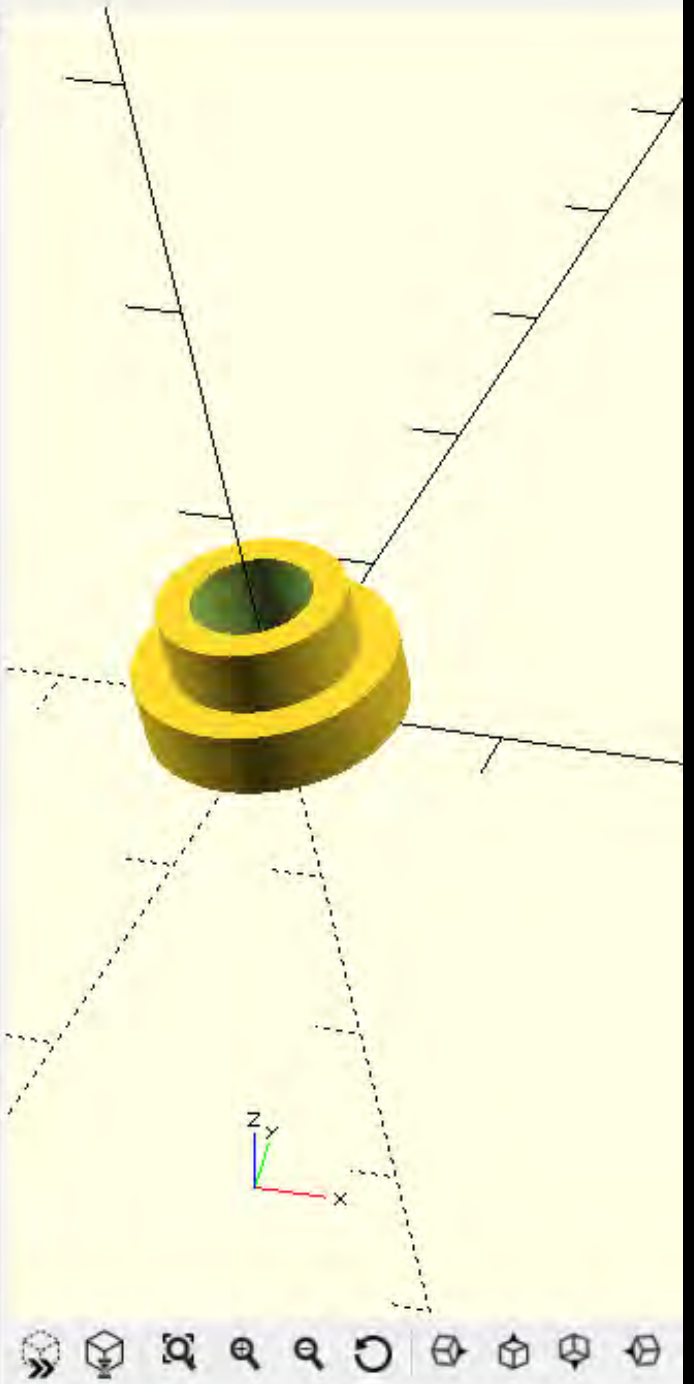
Antenna Element Insulators

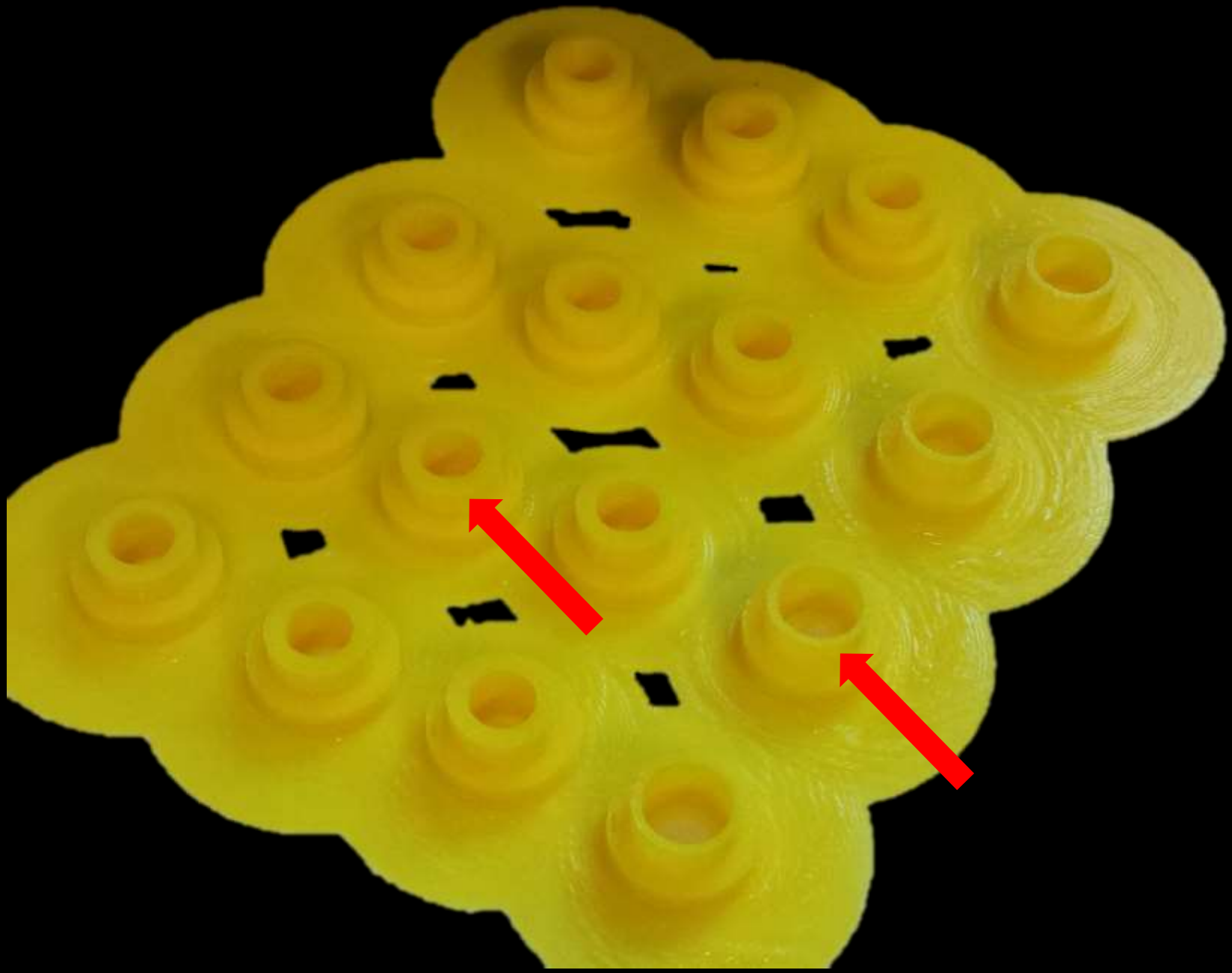


File Edit Design View Help

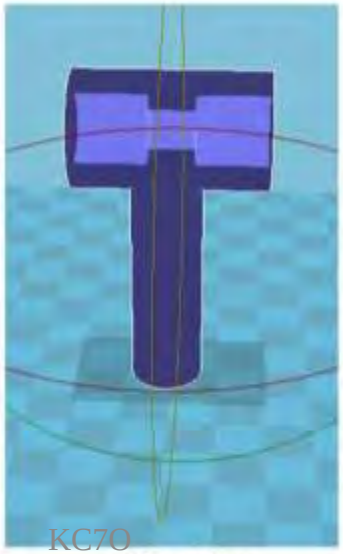
Editor

```
1  //Antenna element grommets
2  //A. Wolff - KC7O
3  //28 January 2017
4  //small element 5mm (0.197")
5  //3/16" = 0.1875
6
7  $fn=60;
8  difference(){
9  union(){
10 cylinder(3,5.5,5.5);
11 cylinder(6,3.9,3.9);
12 }
13 cylinder(10,2.5,2.5);
14 }
```

