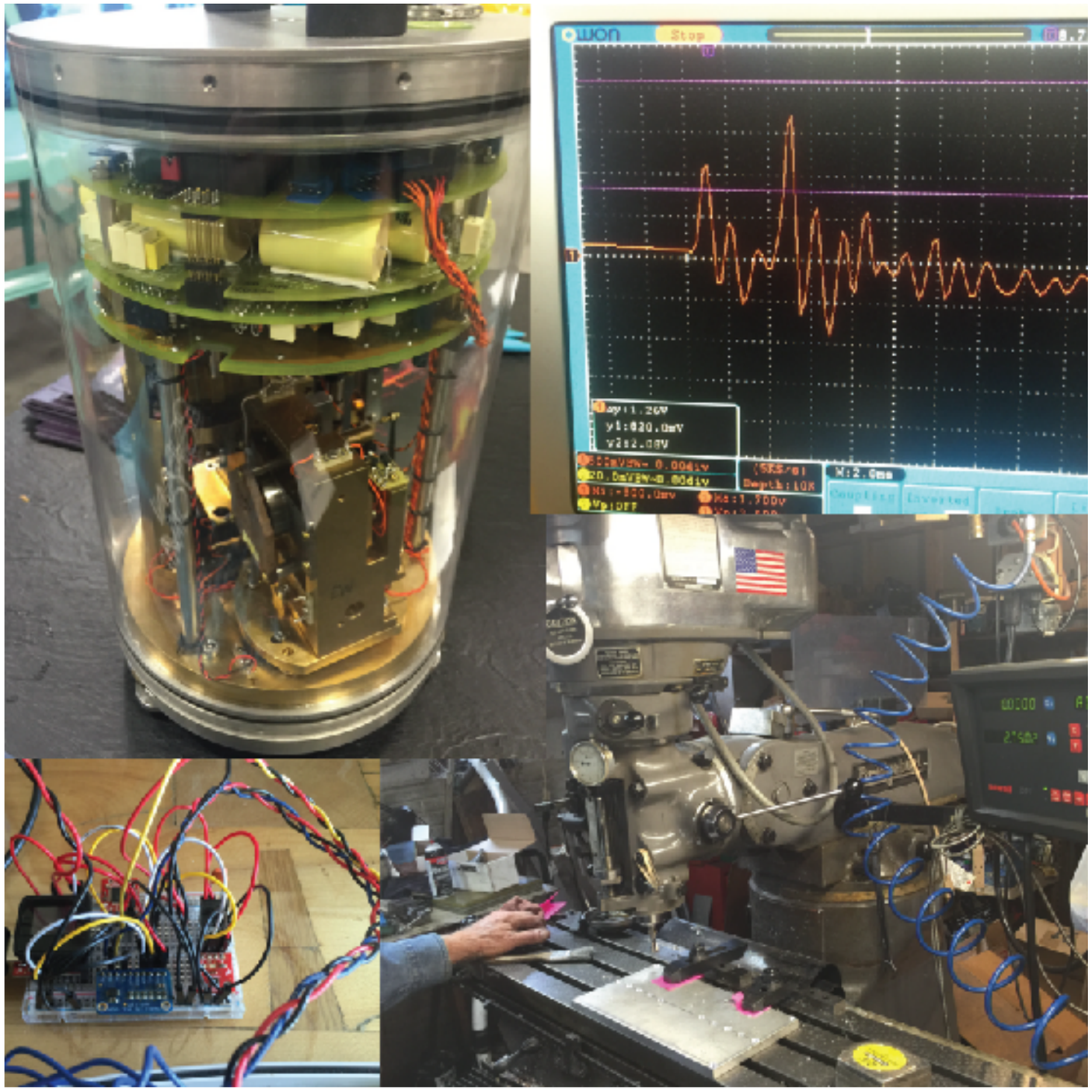
3D CAD and Design for Printing

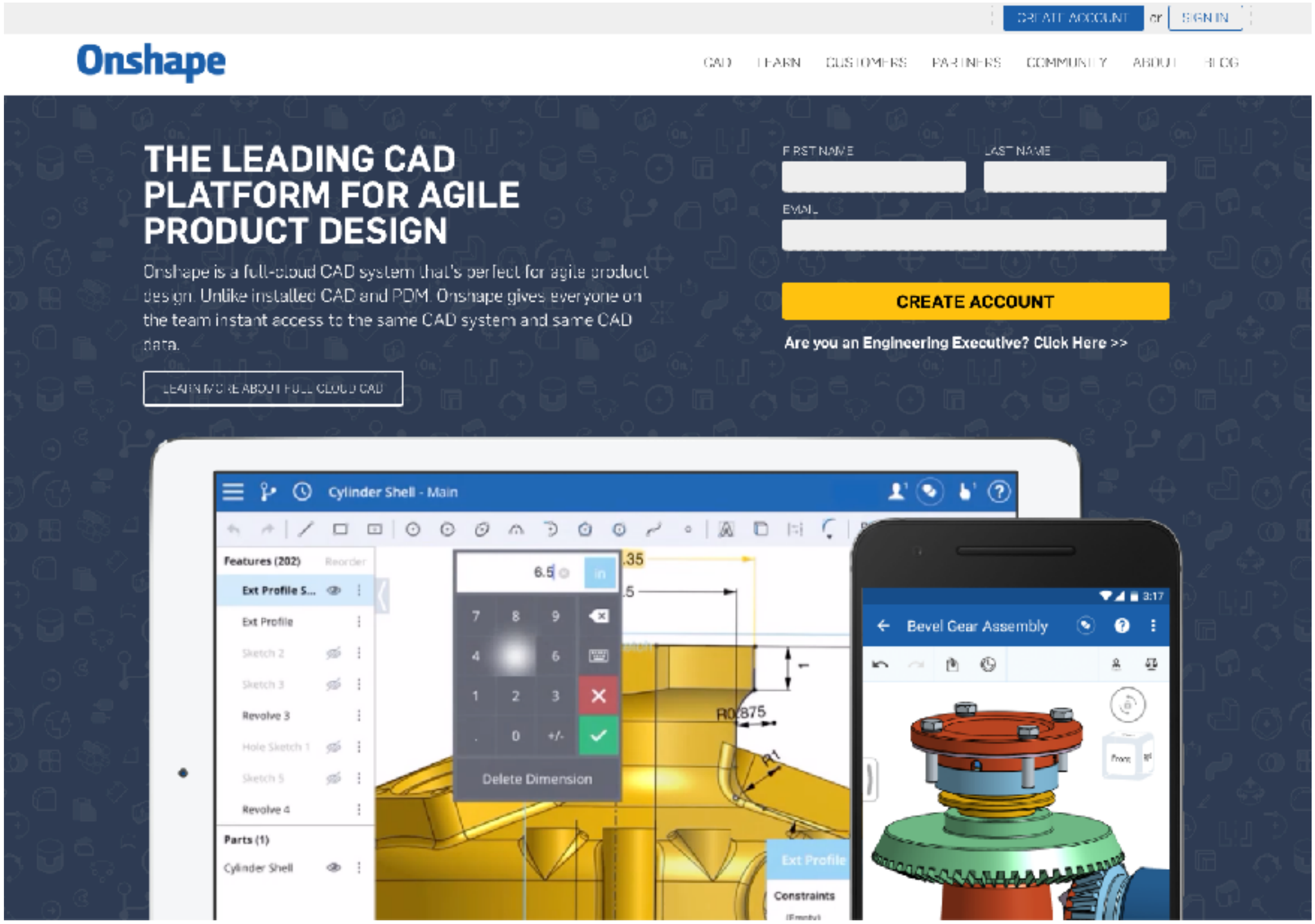
J.R. Leeman and C. Marone

Techniques of Geoscientific Experimentation

September 27, 2016



Today we'll go over how to use OnShape as well as how to effectively design parts for 3D printing



3D printing is available in many locations

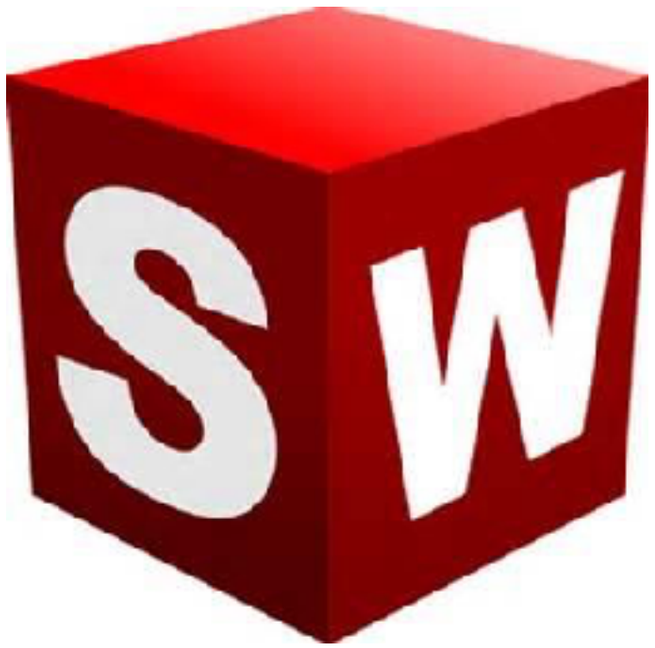
- Hackerspaces
- Libraries
- Campus
- Online Services

