VINTAGE COMPUTER DESIGN AND REPAIR WITH 3D PRINTING

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INTRODUCTION

A BRIEF HISTORY OF 3D PRINTING

- 1981: Hideo Kodama, from Nagoya Municipal Industrial Research Institute, describes a rapid protoyping system, which uses photopolymer
- 1984: Charles Hull (founder of 3D Systems) invents stereolithography, and with it, the STL file format
- 1988: S. Scott Crump (founder of Stratasys) invents fused deposition modeling (FDM)
- 1992: 3D Systems creates the first practical stereolithography (SLA) machine and Dr. Carl Deckard and Dr. Joe Beaman launch DTM, which makes selective laser sintering (SLS) practical

3D PRINTING TECHNOLOGIES

STEREOLITHOGRAPHY (SLA)

- Stereolithography is the process in which a photopolymer is activated by a focused laser beam, to form, layer by layer, a solid object from a fluid base
- SLA printing produces very detailed parts fairly quickly, but the cost is fairly high, since the raw liquid plastic is manufacturer-specific, and a significant amount is wasted during the printing process
- SLA is most often used to create models with fine details that do not require significant physical durability, in the finished product

SELECTIVE LASER SINTERING (SLS)

- In selective laser sintering (SLS), a laser is focused on powdered material, causing it to fuse together
- SLS requires a fairly high-powered laser, causing the cost for printers to be high
- In addition, there is significant waste, as most of the unfused powder must be disposed of
- In comparison to other 3D printing technologies, SLS-created models can be made from a much wider selection of materials (metals, glass, ceramics), and finished products are very durable, and are suitable for use in demanding environments

FUSED DEPOSITION MODELING (FDM)

- FDM is almost always the technology being described, by those outside of the hobby, when they say “3d printing”
- In FDM printing, a solid plastic filament (PLA, PET, ABS, to name a few) is heated to melting temperature, and extruded by pressure on the filament, above the heating element
- The filament is unwound from a spool, and either pulled or pushed into the printer

HARDWARE

TOOLS

- A good pair of calipers is an absolute must. I suggest these, for ~$40 USD
- Get yourself a ruler that has both inches (1/32") and millimeters
- Blue painter's tape. Get some that is at least a 2 inches wide
- PVA glue stick. Elmer's is fine
- Tweezers
- Putty knife. Get one with as thin an edge as possible
- Patience. You will mis-measure, create unprintable objects, have printer problems, and break parts. At least, I do!