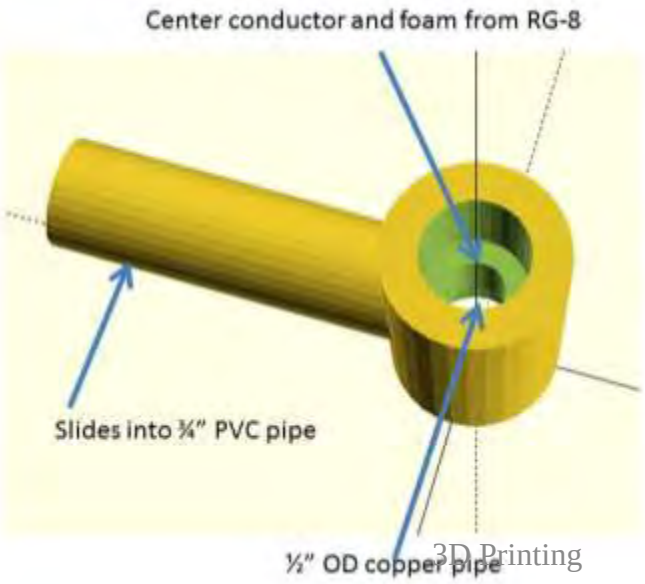


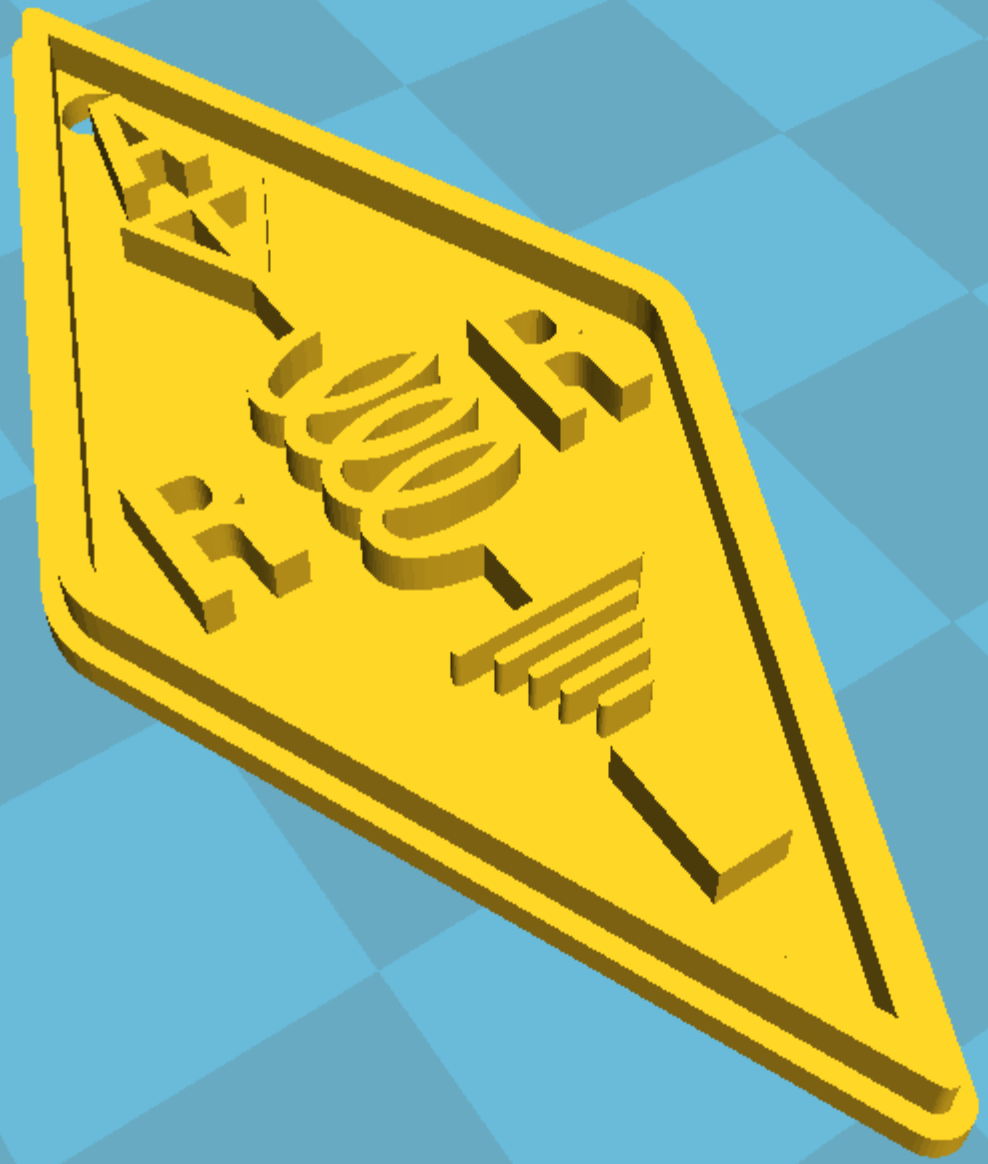


Insulator for a Loop Antenna



X-Ray View





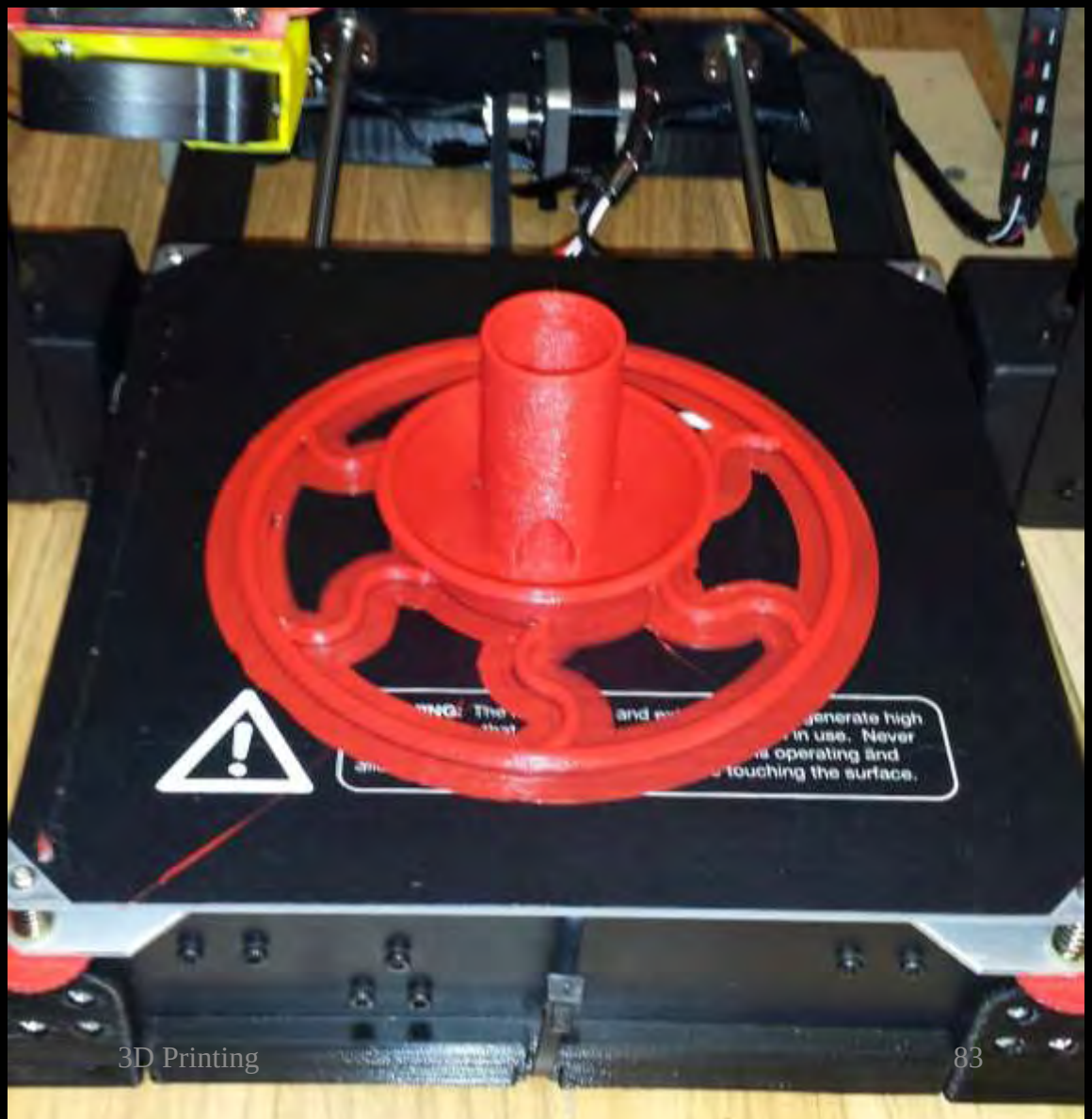
by WX7JM

SDR IQ
MFJ Voice Keyer
KC7O
YAESU
FT-950
Magnet

Other Projects

Bottle Bird Feeder from Thingiverse.com

by Gazorpa



Toys for grandson
from Thingiverse.com

Thingiverse
LeFabShop

Hummingbird Feeder Ant Moat

Commercial 3” x 1 ¾” too small

Designed 4 ½” x 2 ½” & Printed

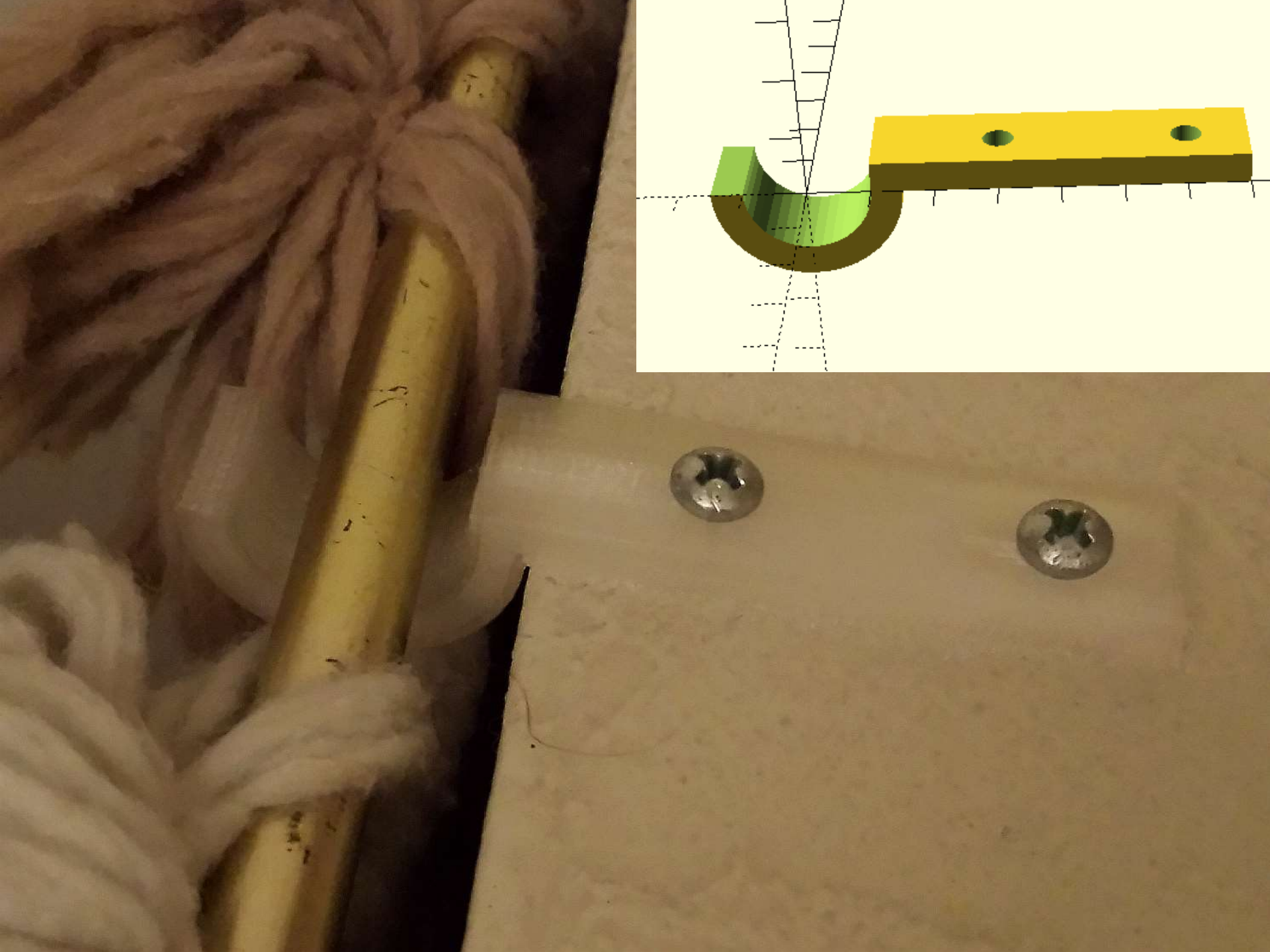
Problem
Solution

From Thingiverse – a Bottle Opener

by Nelujones

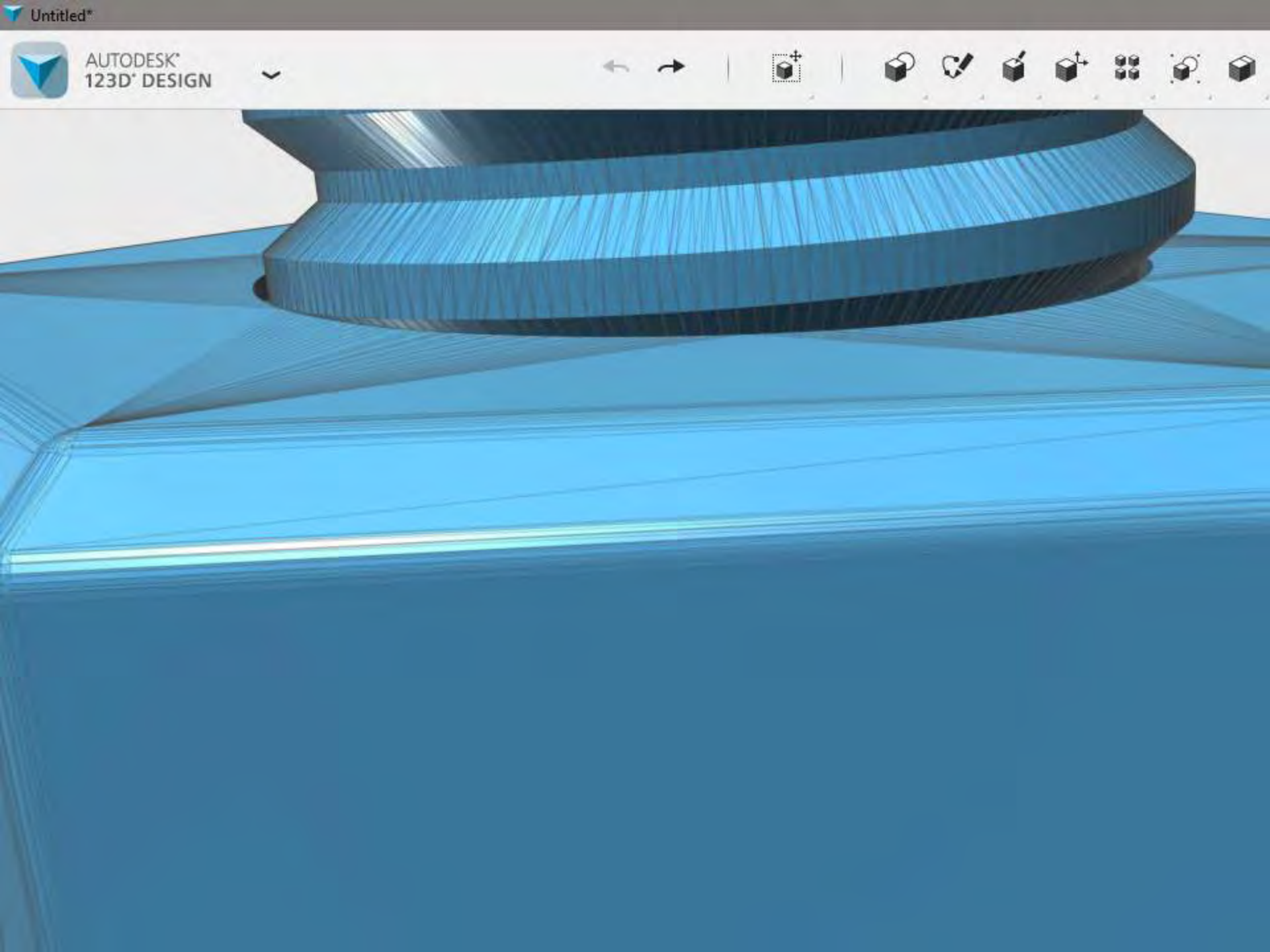
Plug for Umbrella Hole in a Glass Table

Curtain rod hanger for a wall hanging



Impossible 3D Bolt

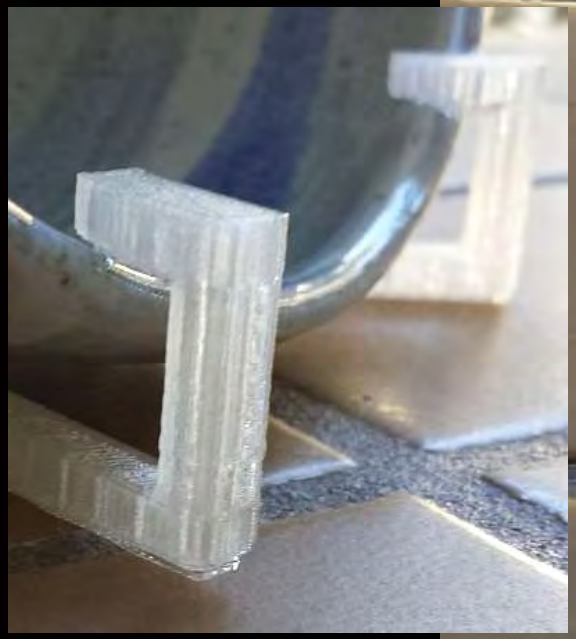
by CreativeTool


Untitled*
AUTODESK®
123D® DESIGN

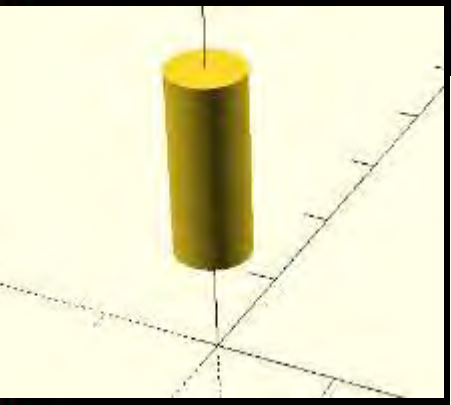
Fidget From Thingiverse

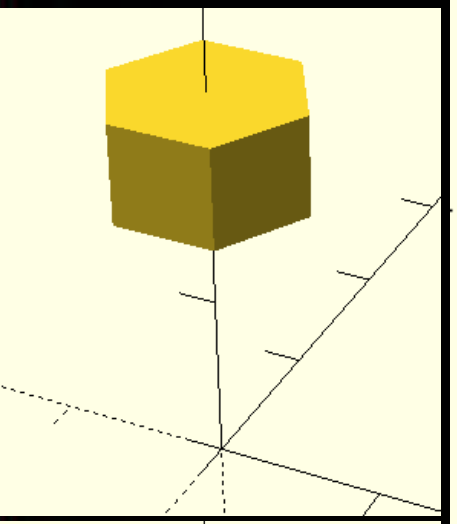
by timrbsnow

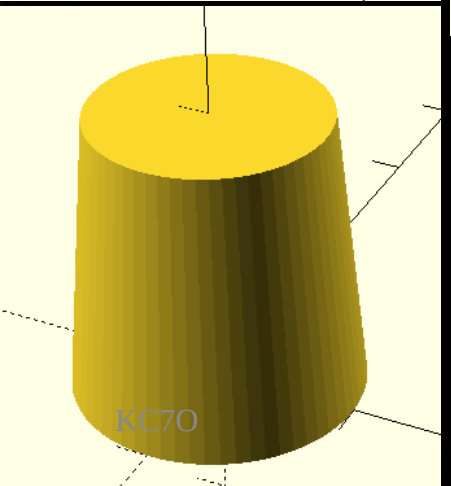
7 hour print

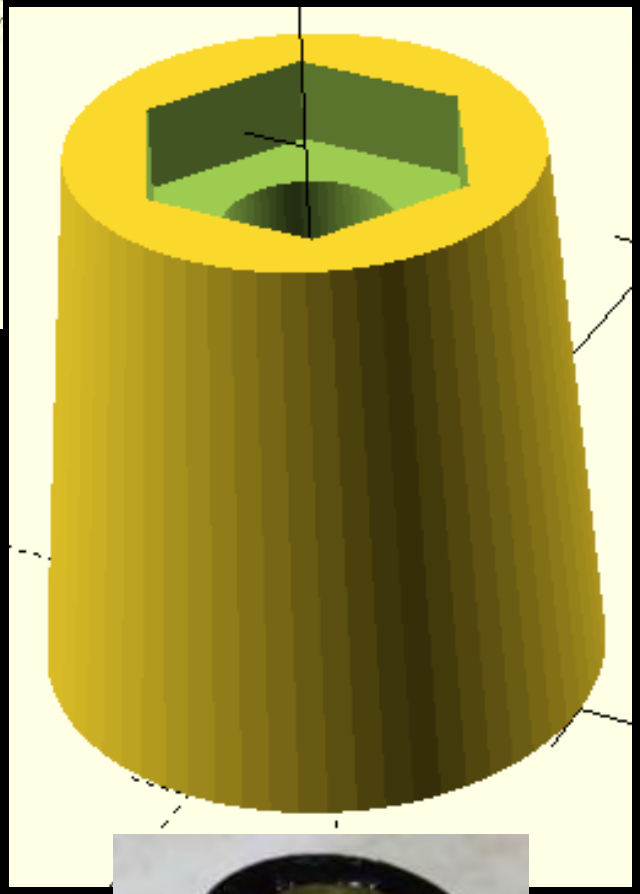


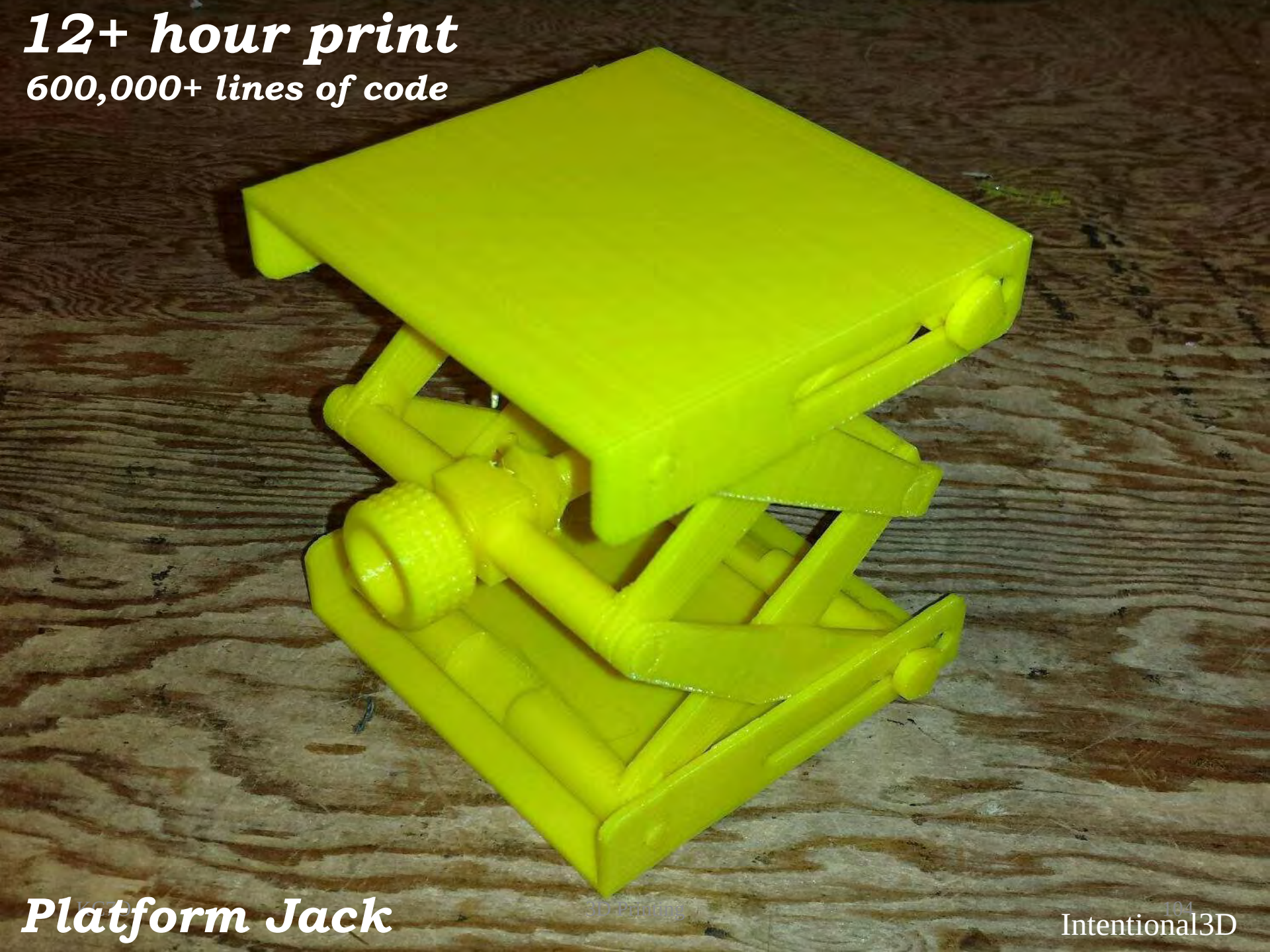
Knob for a #10 Thread



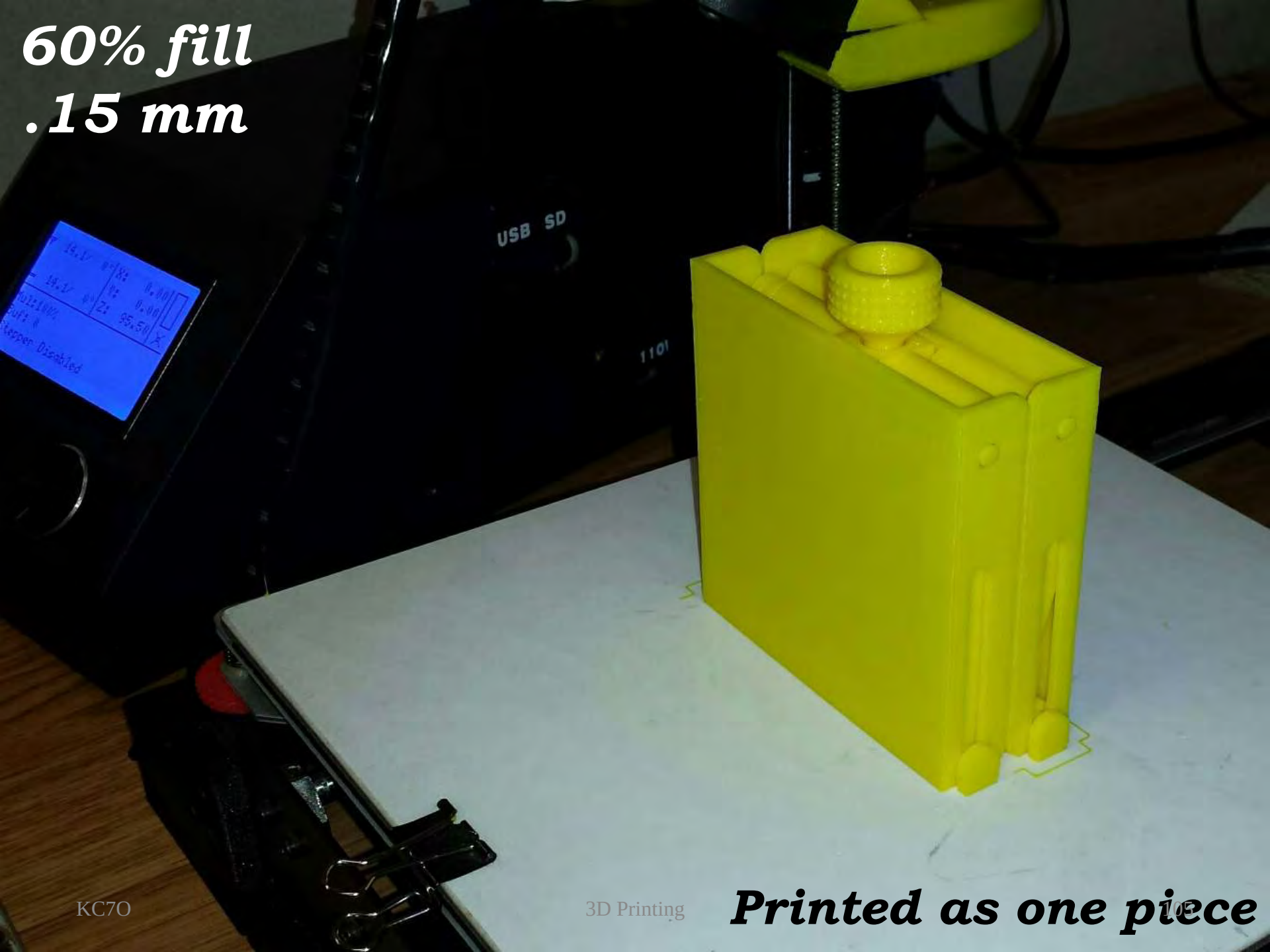








Intentional3D


60% fill
.15 mm
USB SD
Printed as one piece

First print failure
15% fill
.3 mm

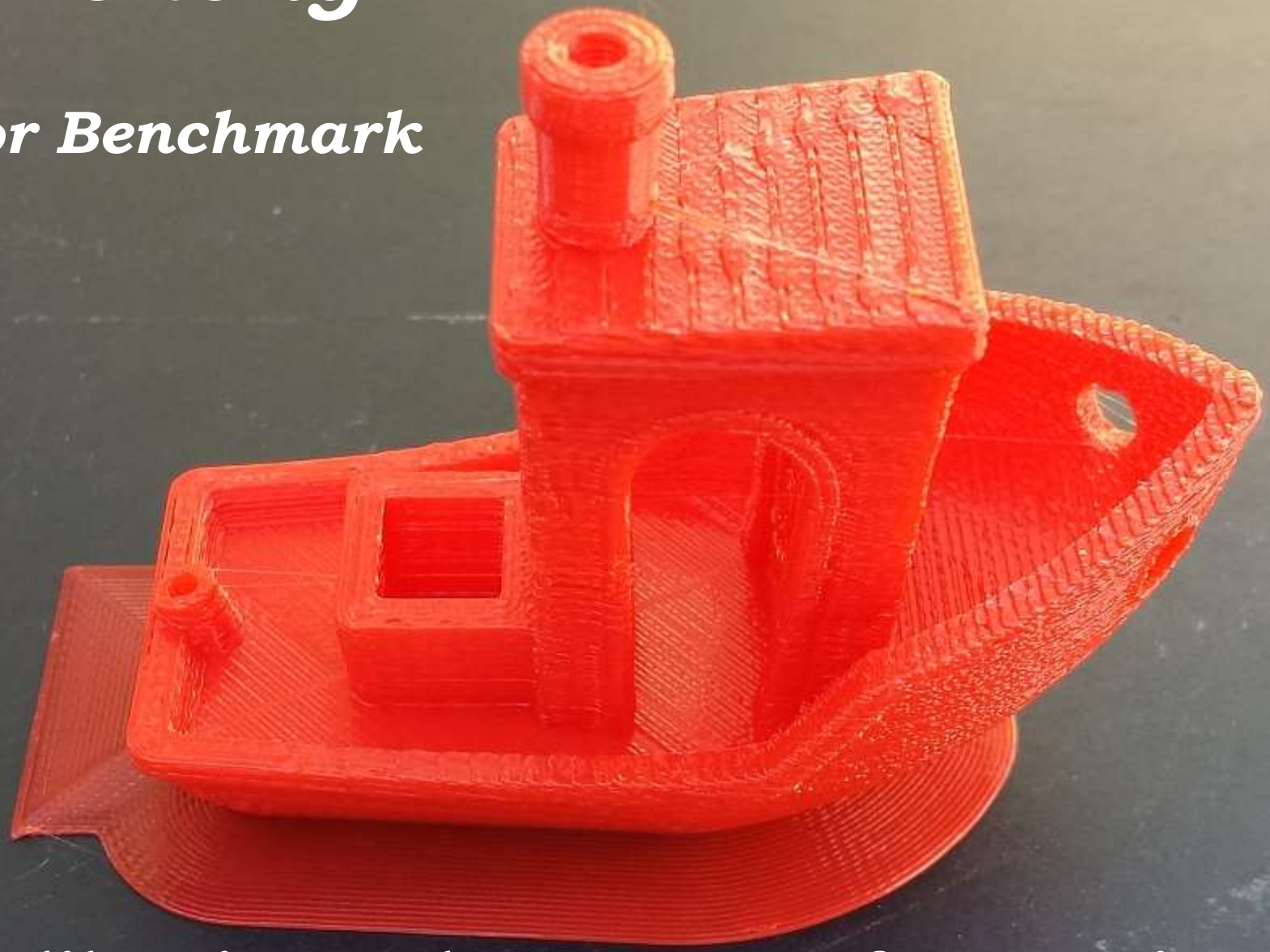