Image: sparkfun.com

Prints can go horribly wrong if you just send any design

Images: http://gizmodo.com/11-spectacular-3d-printer-failures-511092085

Understanding the 3D printing toolchain will help you understand its strengths and limitations



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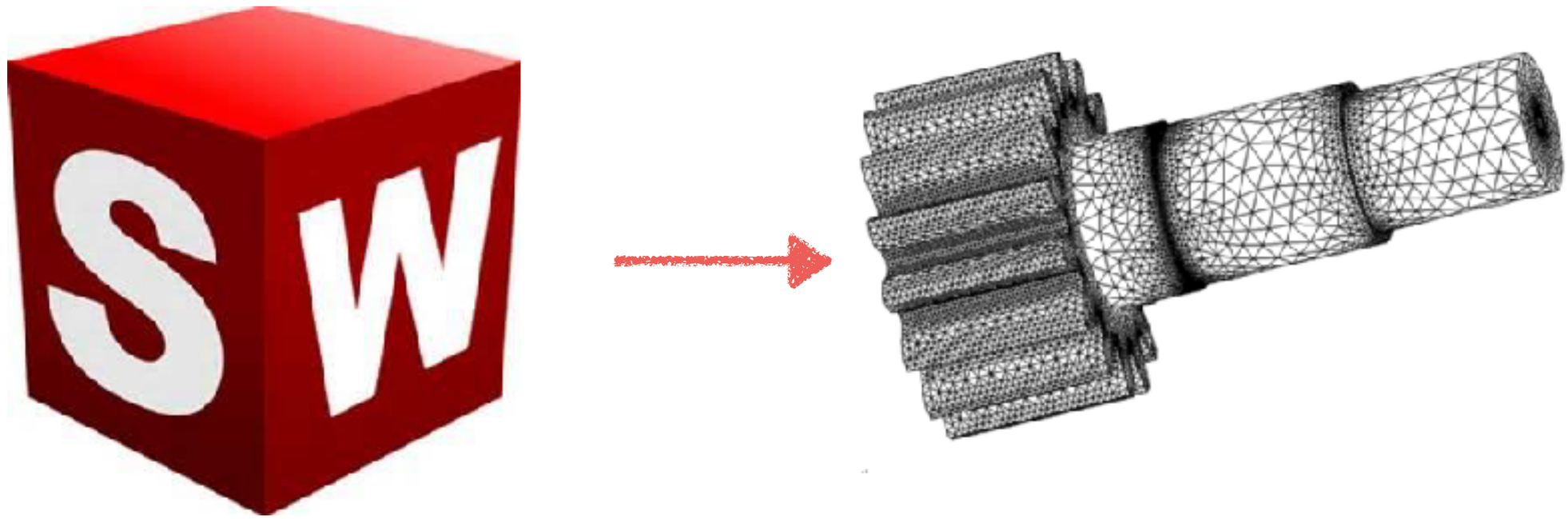

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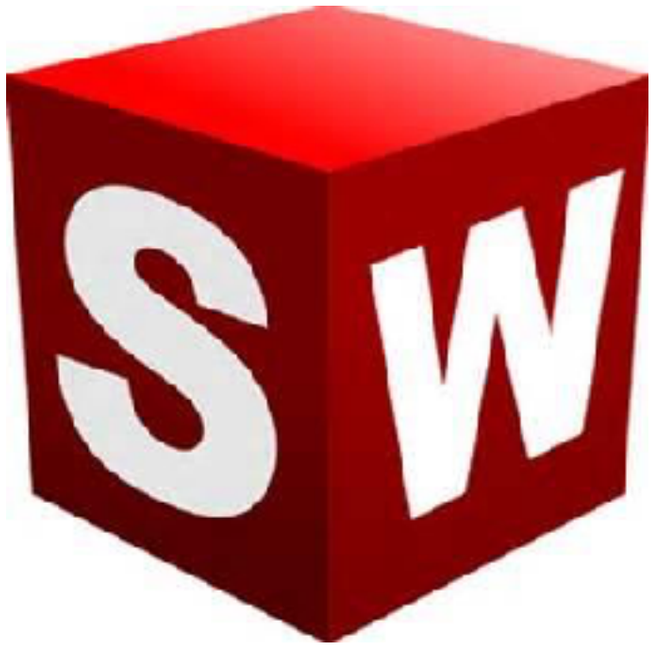

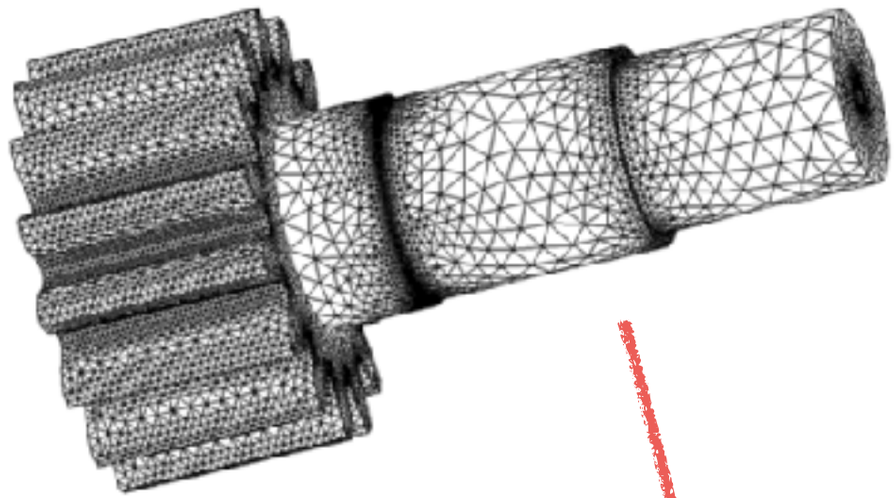

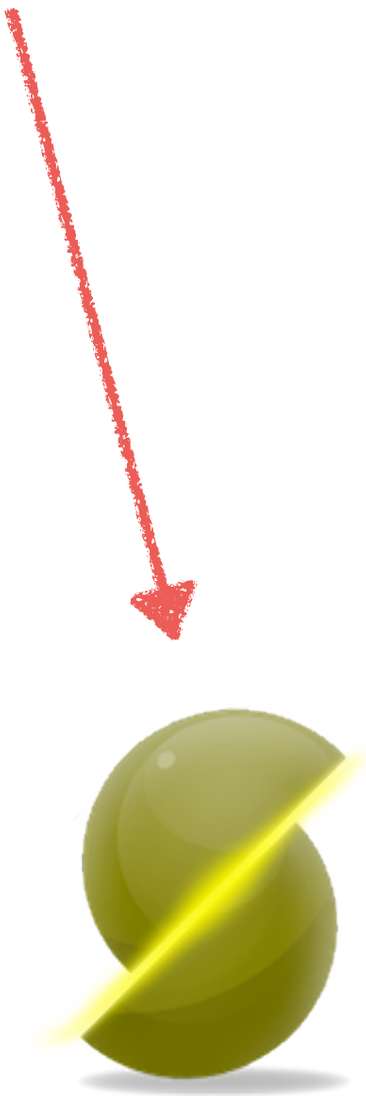

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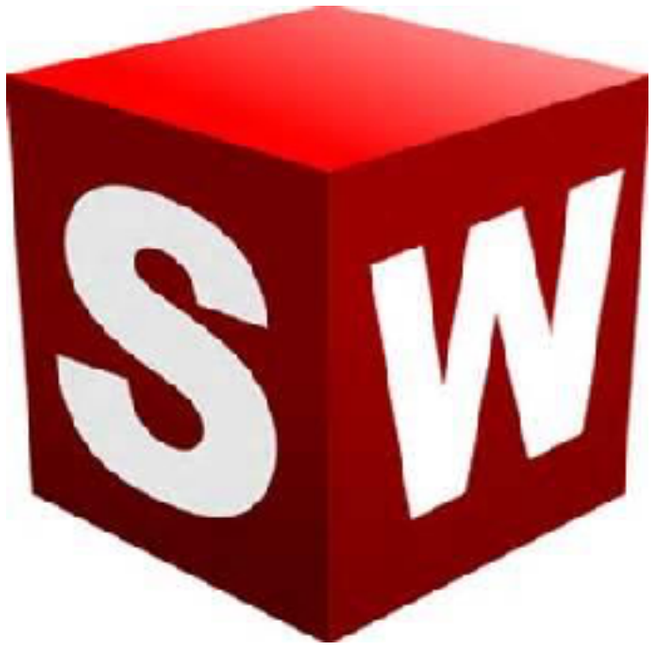