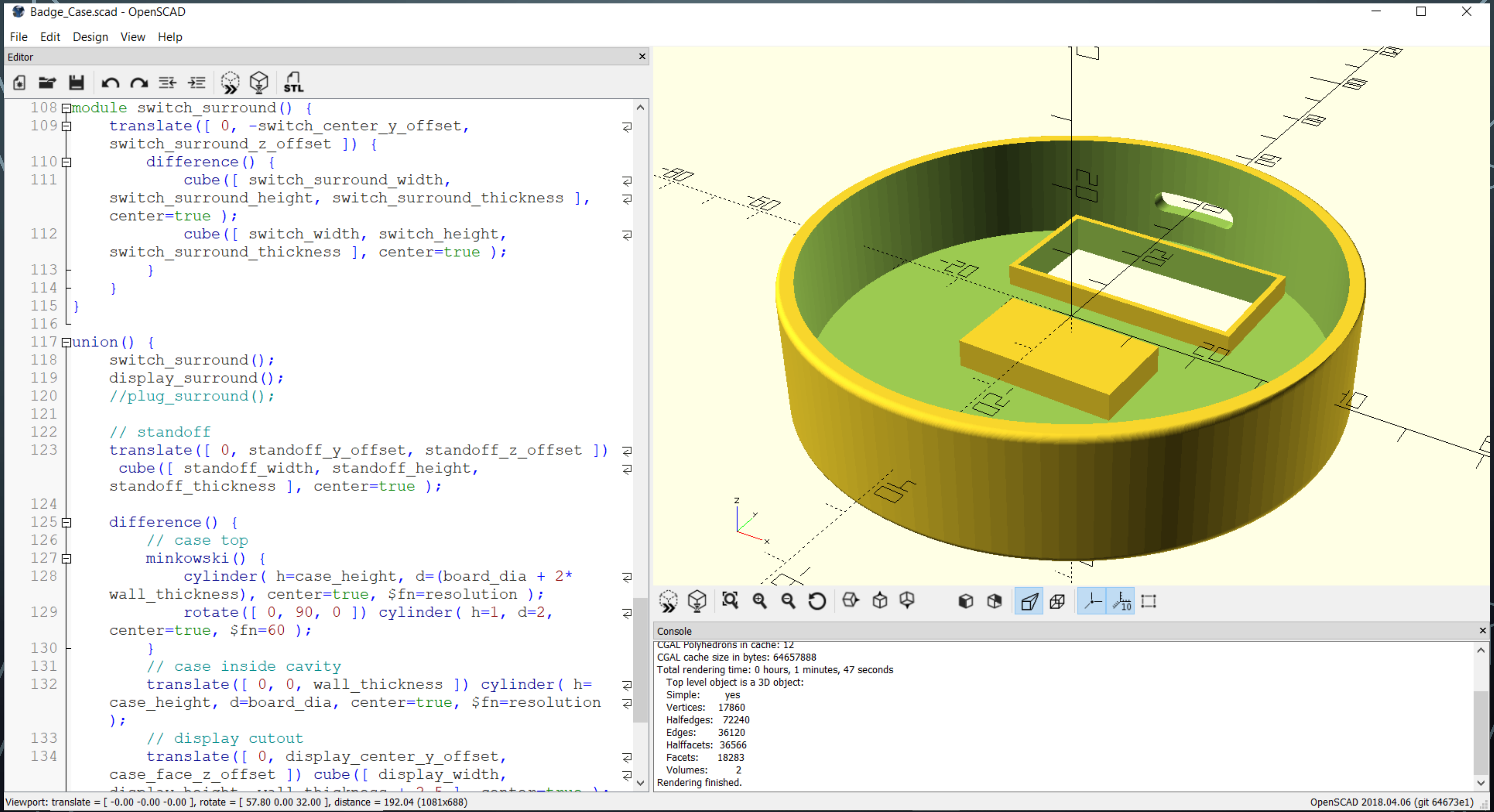
PRINTER SUGGESTIONS

- This is definitely not an exhaustive list!
  - Prusa i3 MK2/2S/3. The MK2S is available here, for $599 USD, in kit form. 250x210x200mm.
  - Creality CR-10. Slightly larger 300x300x400mm build area, and very popular. Available widely, GearBest often has the best prices, currently ~$400 USD.
  - Cetus 3D Printer, MKII. Linear rail-based 3D printer which produces very high quality small objects. The manufacturer's website lists it for ~$359 USD. 180x180x180mm.
  - Monoprice MP Select Mini V2. Another linear raid printer, good for beginners. 120x120x120mm. Available here for ~$200 USD.
- Note that I am only suggesting cartesian printers. They are the easiest for new users to get good results from