Triclosan 0.30%
Uses aids in the prevention of: • cavities • plaque
Warnings Keep out of the reach of children under 6 years of age.
brushing is accidentally swallowed, get medical help or contact a Poison
right away. Ask a dentist before use if you have • bleeding or redness
weeks • pain, swelling, pus, loose teeth, or more spacing between teeth
These may be signs of periodontitis, a serious form of gum disease.
Questions or comments?
Call toll-free 1-800-468-6502
www.colgatetotal.com

tomaspdc

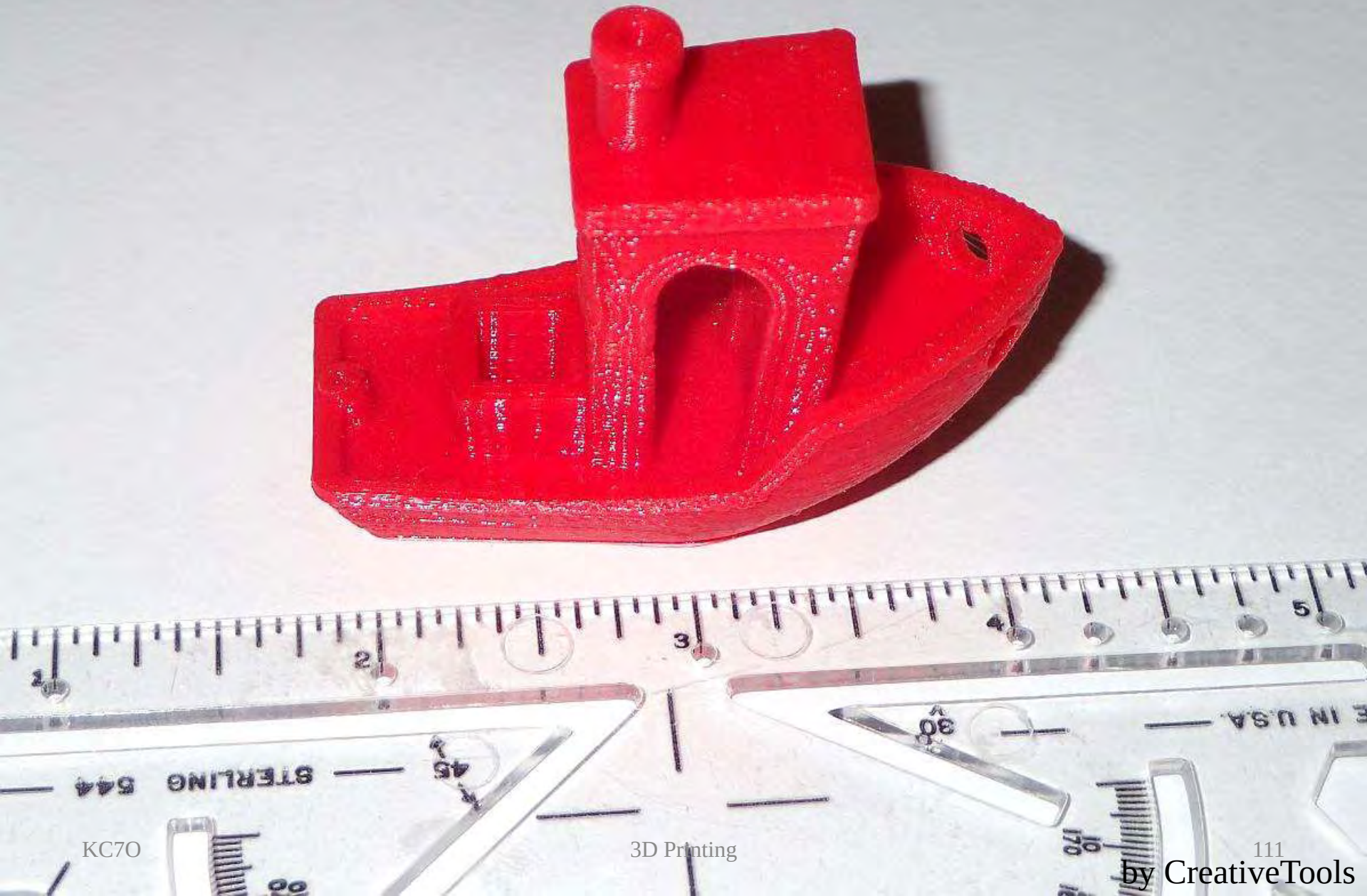
FixAll
ADHESIVE • ADHÉSIF
• ADHESIVO
SUPER GLUE
akshay_d21

Benchy

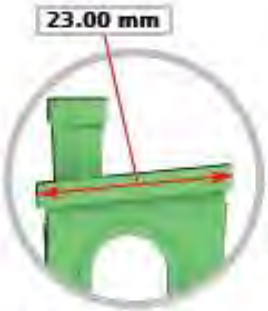
for Benchmark



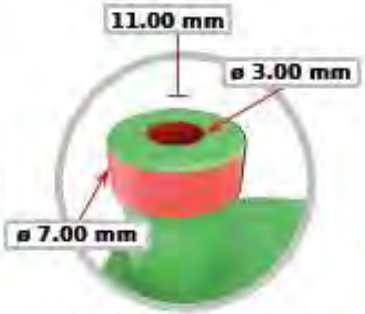
Calibration and torture-test for 3D printers



by CreativeTools



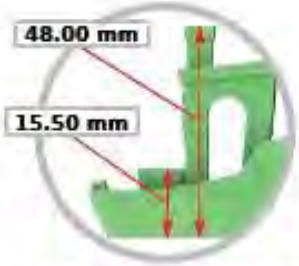
The front and rear surfaces of the roof are parallel at a distance of 23.00 mm.



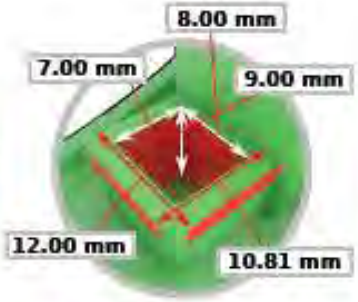
The cylindrical hole and outer top part of the chimney measure 3.00 and 7.00 mm in diameter. The depth of the blind hole measures 11.00 mm.

#3DBenchy's horizontal overall-length from bow to stern measures 60.00 mm.

#3DBenchy's horizontal overall-width from port to starboard measures 31.00 mm.