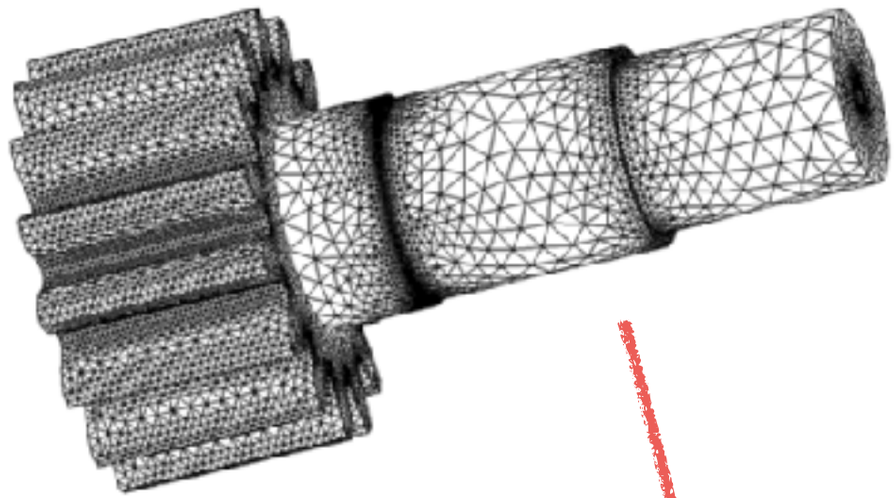

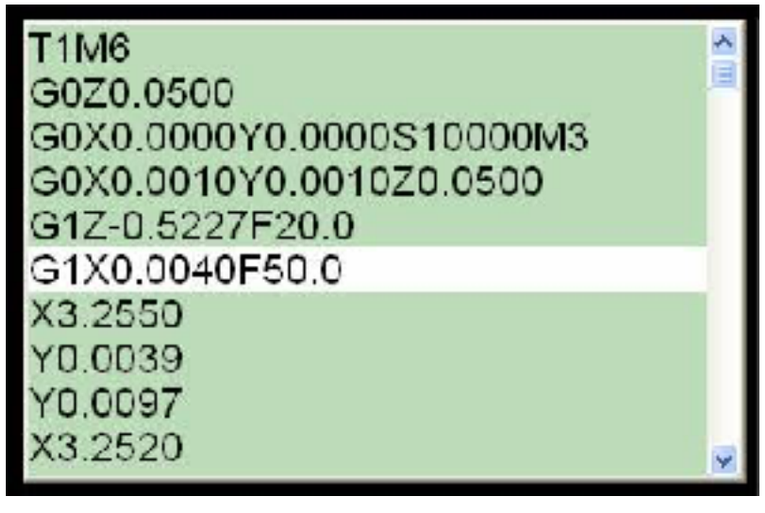

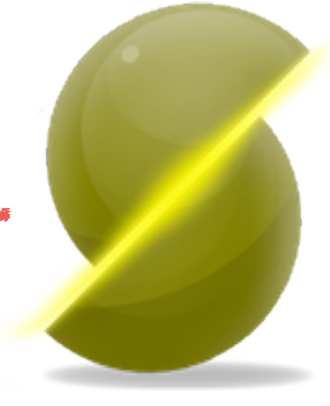

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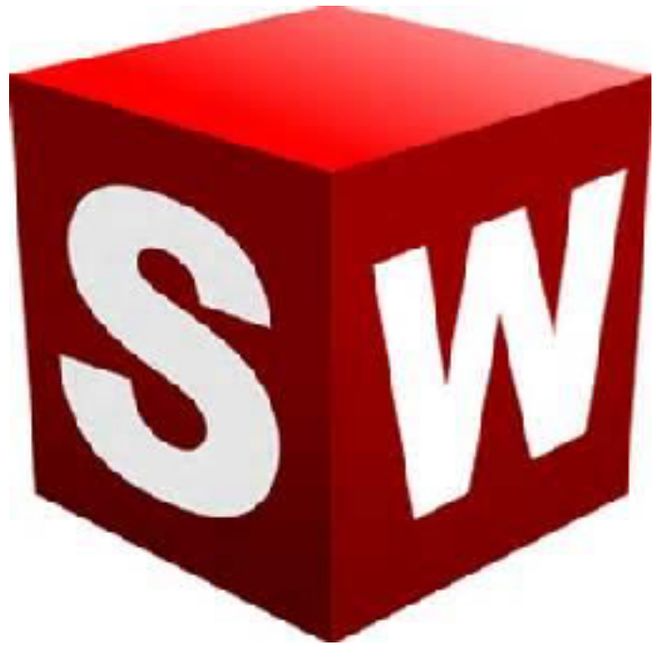
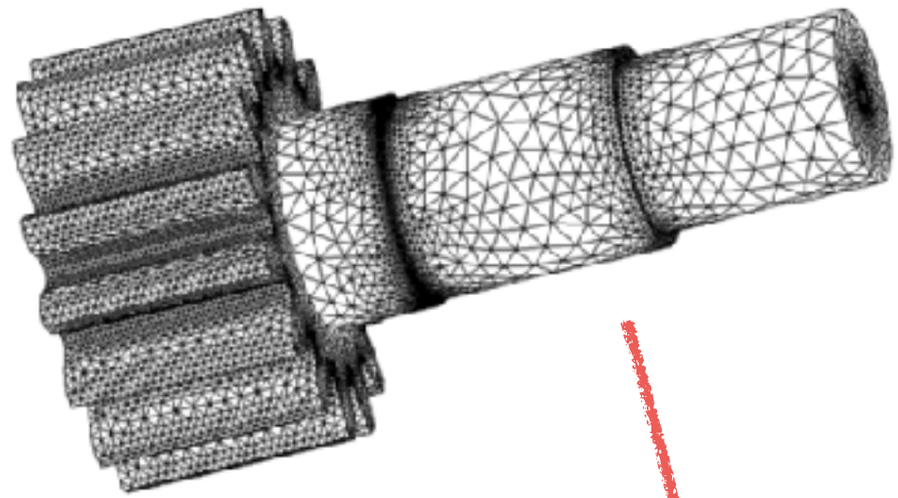
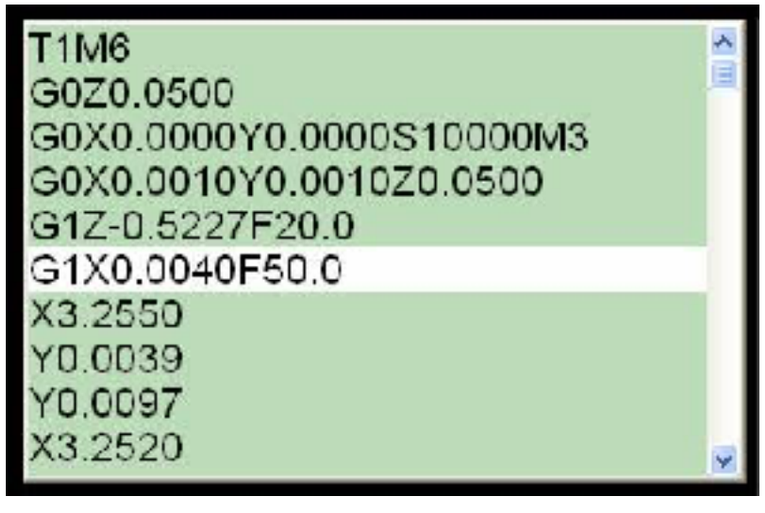
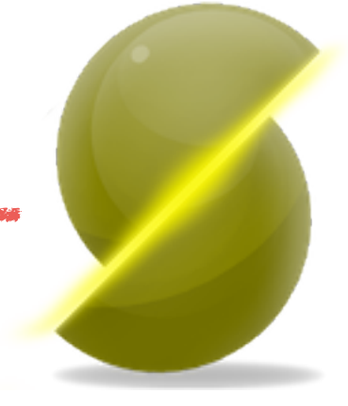
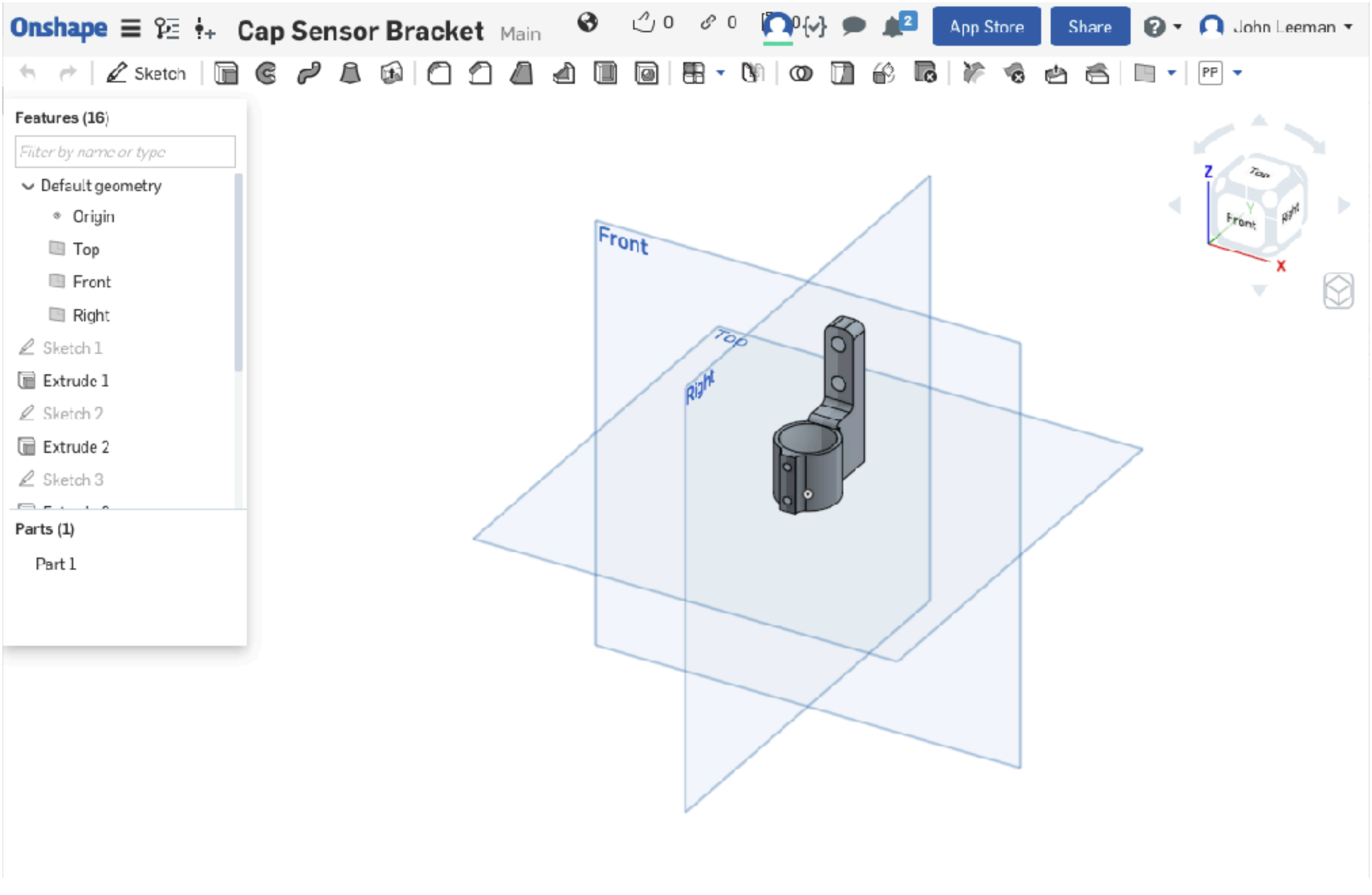