CAD PROGRAMS

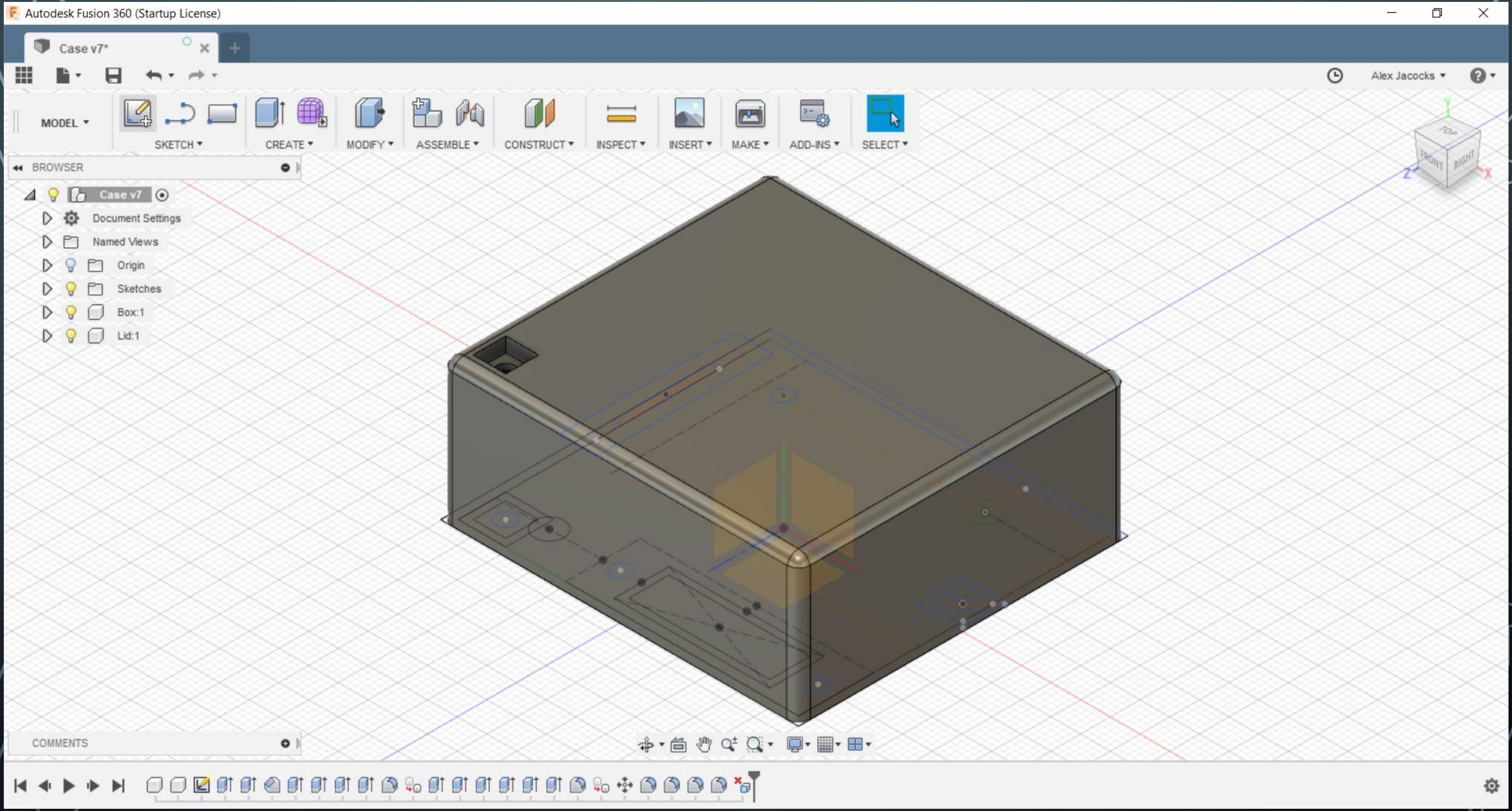
OPENSCAD

- OpenSCAD is often referred to as “the programmer’s CAD package”
- Objects are defined by their position and size, in text
- OpenSCAD is very powerful, in that techniques most often used for programming can be applied to modeling:
  - Variables
  - Functions
  - Loops


Badge_Case.scad - OpenSCAD
File Edit Design View Help
Editor
module switch_surround() {
translate([0, -switch_center_y_offset, switch_surround_z_offset]) {
difference() {
cube([switch_surround_width, switch_surround_height, switch_surround_thickness], center=true);
cube([switch_width, switch_height, switch_surround_thickness], center=true);
}
}
}
union() {
switch_surround();
display_surround();
//plug_surround();
// standoff
translate([0, standoff_y_offset, standoff_z_offset]) cube([standoff_width, standoff_height, standoff_thickness], center=true);
difference() {
// case top
minkowski() {
cylinder(h=case_height, d=(board_dia + 2* wall_thickness), center=true, $fn=resolution);
rotate([0, 90, 0]) cylinder(h=1, d=2, center=true, $fn=60);
}
// case inside cavity
translate([0, 0, wall_thickness]) cylinder(h= case_height, d=board_dia, center=true, $fn=resolution);
// display cutout
translate([0, display_center_y_offset, case_face_z_offset]) cube([display_width,
Console
CGAL Polyhedrons in cache: 12
CGAL cache size in bytes: 64657888
Total rendering time: 0 hours, 1 minutes, 47 seconds
Top level object is a 3D object:
Simple: yes
Vertices: 17860
Halfedges: 72240
Edges: 36120
Halffacets: 36566
Facets: 18283
Volumes: 2
Rendering finished.
Viewport: translate = [-0.00 -0.00 -0.00], rotate = [57.80 0.00 32.00], distance = 192.04 (1081x688)
OpenSCAD 2018.04.06 (git 64673e1)