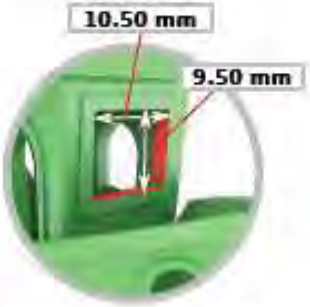


#3DBenchy's vertical overall-height from top to bottom measures 48.00 mm. The top of the box measures 15.50 mm above the bottom surface.

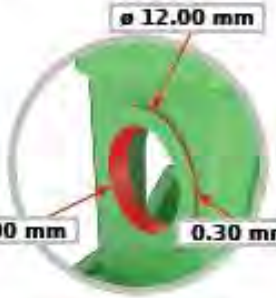


The box on #3DBenchy's deck measures 12.00 x 10.81 mm on the outside and 8.00 x 7.00 mm on the inside. The depth measures 9.00 mm.

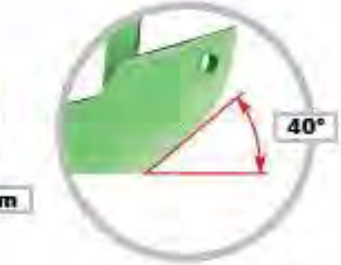
The inner diameter of #3DBenchy's hawsepipe measures 4.00 mm. The depth of the flange against the hull is 0.30 mm.



The rectangular front window measures 10.50 x 9.50 mm. Its parallel inner surfaces are horizontally cut into the bridge.



The inner diameter of the cylindrical stern window measures 9.00 mm. Its outer diameter measures 12.00 mm. The flange's depth is 0.30 mm.



#3DBenchy's high-cain spoon bow has a 40° overhang angle to the horizontal plane.

The roof of the bridge slopes at a 5.5° angle to the horizontal plane.

The sign and small letters at the stern are extruded at 0.10 mm.

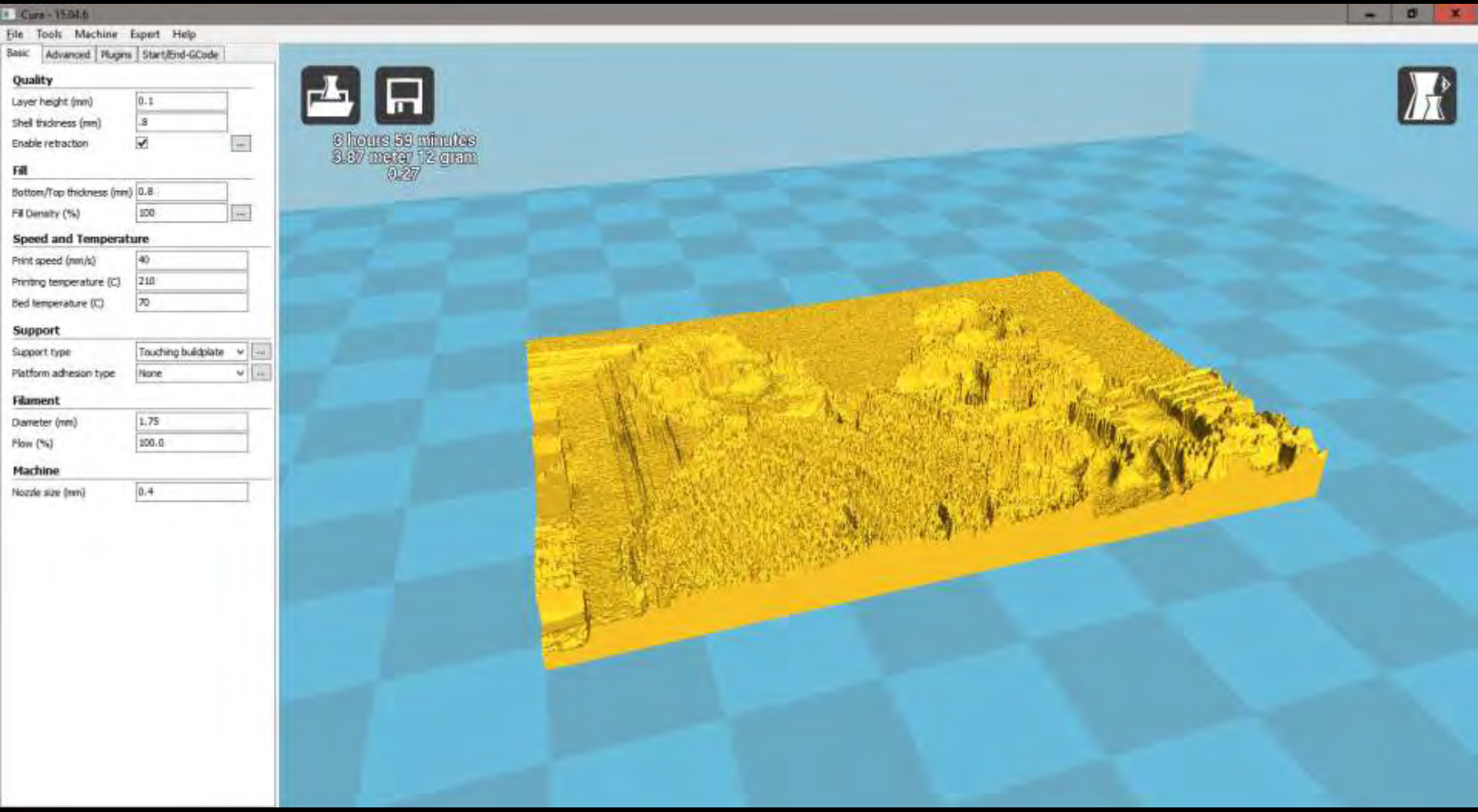
Lithophane

- ***French - is an etched or molded artwork in very thin translucent porcelain that can only be seen clearly when backlit with a light source ~ 1820's***
- ***It is a design or scene engraved that appears in gray tones***