The design starts in a CAD tool



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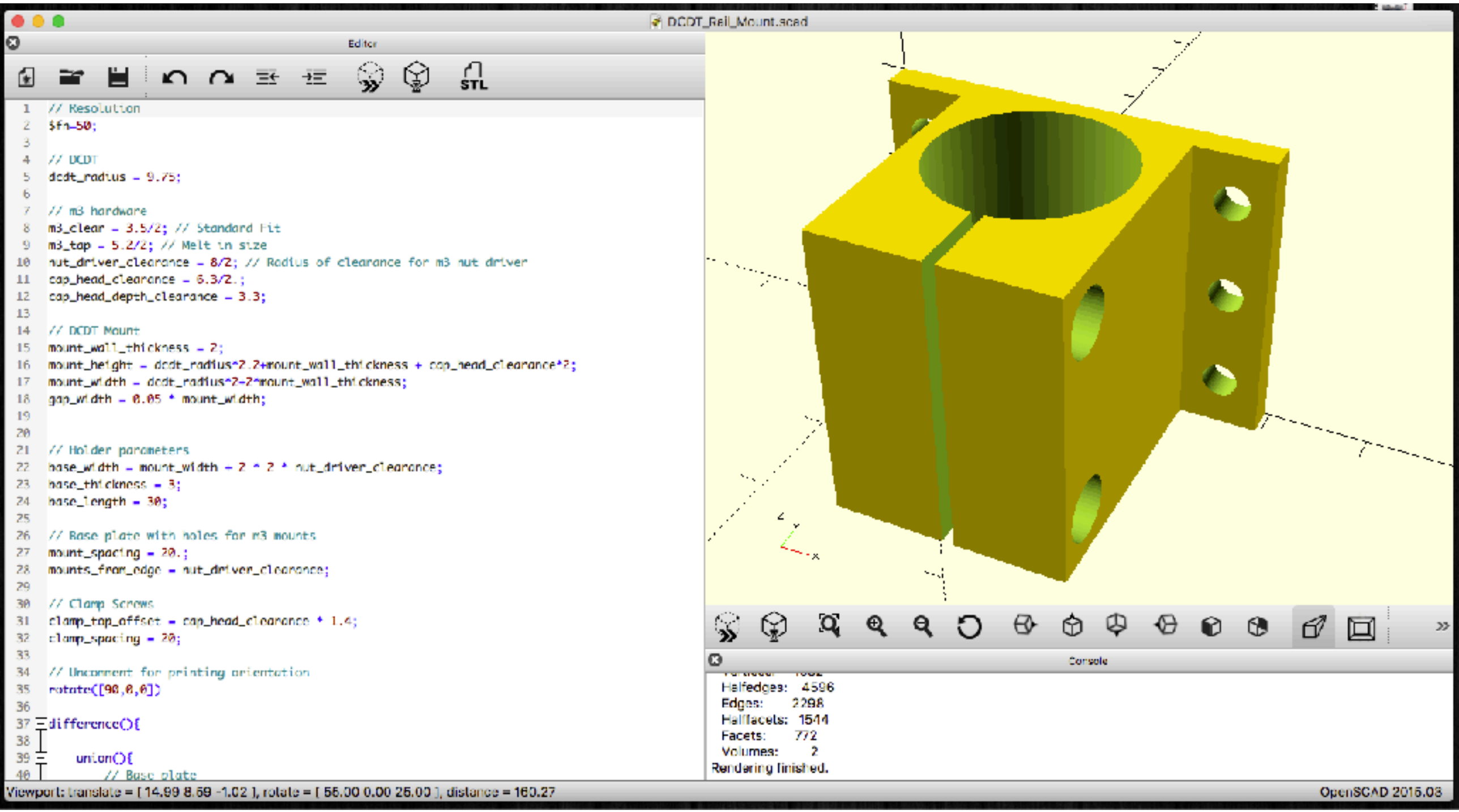


The design is then exported, generally to a STL file

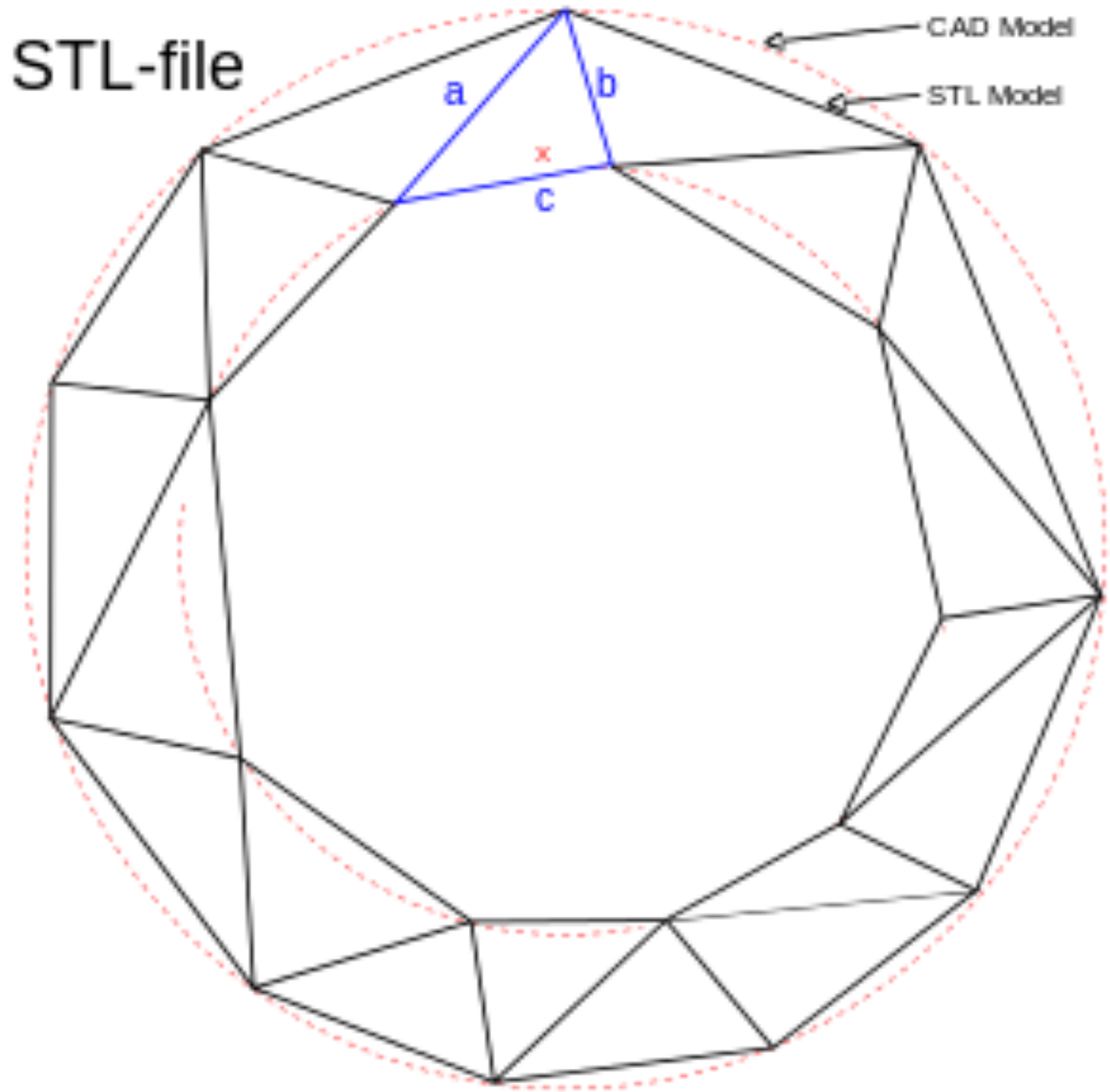


Image: wikipedia.com

We then slice the file to generate fills, rafts, etc.