FUSION 360

- Fusion 360 is a closed-source 3D CAD/CAM package, by Autodesk
- Most modeling in Fusion is done by creating a two-dimensional sketch, and then extruding it into the third dimension
- Fusion is a very powerful package, even in its free version. It includes both advanced modeling and slicing (CAM) capabilities, and can generate output suitable for a milling machine or laser cutter, in addition to 3D printers


Autodesk Fusion 360 (Startup License)
Case v7*
Alex Jacocks
MODEL
SKETCH
CREATE
MODIFY
ASSEMBLE
CONSTRUCT
INSPECT
INSERT
MAKE
ADD-INS
SELECT
BROWSER
Case v7
Document Settings
Named Views
Origin
Sketches
Box:1
Lid:1
COMMENTS

OTHERS

- FreeCAD. https://www.freecadweb.org/
  - Open source, powerful, has Linux, Mac OS X, and Windows versions
- SketchUp. https://www.sketchup.com/
  - Popular closed-source package, created by Google, runs on Mac OS X and Windows
- TinkerCAD. https://www.tinkercad.com/
  - Another Autodesk product, simple to use, but limited to 200x200x200mm objects. Web-based

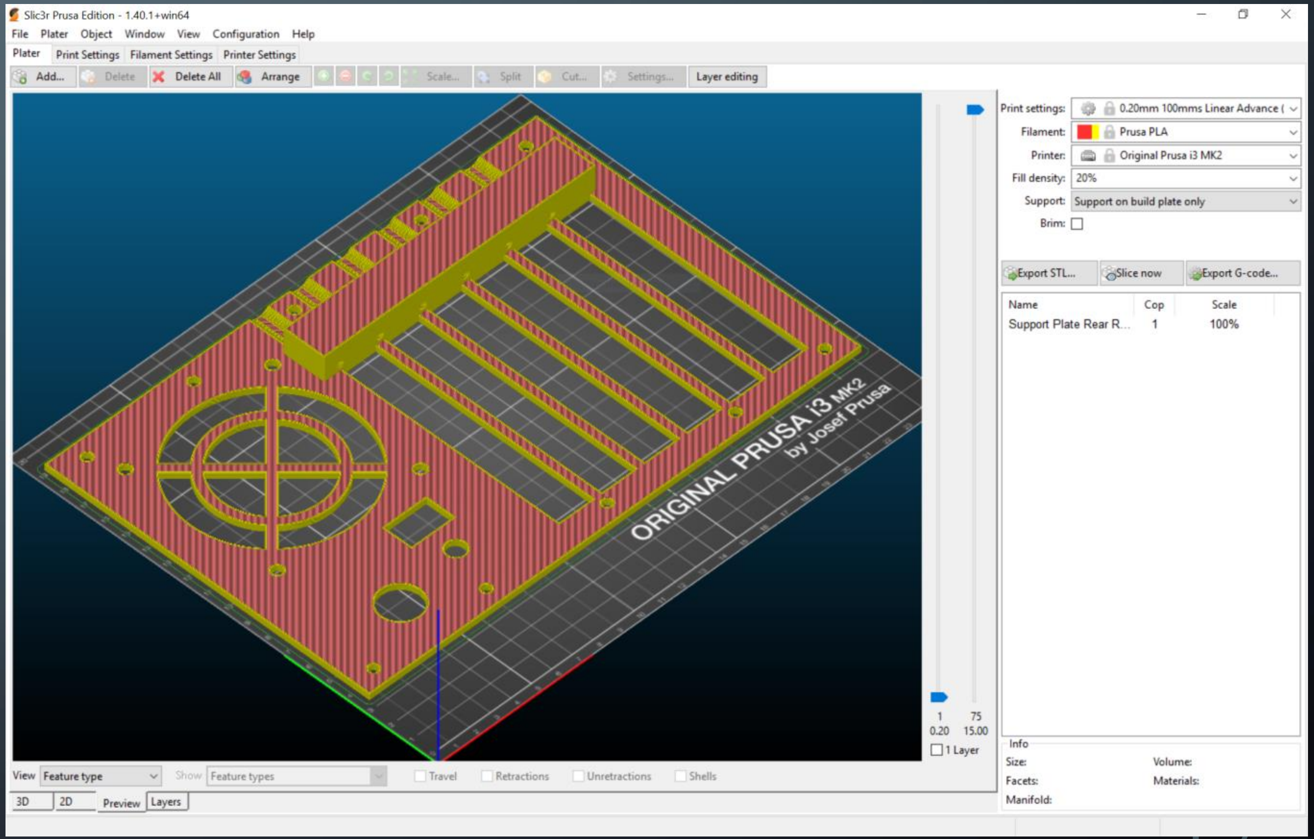
SLICER (CAM) PROGRAMS

SLICING SOFTWARE OVERVIEW

- Slic3r
  - Popular and fairly easy to use. Open-source, backed by Prusa Research
- Cura
  - Another Open Source alternative, backed by Ultimaker
- Simplify 3D
  - Closed source, but very powerful, especially useful for custom supports. Learning curve, ~$150 USD
- Repetier
  - Open source, but not as popular as it was in years past. Moderately easy to use
- Octoprint
  - Printing front end specifically designed to provide a web front-end for printers lacking one. Open source