https://en.wikipedia.org/wiki/Lithophane

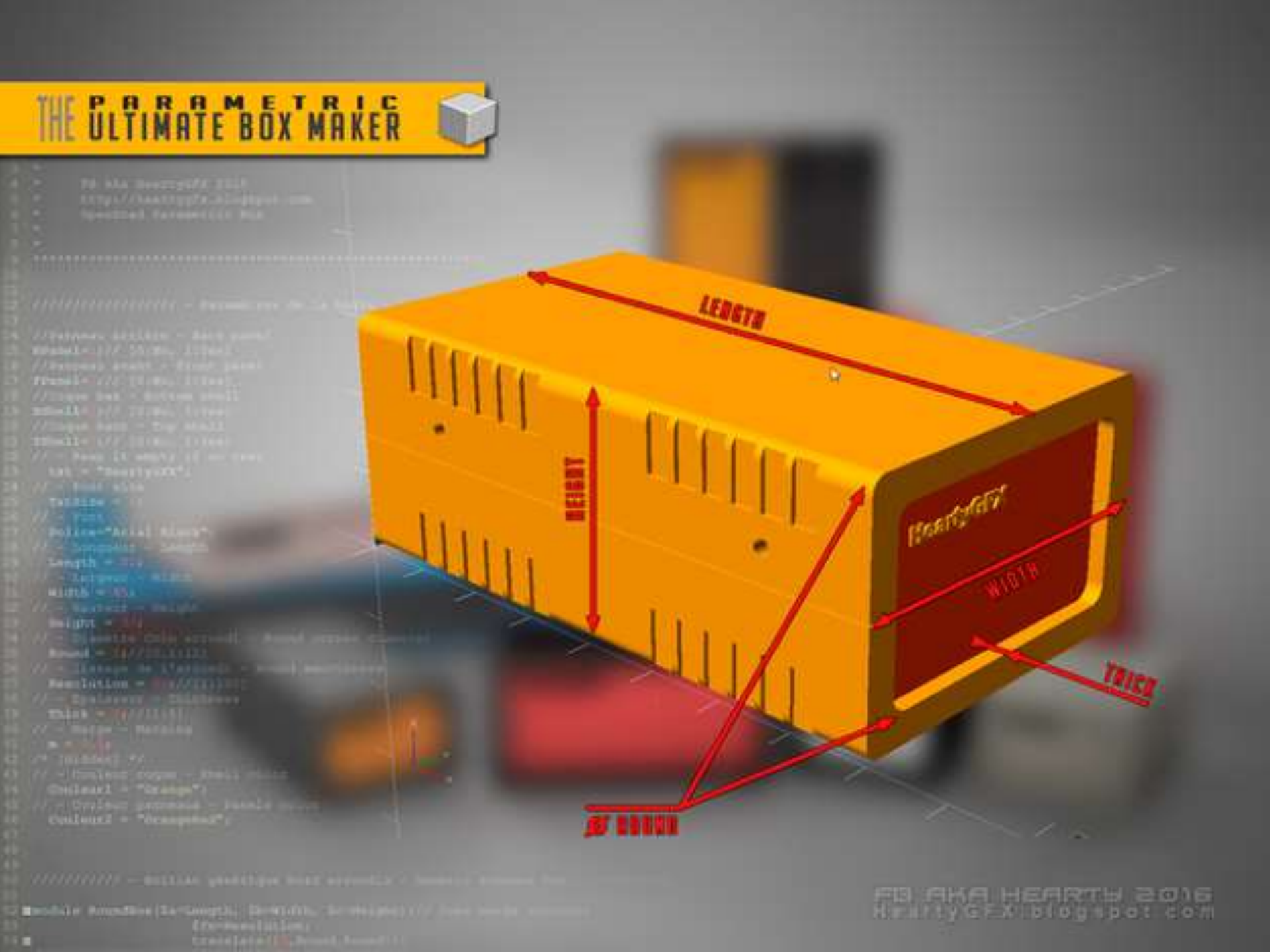
Lithophane

https://en.wikipedia.org/wiki/Lithophane


Cura - 15.04.6
File Tools Machine Expert Help
Basic Advanced Plugins Start/End-GCode
Quality
Layer height (mm) 0.1
Shell thickness (mm) .8
Enable retraction
Fill
Bottom/Top thickness (mm) 0.8
Fill Density (%) 100
Speed and Temperature
Print speed (mm/s) 40
Printing temperature (C) 210
Bed temperature (C) 70
Support
Support type Touching buildplate
Platform adhesion type None
Filament
Diameter (mm) 1.75
Flow (%) 100.0
Machine
Nozzle size (mm) 0.4
3 hours 59 minutes
3.87 meter 12 gram
0.27

Parametric Designs

THE PARAMETRIC ULTIMATE BOX MAKER

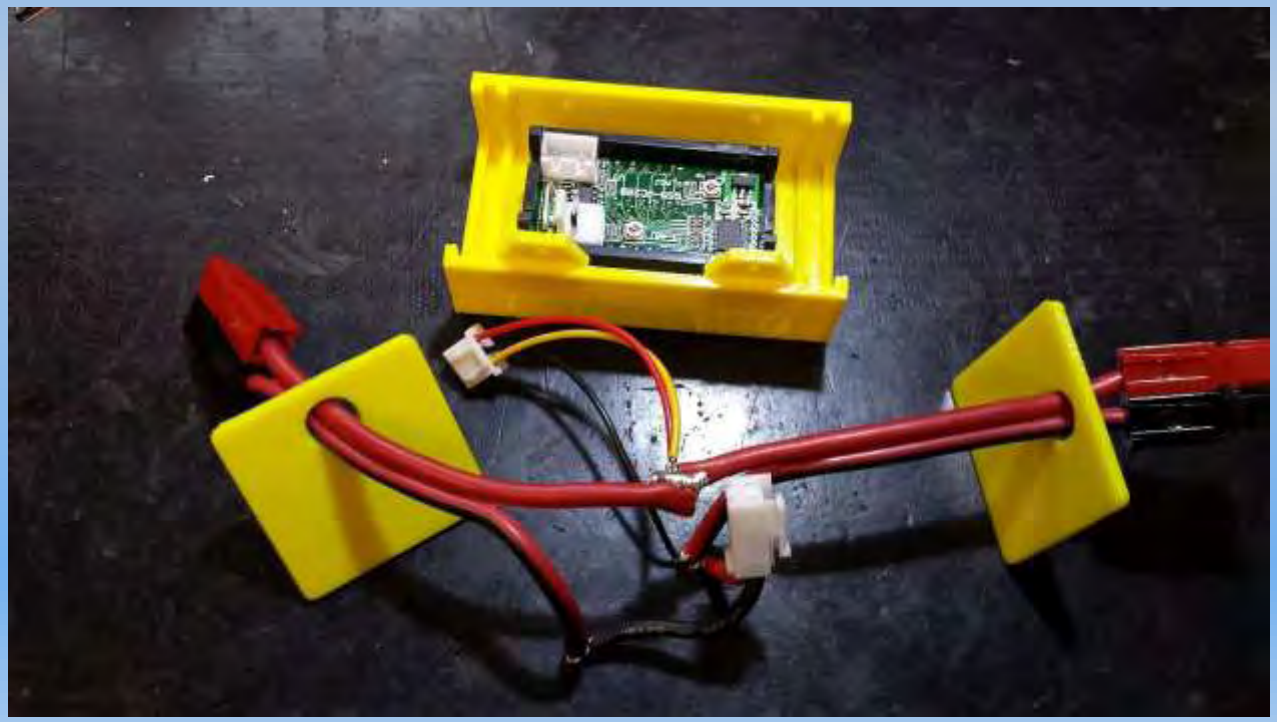


FB AKA HEARTY 2016
HeartyFX.blogspot.com

OpenSCAD Parametric Box

- ***Parametric (.scad) files***
- ***Parameters can be changed in one place***
- ***All code related to the parameters change at once***
- ***In this case the width, height and length is described once***

http://heartygfx.blogspot.com



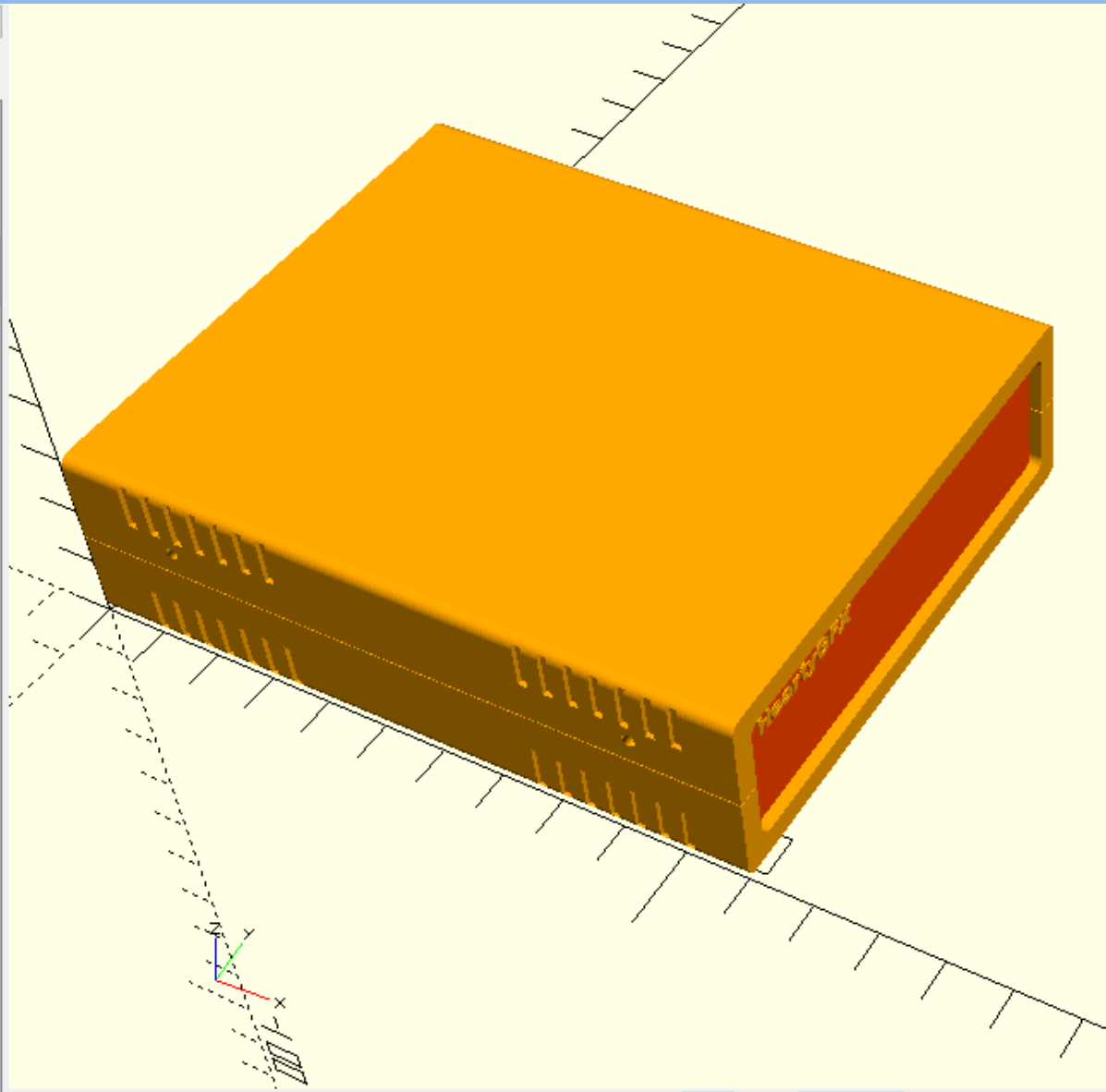
http://heartygfx.blogspot.com

Editor

```
25
26
27  ////////// - Paramètres de
        la boite - Box
        parameters - ////////////
28
29  /* [Box dimensions] */
30  // - Longueur - Length
31    Length          = 110;
32  // - Largeur - Width
33    Width           = 90;

34  // - Hauteur - Height
35    Height          = 30;
36  // - Epaisseur - Wall
        thickness
37    Thick           = 2;//[2:5]
38
39  /* [Box options] */
40  // Pieds PCB - PCB feet (x4)
41    PCBFeet         = 0;//
        [0:No, 1:Yes]
42  // - Decorations to
        ventilation holes
43    Vent            = 0;//
        [0:No, 1:Yes]
44  // - Decoration-Holes width
        (in mm)
45    Vent_width      = 1.5;
46  // - Text you want
47    txt             = "HeartyGFX"
        ;
48  // - Font size
49    TxtSize         = 3;

50  // - Font
51    Police          ="Arial
        Black";
```