Image: https://cmumrsdproject.wikispaces.com/All+About+3D+Printers

GCODE generated by the slicer is then sent to the printer

```
; generated by Slic3r 1.0.1 on 2014-08-25 at 19:03:28

; layer_height = 0.22
; perimeters = 2
; top_solid_layers = 3
; bottom_solid_layers = 3
; fill_density = 0.5
; perimeter_speed = 100
; infill_speed = 115
; travel_speed = 180
; nozzle_diameter = 0.35
; filament_diameter = 2.89
; extrusion_multiplier = 1
; perimeters extrusion width = 0.35mm
; infill extrusion width = 0.46mm
; solid infill extrusion width = 0.46mm
; top infill extrusion width = 0.46mm
; first layer extrusion width = 0.70mm

G21 ; set units to millimeters
M107
G28 ; home all axes
M203 X192 Y208 Z3 ; Speed limits to minimize skipped steps when moving really fast courtesy of forun.lulzbot.com user 1013
G90 ; use absolute coordinates
G92 E0
M82 ; use absolute distances for extrusion
G1 F1800.000 E-2.00000
G92 E0
G1 Z0.350 F10800.000
G1 X110.380 Y86.290 F10800.000
G1 E2.00000 F1800.000
G1 X111.300 Y85.380 E2.04314 F1800.000
G1 X112.370 Y84.660 E2.08615
G1 X113.570 Y84.160 E2.12949
G1 X114.840 Y83.910 E2.17265
G1 X144.840 Y80.910 E3.17788
G1 X145.500 Y80.880 E3.19991
G1 X152.500 Y80.880 E3.43330
G1 X153.160 Y80.910 E3.45533
G1 X183.160 Y83.910 E4.46056
G1 X184.430 Y84.160 E4.50372
G1 X185.630 Y84.660 E4.54706
G1 X186.700 Y85.380 E4.59006
G1 X187.620 Y86.290 E4.63321
```

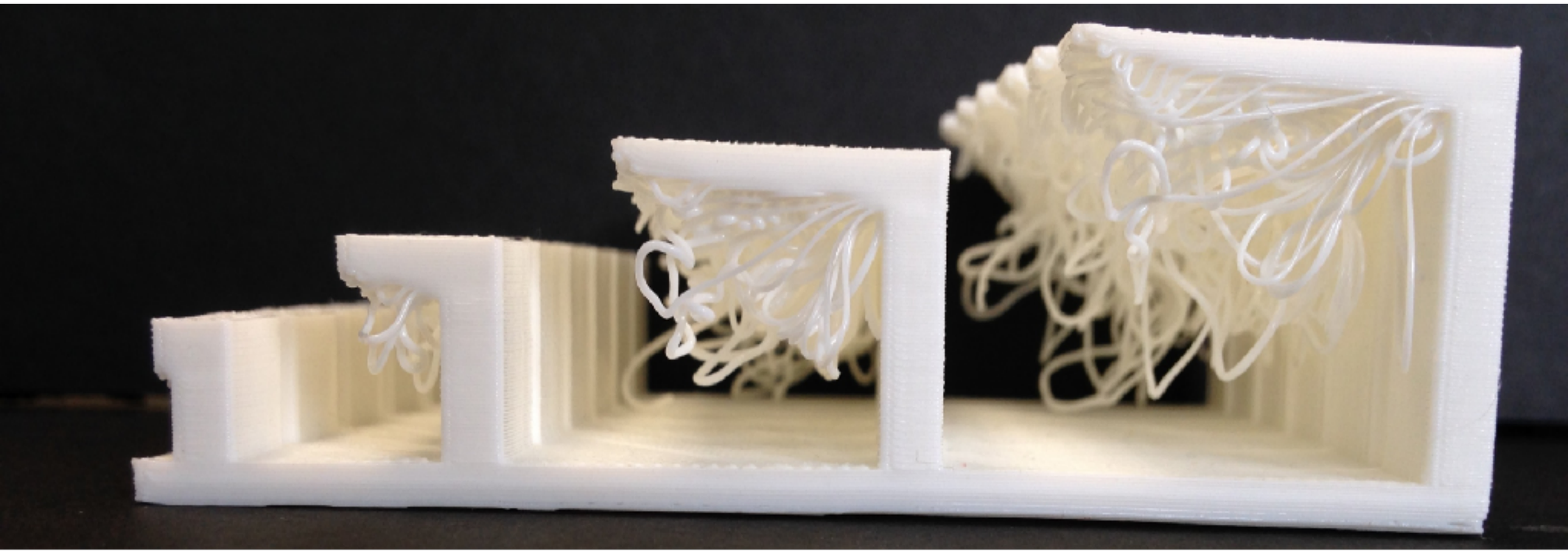
There is a limit to the bridging distance

Clockwise from top left

≤36mm – 0-0.5mm drooping, 36-60mm – 0.5-2mm drooping, ≥60mm – 2-5mm drooping

Image: https://innovationstation.utexas.edu/tip-design/

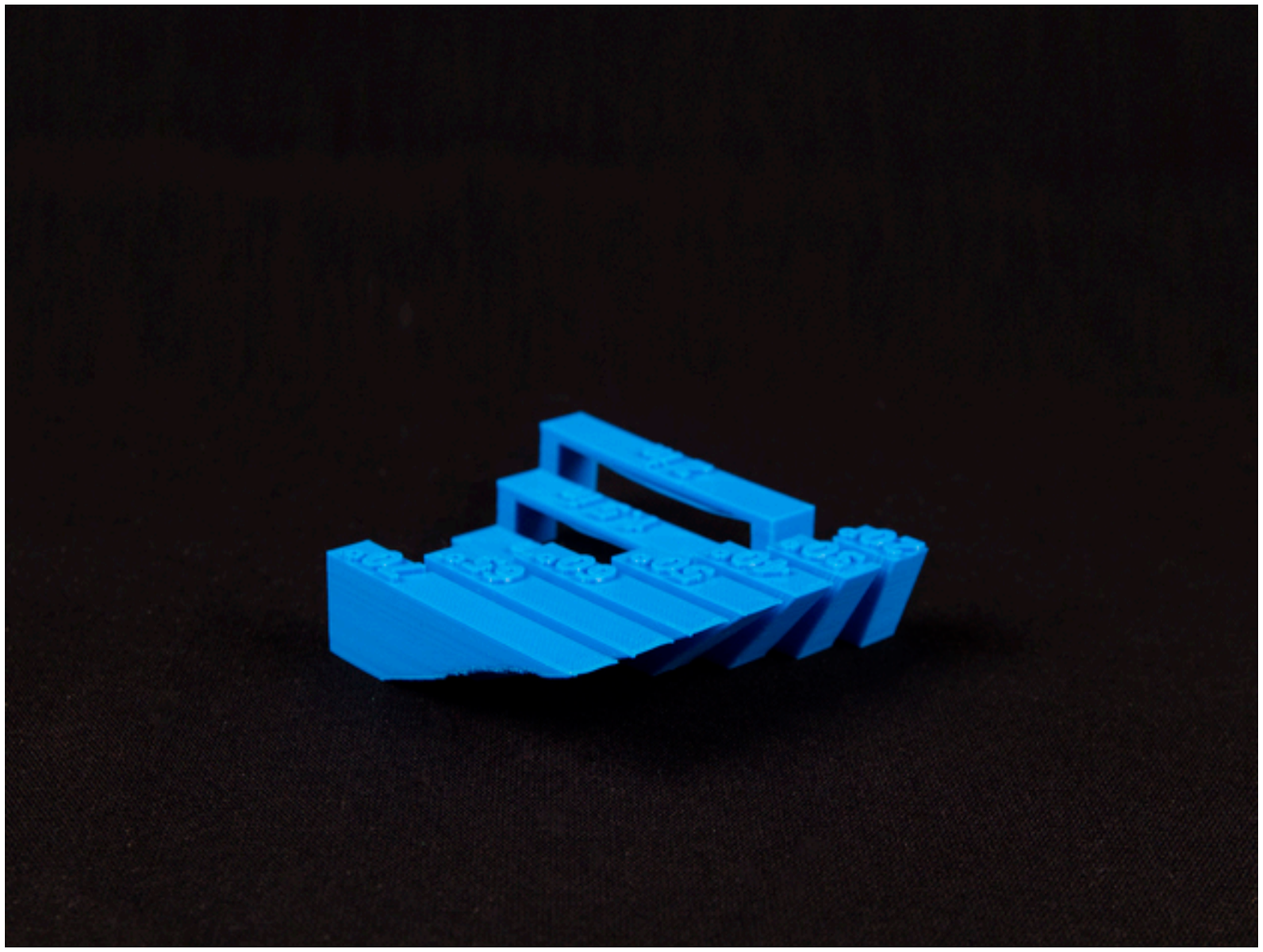
Overhangs should be limited to less than 45 degrees



Failed Horizontal Overhangs

Image: https://innovationstation.utexas.edu/tip-design/

Do a variety of test prints to help you understand a printers capabilities or ask the service provider