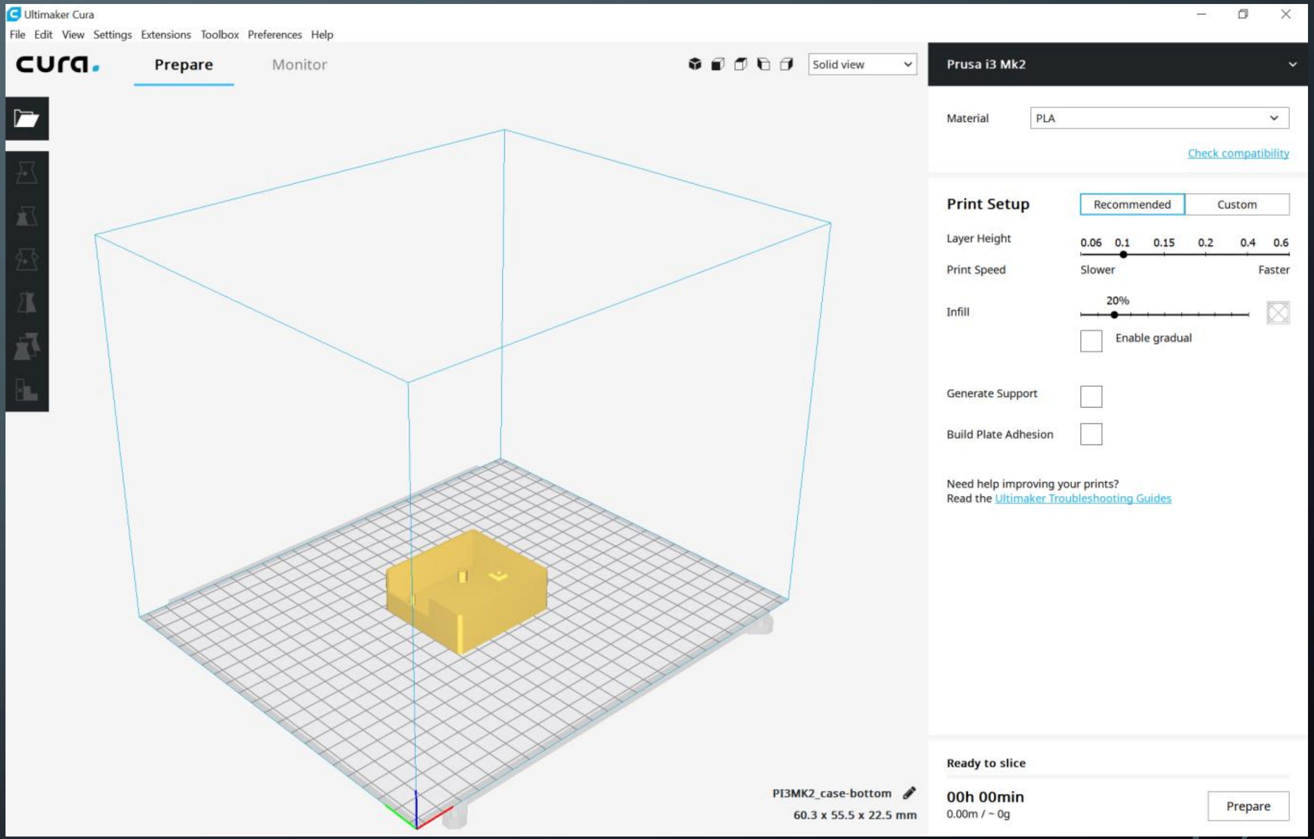
SLIC3R PRUSA EDITION

- This is Slic3r Prusa Edition, v1.40.1
- You can see the ISA riser for my micro 386 case, on the virtual build plate, showing a preview of how it will be printed