Console

```
Geometries in cache: 41
Geometry cache size in bytes: 307032
CGAL Polyhedrons in cache: 0
CGAL cache size in bytes: 0
Compiling design (CSG Products normalization)...
Normalized CSG tree has 109 elements
```

Editor

```
25
26
27  ////////// - Paramètres de
        la boite - Box
        parameters - ////////////
28
29  /* [Box dimensions] */
30  // - Longueur - Length
31    Length          = 60;
32  // - Largeur - Width
33    Width           = 90;
34  // - Hauteur - Height
35    Height          = 30;
36  // - Epaisseur - Wall
        thickness
37    Thick           = 2;//[2:5]
38
39  /* [Box options] */
40  // Pieds PCB - PCB feet (x4)
41    PCBFeet         = 0;//
        [0:No, 1:Yes]
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        ventilation holes
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        [0:No, 1:Yes]
44  // - Decoration-Holes width
        (in mm)
45    Vent_width      = 1.5;
46  // - Text you want
47    txt             = "HeartyGFX"
        ;
48  // - Font size
49    TxtSize         = 3;
50  // - Font
51    Police          ="Arial
```
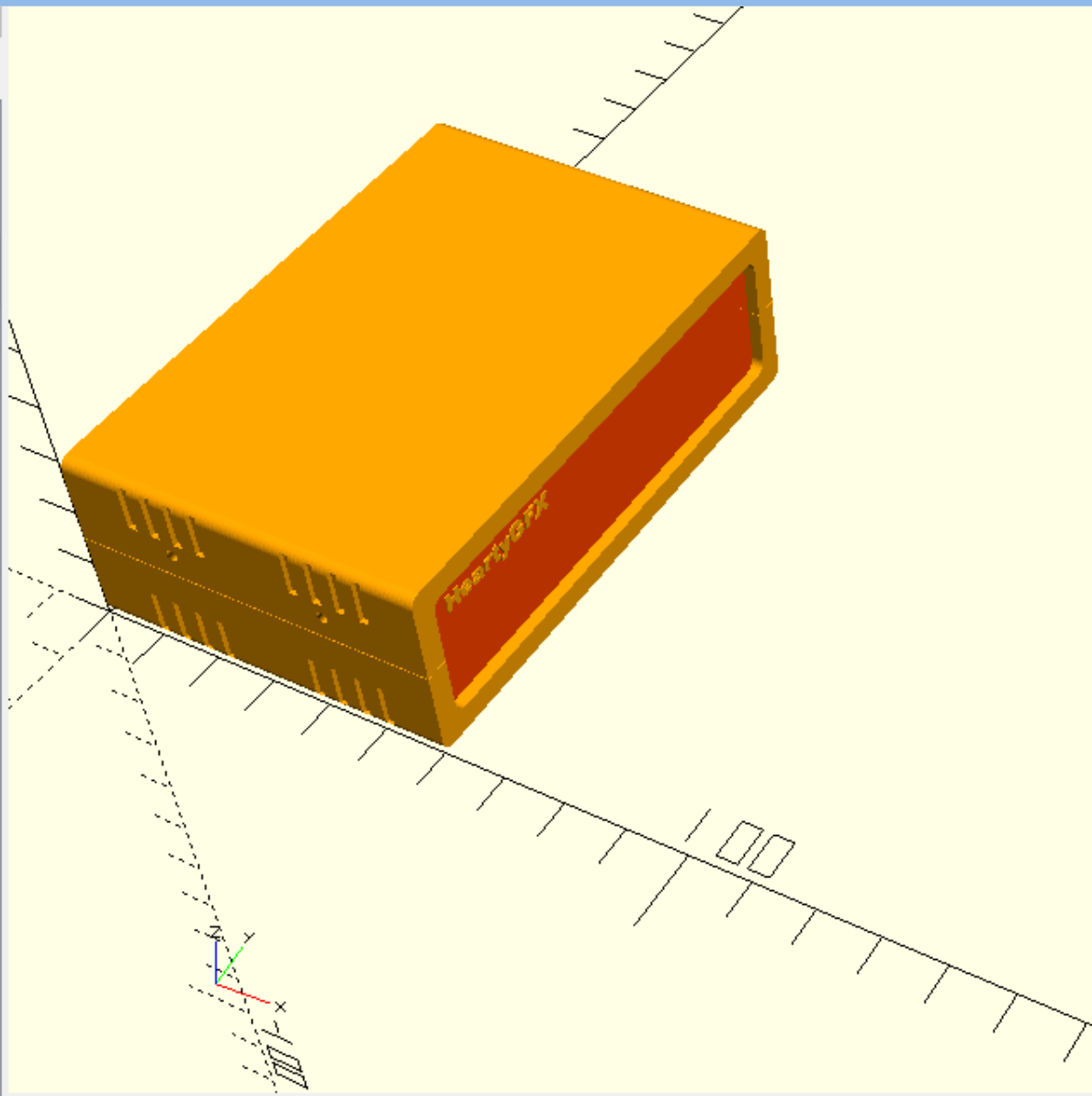
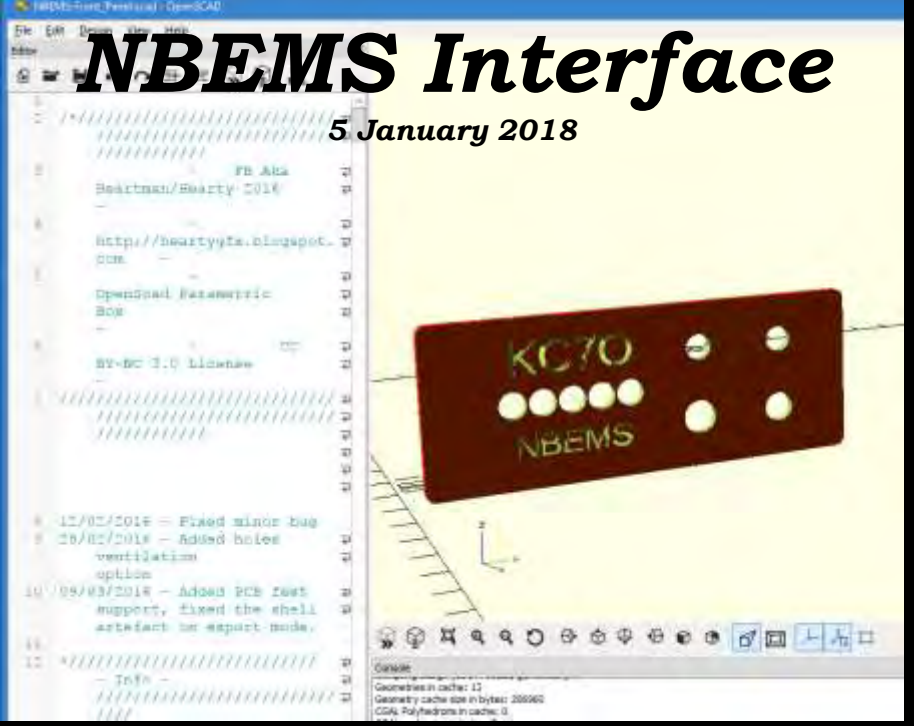



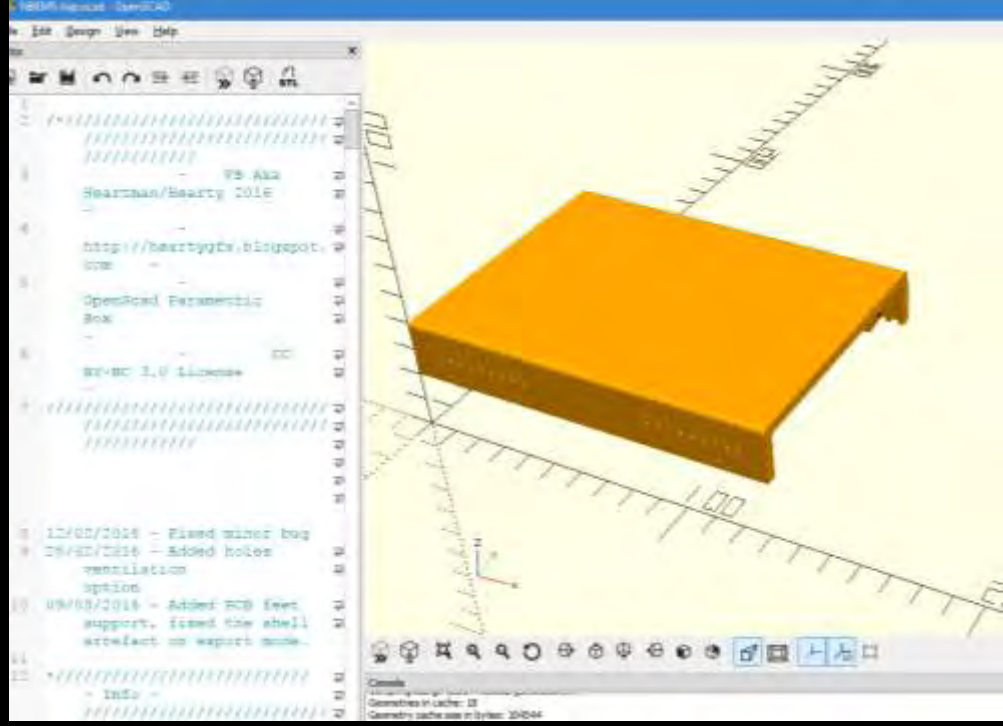
Console

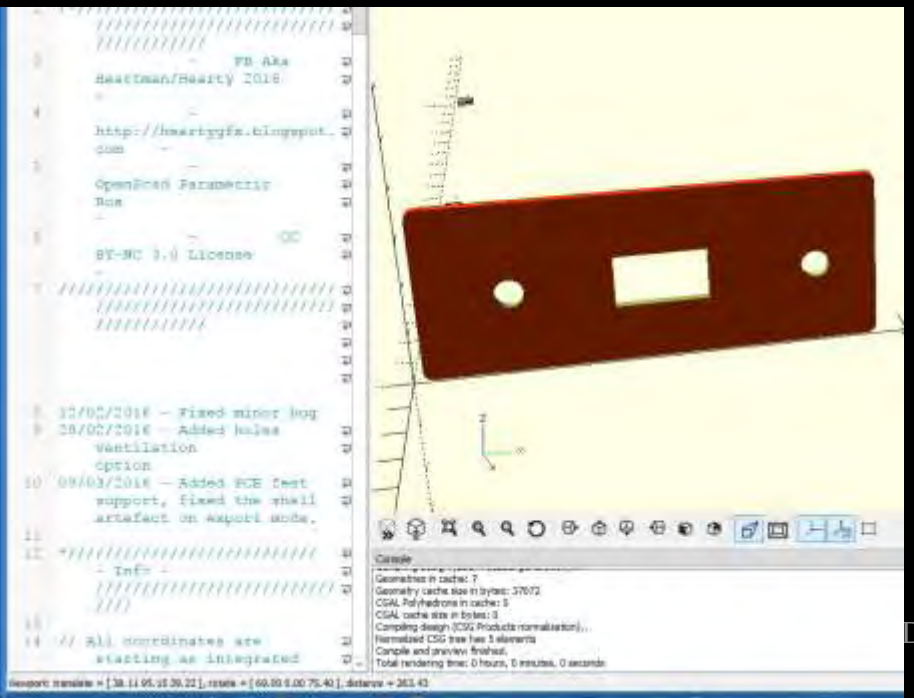
```
Geometries in cache: 59
Geometry cache size in bytes: 419064
CGAL Polyhedrons in cache: 0
CGAL cache size in bytes: 0
Compiling design (CSG Products normalization)...
```