Images: http://www.thingiverse.com/thing:858835

Make sure you export the file at a high enough resolution

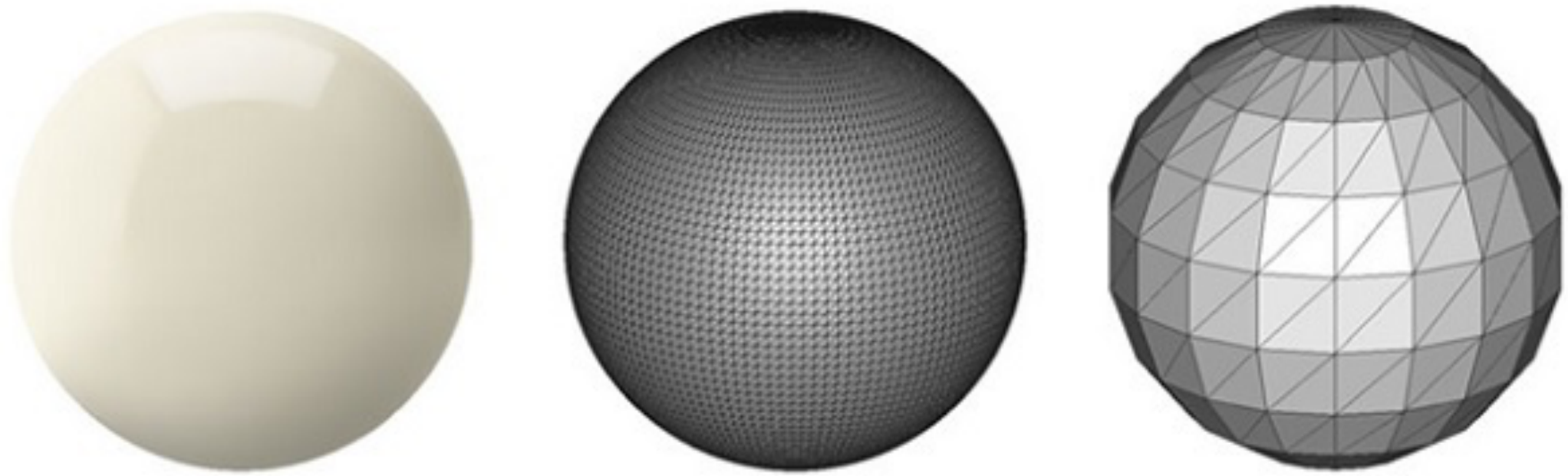
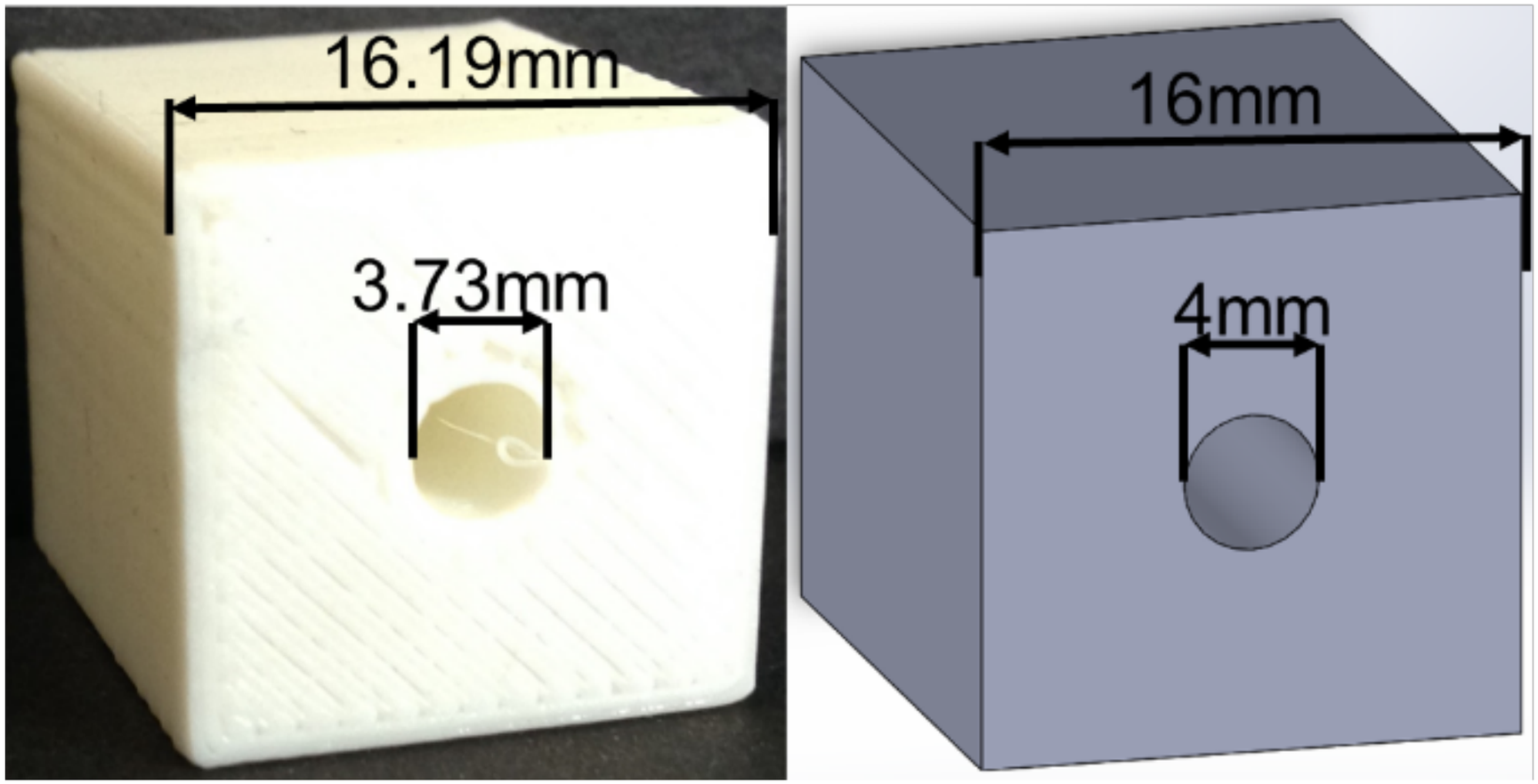


Image: i.materalise.com

You will likely need to account for machine and thermal accuracy



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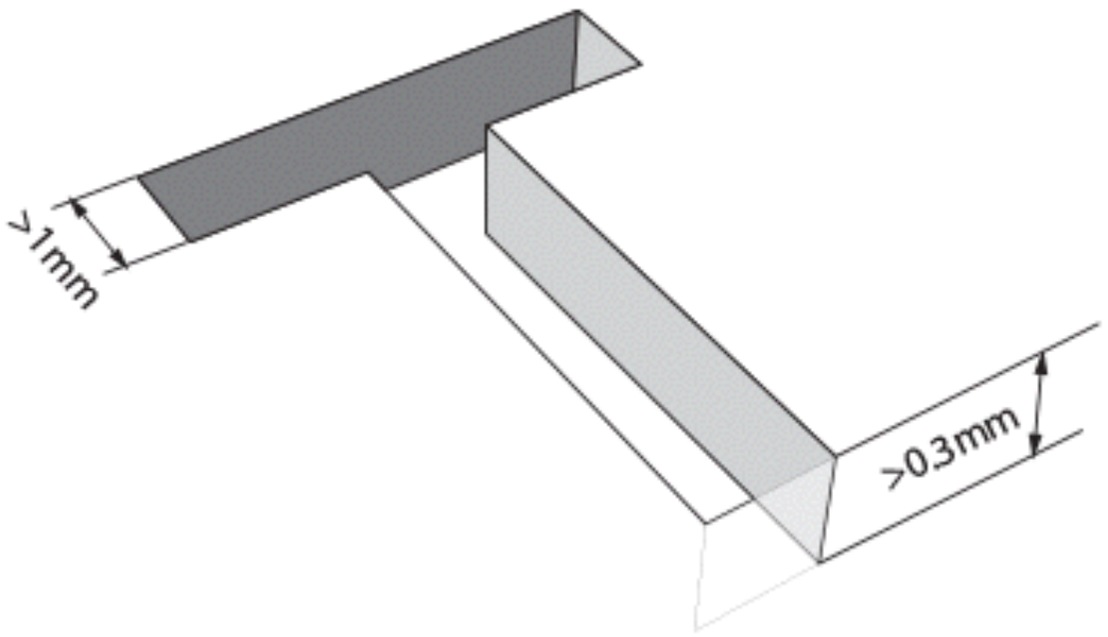
It is easy to make something impossible to machine

Images: http://news.mit.edu/2016/first-3d-printed-robots-made-of-both-solids-and-liquids-0406