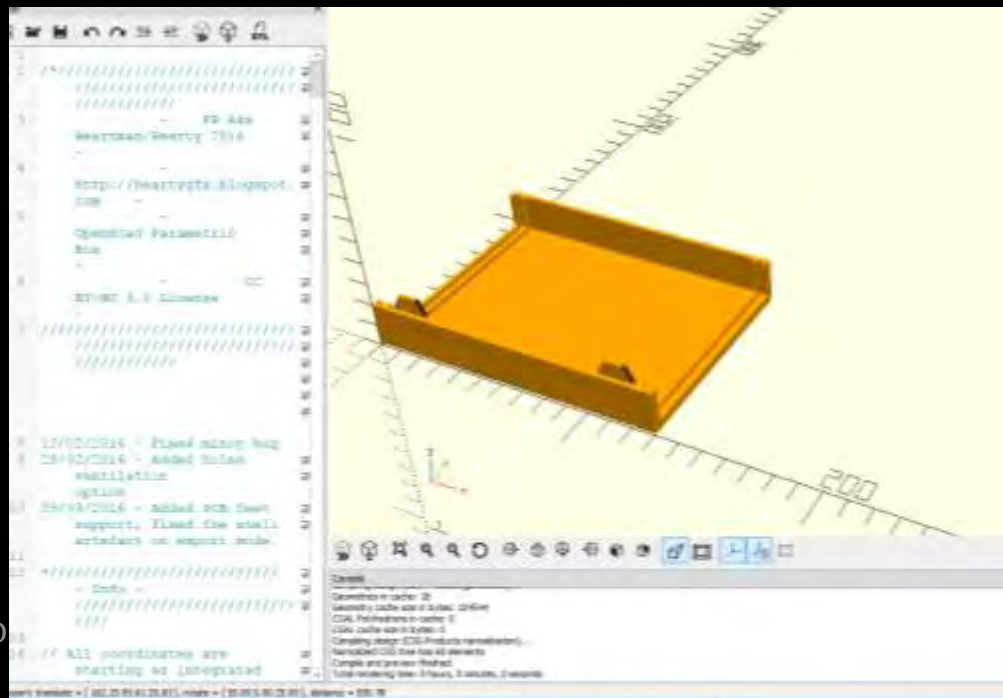
NBEMS Interface

5 January 2018









1725
2.2MF 2.2MF

KC7O
NBEMS

KC7O
NBEMS

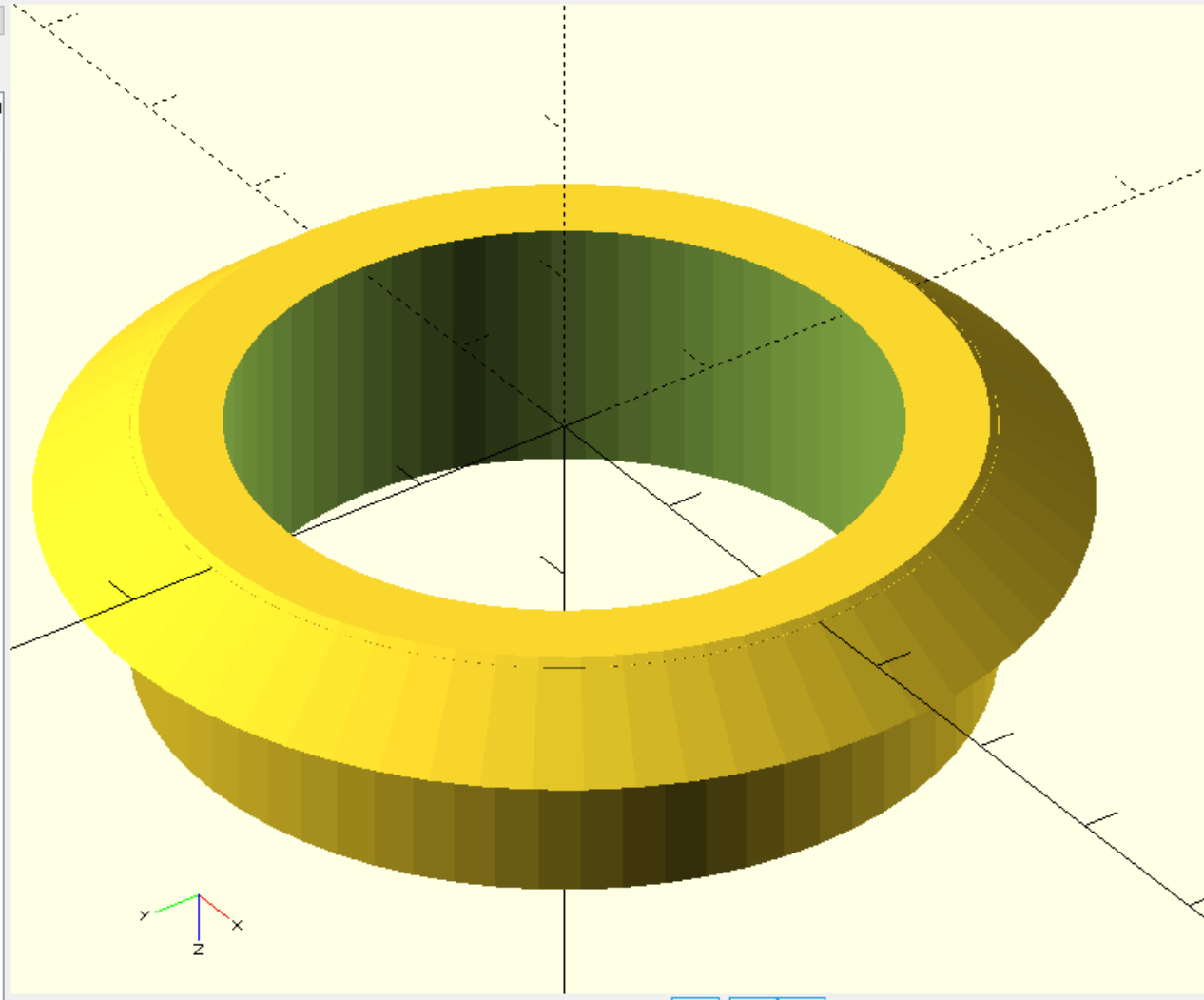
Protector for Umbrella Pole in a glass table

Protector.scad* - OpenSCAD

File Edit Design View Help

Editor

```
1  //Glass Table Umbrella Protect
       Insert - Parametric
2  //A. Wolff - 29 November 2016
3  $fn=64;
4  //Hole In Glass
5      h = 49;
6  //Tube Diameter
7      t = 38.5;
8  //Outside Diameter Of Plug
9      d = 60;
10 //Height above table
11     p=5;
12 //Plug height through Glass
13     g=15;
14 difference(){
15 union(){
16 //Lip
17     translate([0,0,-.4])
18     cylinder(p,.4*d,.5*d);
19 //Plug
20     cylinder(g,.5*h,.5*h);
21 }
22 //Hole
23     translate([0,0,-.4])
24     cylinder(30,.5*t,.5*t);
25 }
```



Console

```
Simple:     yes
Vertices:   760
Halfedges:  2416
Edges:      1208
Halffacets: 904
Facets:     452
Volumes:    2
Rendering finished.
```

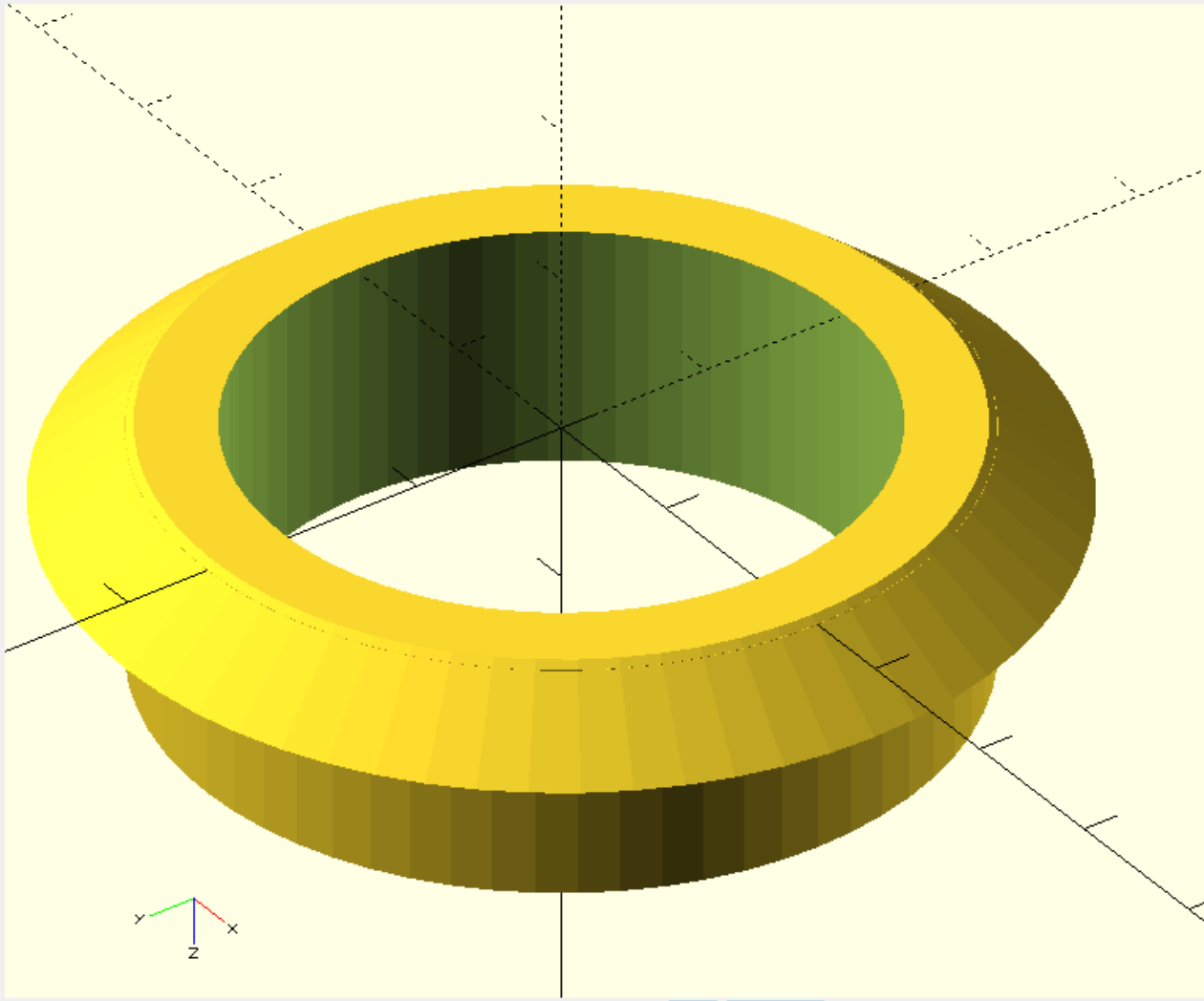
Viewport: translate = [13.85 -16.80 3.99], rotate = [236.30 0.00 305.90], distance = 140.00

Protector.scad* - OpenSCAD

File Edit Design View Help

Editor

```
1  //Glass Table Umbrella Protect
       Insert - Parametric
2  //A. Wolff - 29 November 2016
3  $fn=64;
4  //Hole In Glass
5      h = 49;
6  //Tube Diameter
7      t = 38.5;
8  //Outside Diameter Of Plug
9      d = 60;
10 //Height above table
11     p=5;
12 //Plug height through Glass
13     g=15;
14 difference(){
15 union(){
16 //Lip
17     translate([0,0,-.4])
18     cylinder(p,.4*d,.5*d);
19 //Plug
20     cylinder(g,.5*h,.5*h);
21 }
22 //Hole
23     translate([0,0,-.4])
24     cylinder(30,.5*t,.5*t);
25 }
```



Console

```
Simple:     yes
Vertices:   760
Halfedges:  2416
Edges:      1208
Halffacets: 904
Facets:     452
Volumes:    2
Rendering finished.
```

Viewport: translate = [13.85 -16.80 3.99], rotate = [236.30 0.00 305.90], distance = 140.00