Use recessed text (engraved) when possible



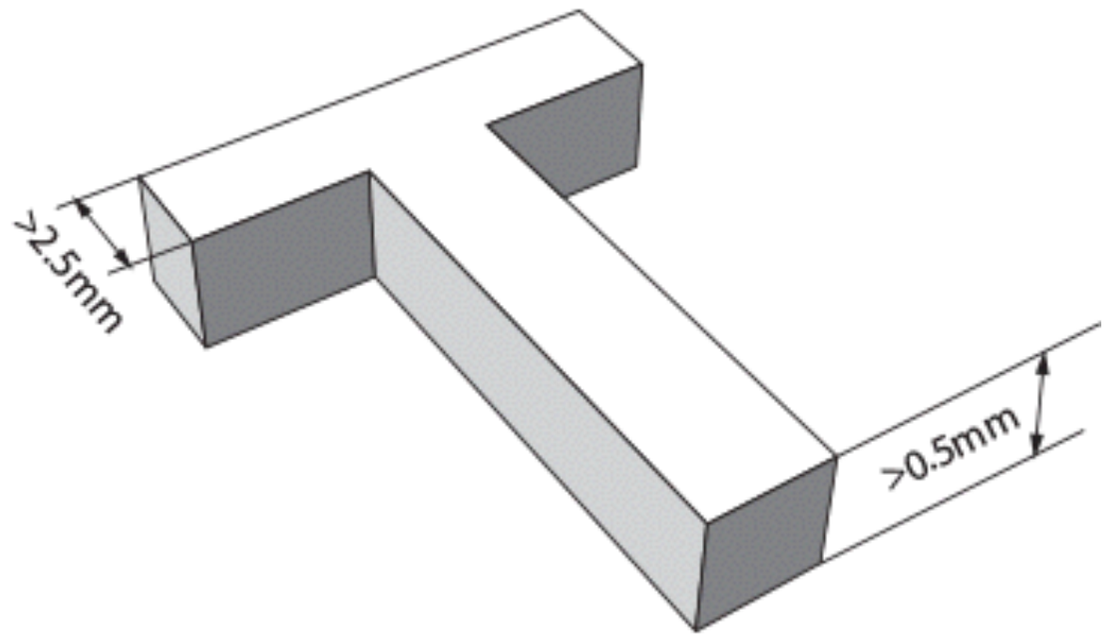
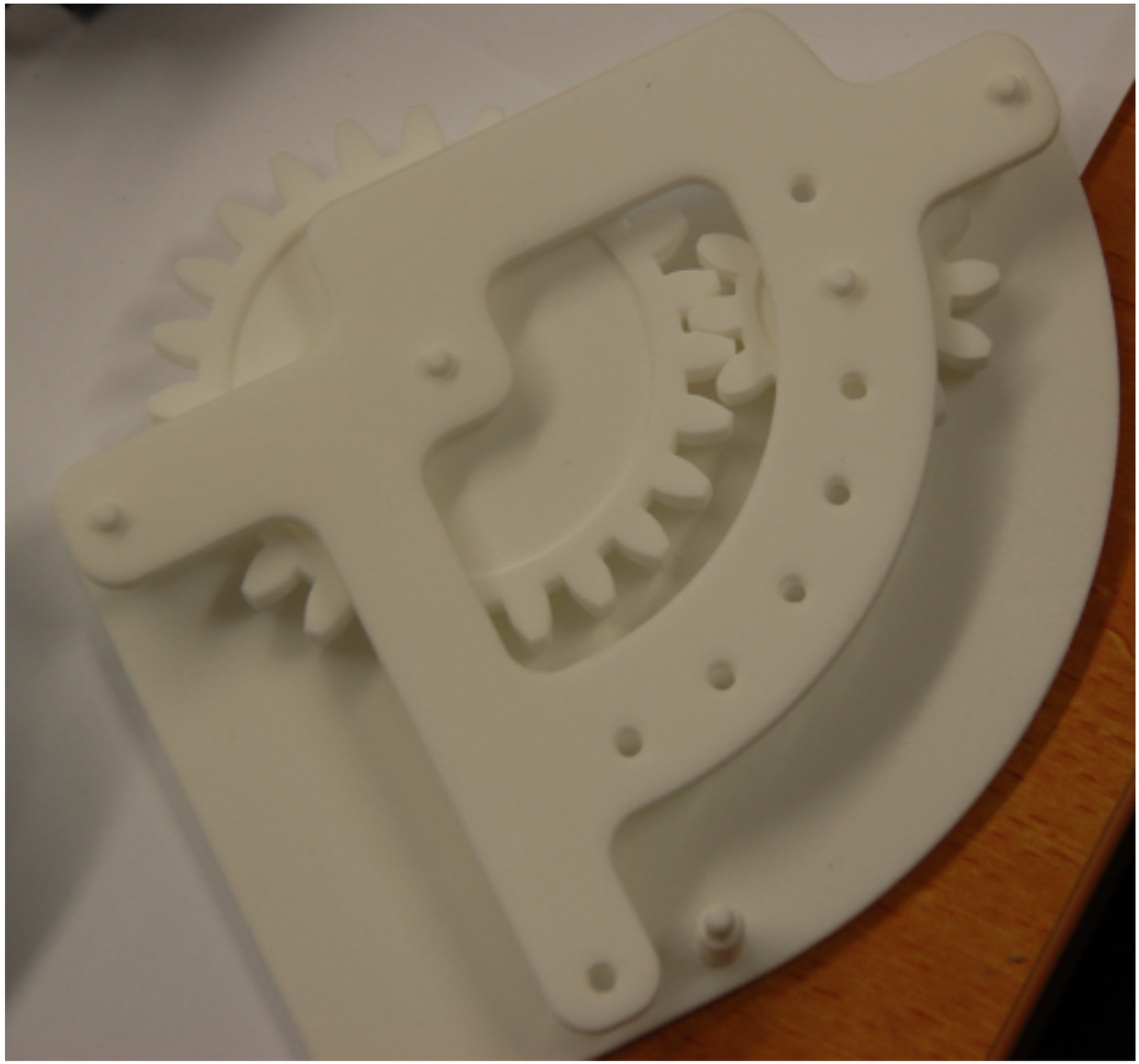


Image: i.materalise.com

Add design clearance for interlocking parts



Images: shapeways.com

Make sure that you use appropriate wall thickness

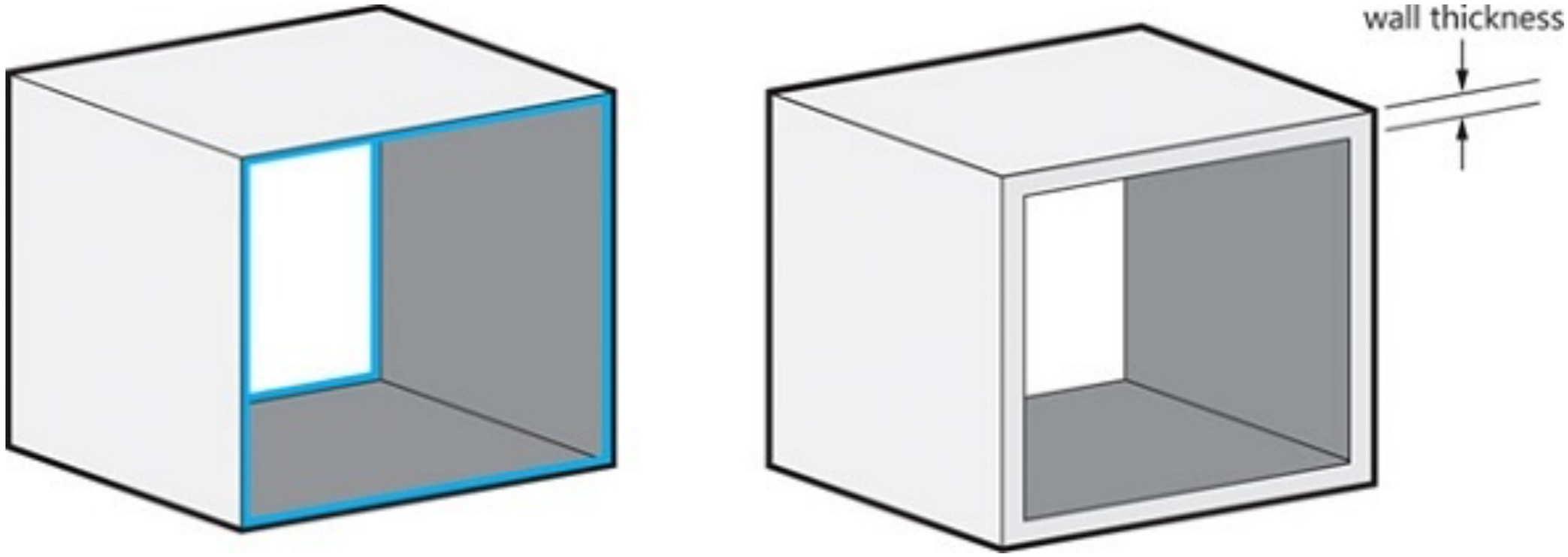


Image: i.materalise.com

The strength of 3D prints is anisotropic

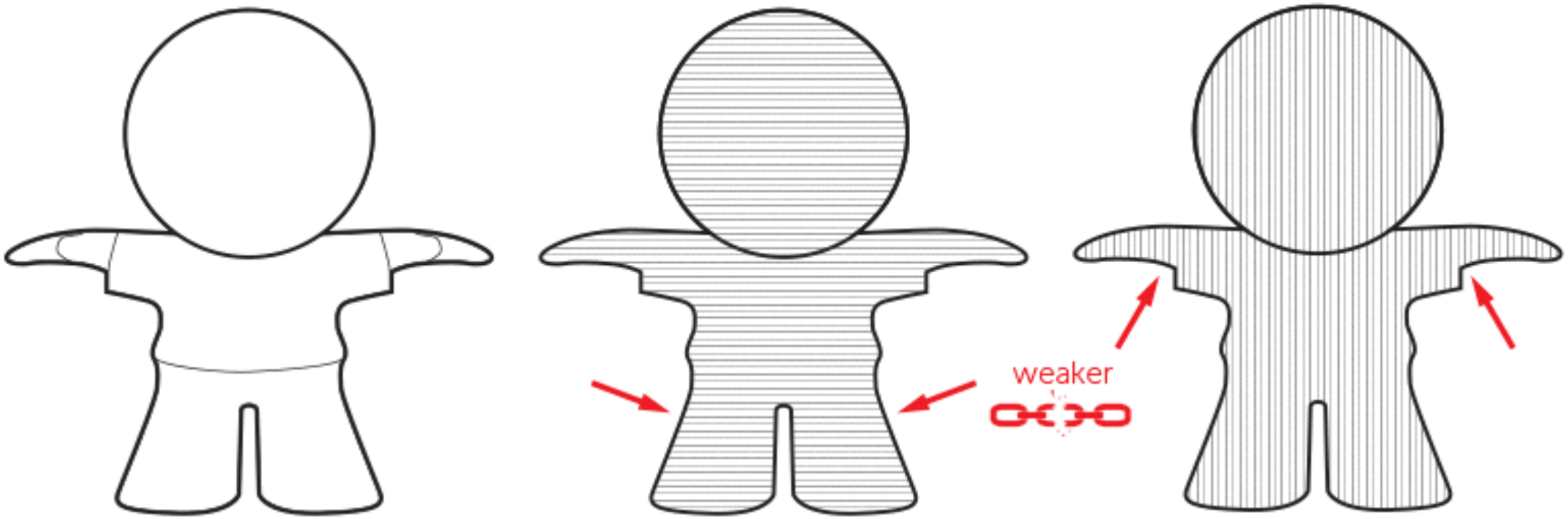


Image: i.materalise.com

There are a number of places to get 3D models online

- http://www.mcmaster.com
- https://grabcad.com
- http://www.thingiverse.com
- https://nasa3d.arc.nasa.gov
- And many more!

Commercial 3D Design Software

3D Studio Max
An extensive suite of 3D design tools, with a unique and intuitive interface.

Windows

AutoCAD
An advanced design and documentation tool. Ideal for architects and design engineers.

Windows, Mac

Cinema 4D
A well known design Suite in the VFX community, it has great tools for 3D modeling for printing as well.

Windows, Mac

Lightwave 3D
A classic 3D graphic software, which includes powerful rendering, animation and modeling tools.

Windows, Mac

Autodesk Maya
A massive, complete suite of tools for professional all aspects of 3D design including modeling, rigging, dynamics and animation.

Windows, Mac

Photoshop CC
The Industry standard software for 2D content editing and creation applied to 3D design. Offers integration directly with Shapeways.

Learn how Photoshop and Shapeways work together

Windows, Mac

Rhinoceros
Very popular curve based modelling software.

Windows, Mac

ZBrush
A popular, advanced 3D sculpting tool with a powerful voxel-based system.

Windows, Mac

Solidworks
An advanced modeling tool that is great for mechanical, precise product design.

Learn how Solidworks and Shapeways work together

Windows, Mac

Free 3D Design Software

Autodesk 123D Design

Easy-to-use yet powerful modeling tool with library of existing components or the ability to create from scratch. Also available for the iPad. Integrated and prints directly to Shapeways.

Learn how 123D Design and Shapeways work together

Windows, Mac, Online Service

Tinkercad

A fantastic beginner program, that leads you to learn complex things through simple quests. Runs right in your browser, and the skills you learn are easily transferable to more advanced programs. Integrated and prints directly to Shapeways!

Learn how Tinkercad and Shapeways work together

Online Service

3D Tin

Another browser based program using WebGL, this is free as long as you share your designs under Creative Commons.

Online Service

Blender

A powerful application with full-fledged professional tools, Blender has a wide community and resources to help you learn.

Learn how Blender and Shapeways work together

Windows, Mac, Linux

FreeCAD

An open source parametric 3D modeler, great for both the home user, hobbyist and experienced designer. Parametric modeling allows for easy editing of your design.

Windows, Mac, Linux

Open SCAD

OpenSCAD is not an interactive 3D design tool. It is something like a programmatic 3D-compiler that reads a script file containing 3D geometry definitions, and in turn generates a solid 3D model as output.

Windows, Mac, Linux, BSD

Sculptris

A free, introductory digital sculpting tool, a great stepping stone for digital sculptors, created by the makers of Zbrush.

Windows, Mac

Sketchup

Drawing-based tool for architects, designers, builders, makers and engineers who design for the physical world. SketchUp Make is a free version and SketchUp Pro is a paid version with additional functionality.

Windows, Mac

3D Model To Print

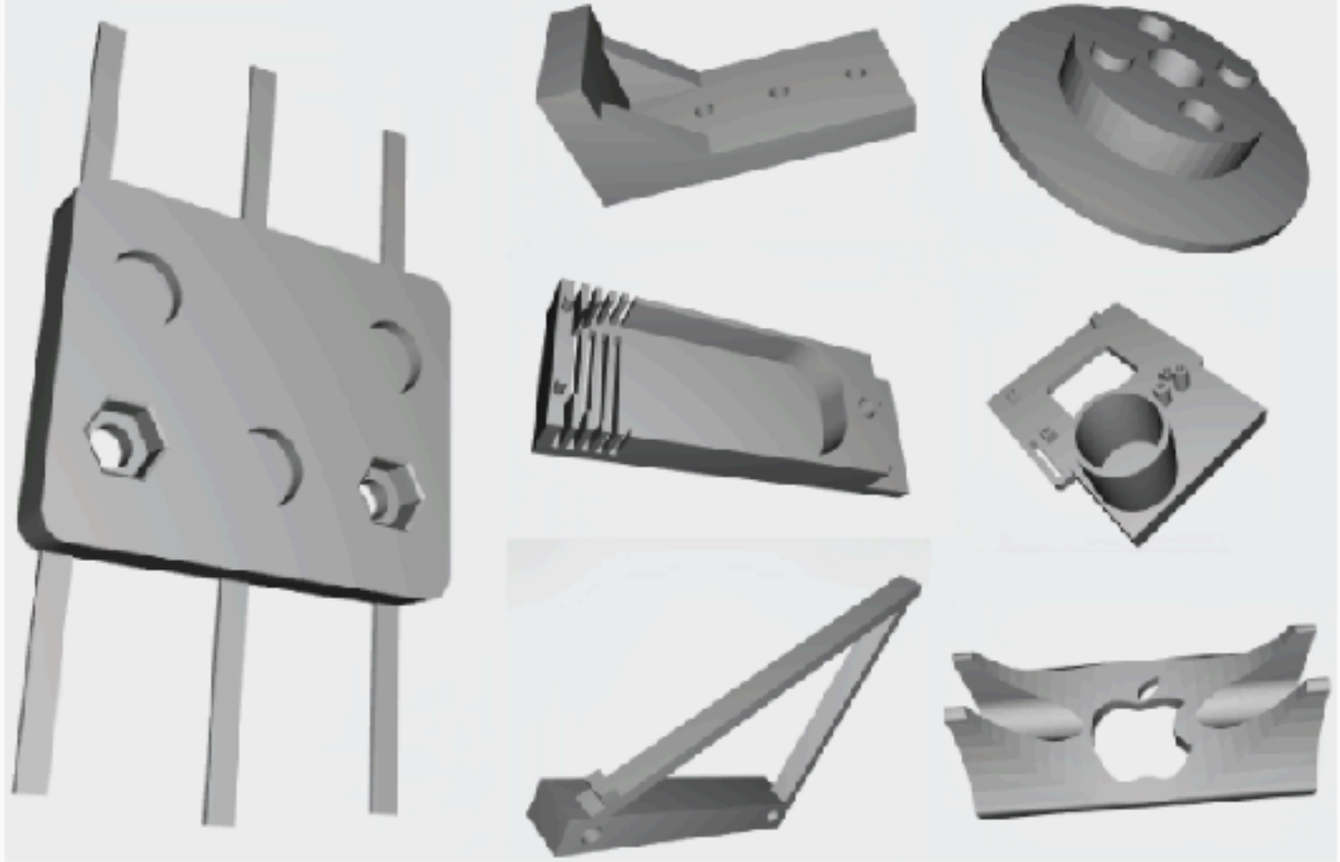
A cloud-based software service, focused on 3D architectural models. 3DMTP automatically and efficiently transforms 3D designs into scalable and 3D printable model files.

Online Service

Assignment: 3D Printing Activity

In this activity you will design and print a 3D part. You may take an existing CAD file from a repository such as Thingiverse, GrabCAD, etc. and modify it to suit your purpose (must be a non-trivial change) or create your own design. You can make your design in your preferred CAD tool, a few great choices are OnShape, OpenSCAD, FreeCAD, AutoDeskInventor , and SketchUp These can be simple brackets and parts or very complex structures. Be sure to make something that actually can be 3D printed though - remember the design concerns we discussed in class. A few examples of CAD files designed for 3D printing are shown below.

Many universities, public libraries, and maker spaces have 3D printers that you can use for little or no cost. Penn State operates the Maker Commons as a part of the library that allows students to print. There are also commercial service bureaus that will make your print on professional grade machines and ship it to your door. Of these, Shapeways seems to have the largest variety of materials and services. Often service bureaus and library services can get very busy, so make sure you allow enough time for manufacturing and shipping!



DUE: 10/13/16

Activity: Designing Parts in OnShape