Protector.scad* - OpenSCAD

File Edit Design View Help

Editor

```
1  //Glass Table Umbrella Protect
       Insert - Parametric
2  //A. Wolff - 29 November 2016
3  $fn=64;
4  //Hole In Glass
5      h = 49;
6  //Tube Diameter
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8  //Outside Diameter Of Plug
9      d = 60;
10 //Height above table
11     p=5;
12 //Plug height through Glass
13     g=15;
14 difference(){
15 union(){
16 //Lip
17     translate([0,0,-.4])
18     cylinder(p,.4*d,.5*d);
19 //Plug
20     cylinder(g,.5*h,.5*h);
21 }
22 //Hole
23     translate([0,0,-.4])
24     cylinder(30,.5*t,.5*t);
25 }
```
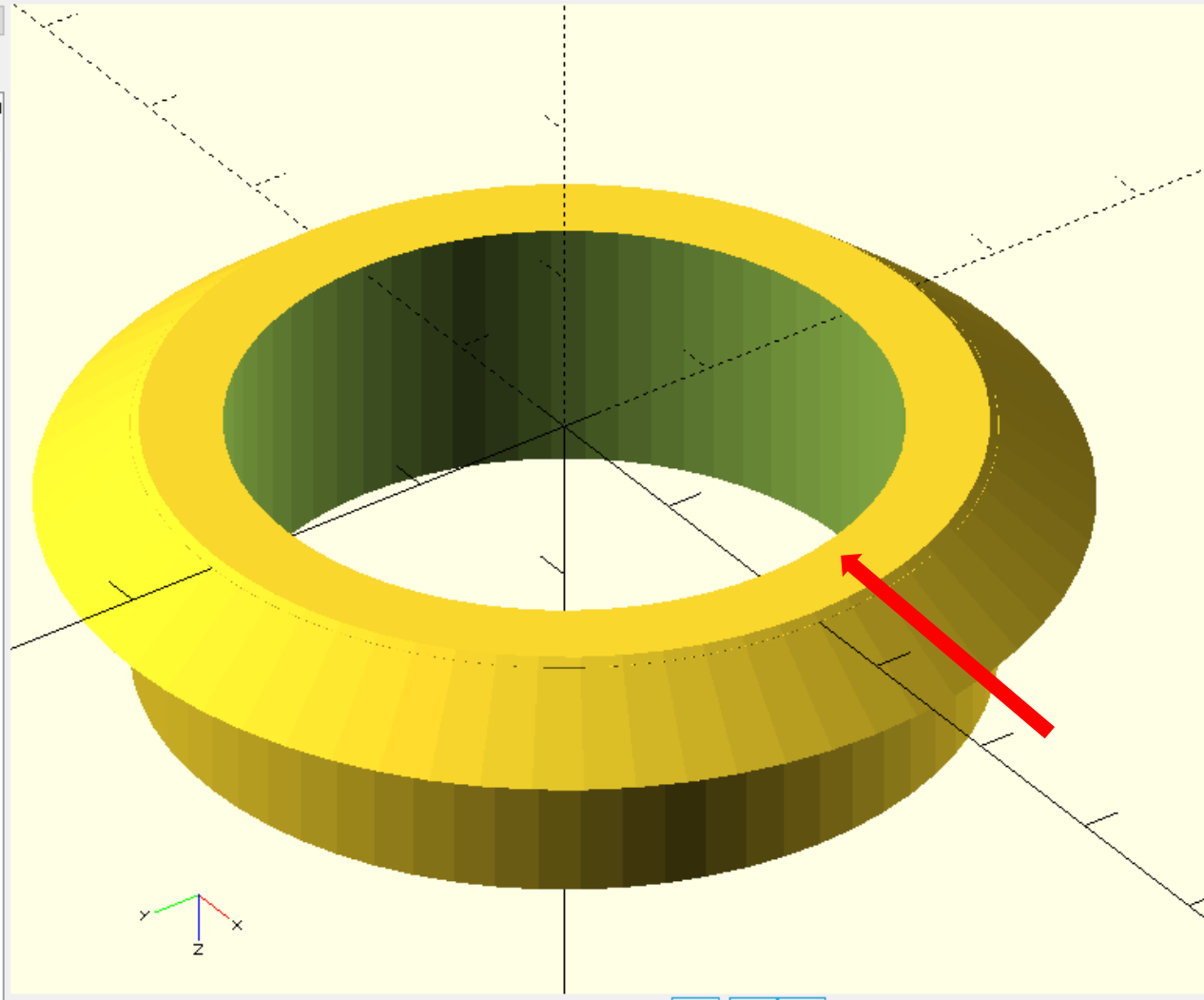
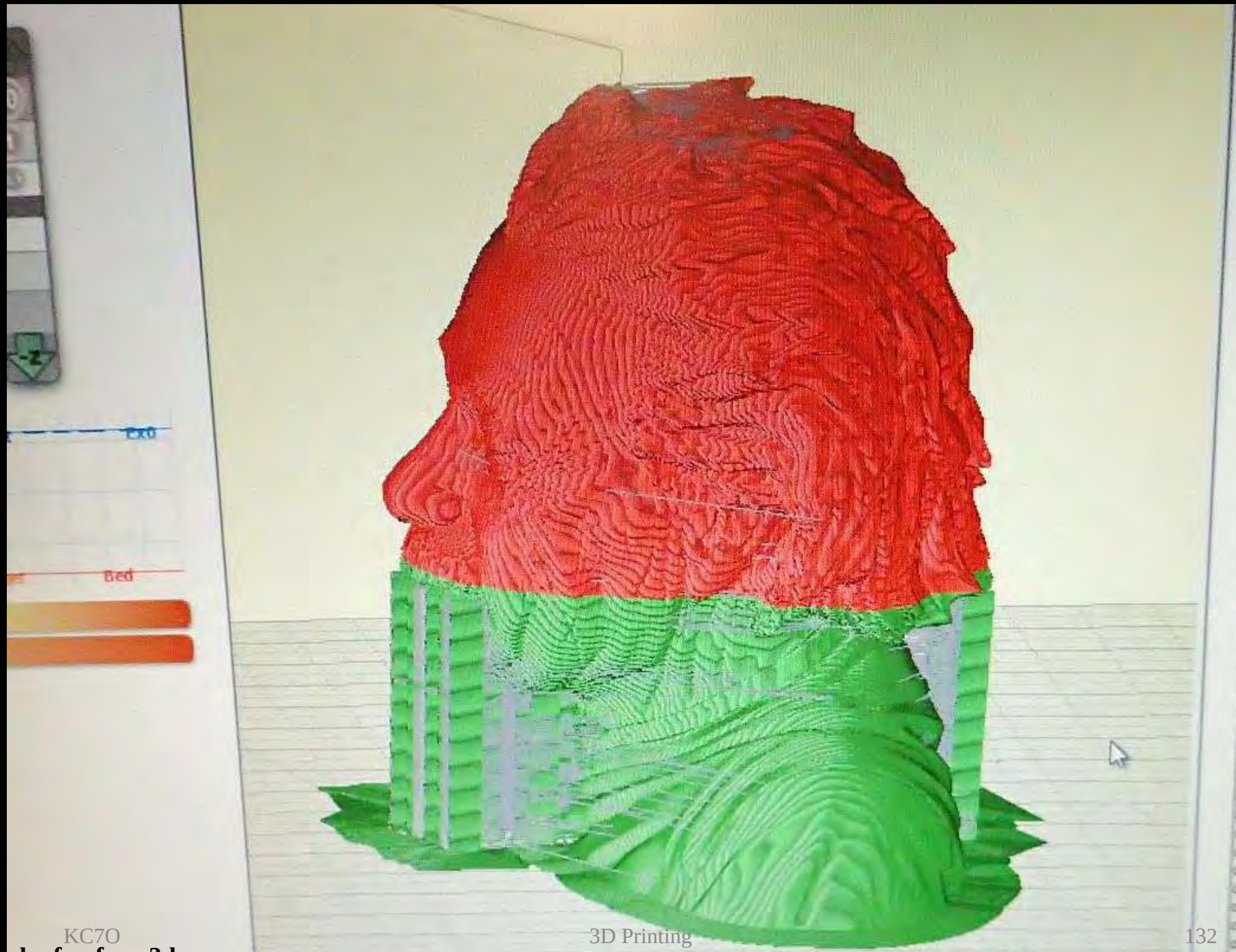



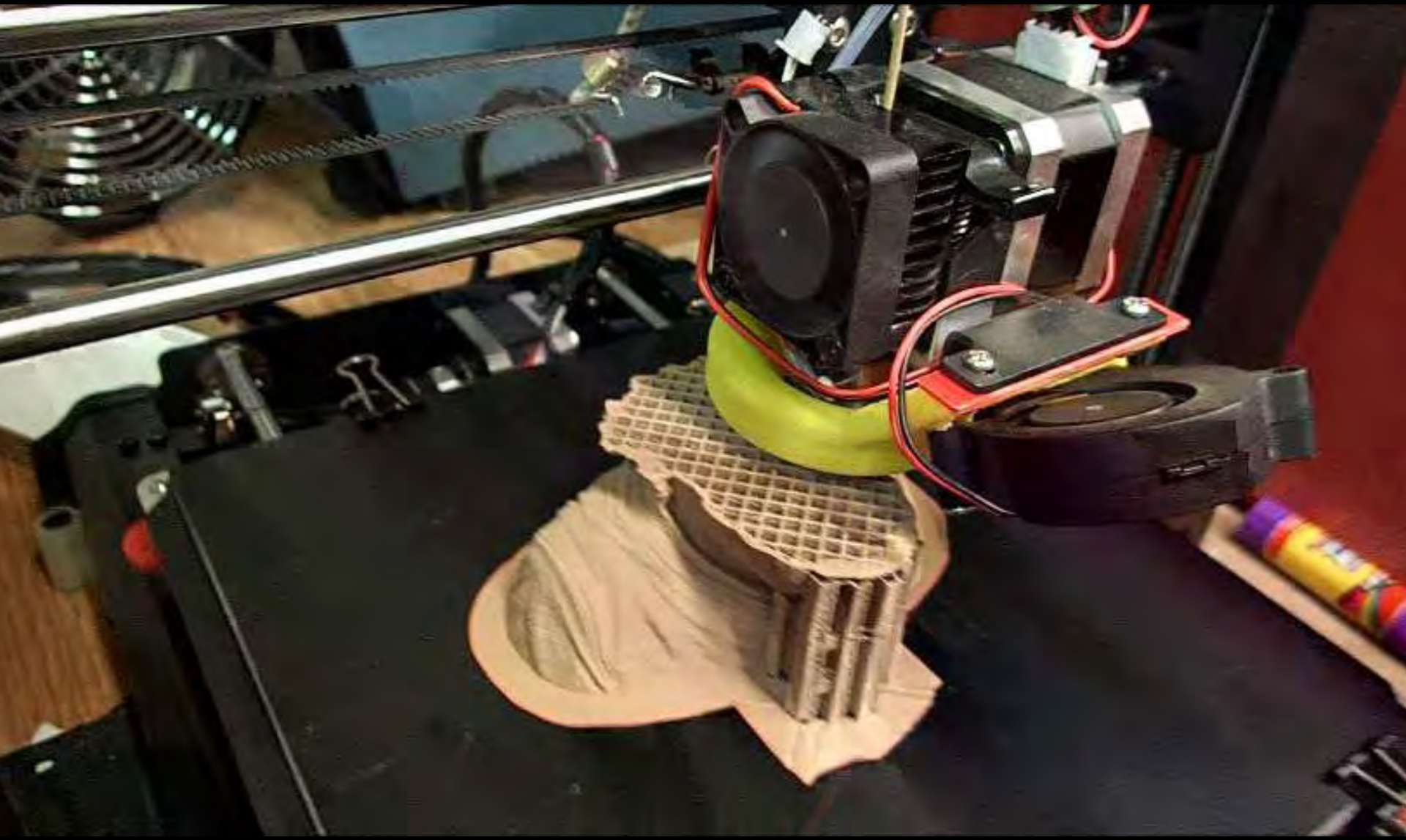
Console

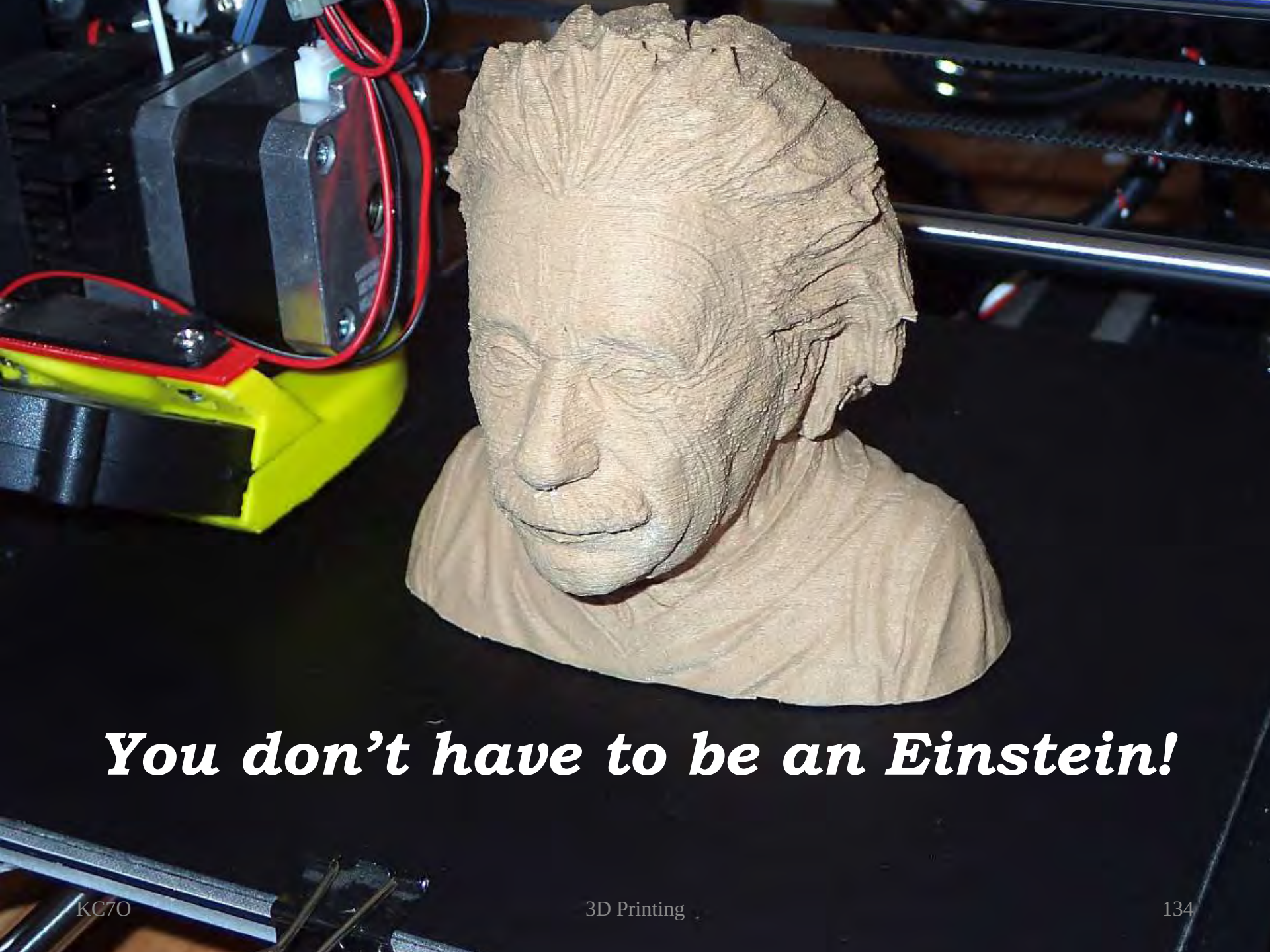
```
Simple:     yes
Vertices:   760
Halfedges:  2416
Edges:      1208
Halffacets: 904
Facets:     452
Volumes:    2
Rendering finished.
```

Viewport: translate = [13.85 -16.80 3.99], rotate = [236.30 0.00 305.90], distance = 140.00

Try 3D Printing


Bed




You don’t have to be an Einstein!