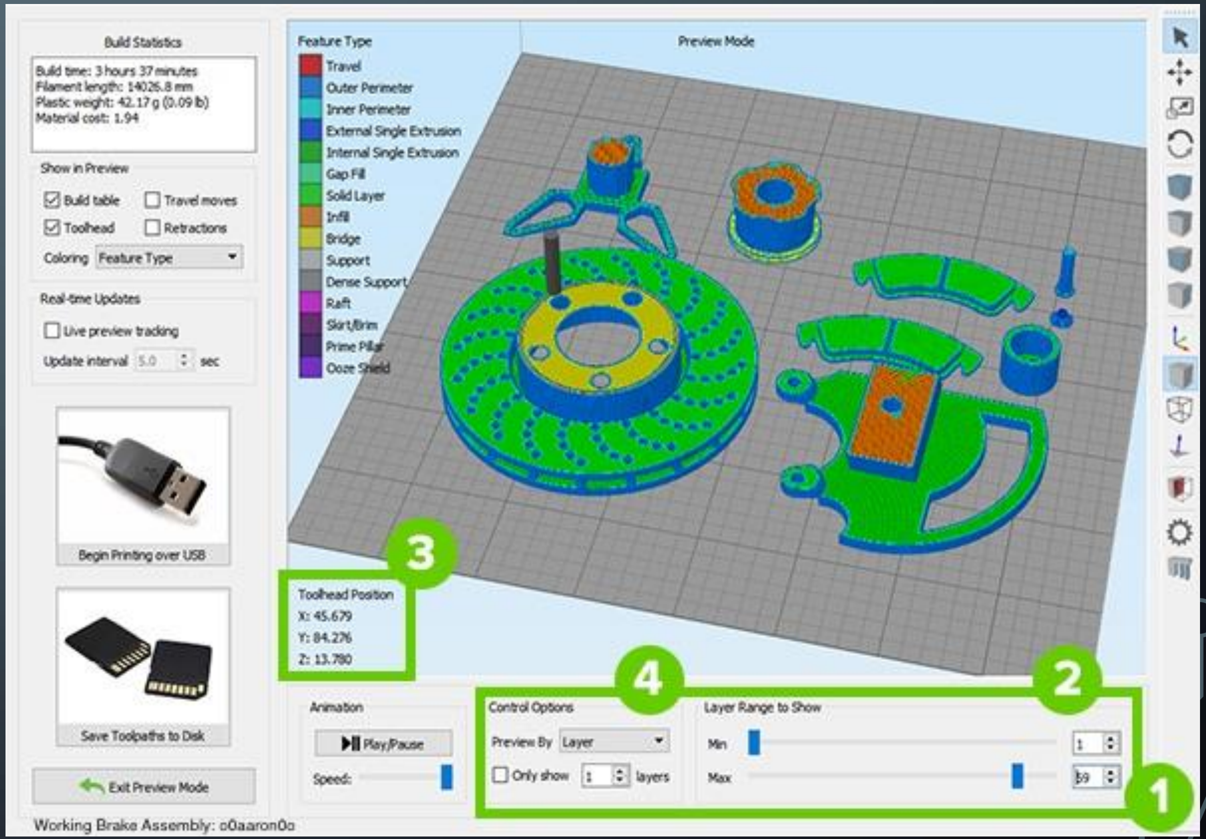
CURA

- This is Cura 3.4.1
- I have placed the back half of my Nishida Radio lic VGA adapter case on the virtual build plate



SIMPLIFY 3D

- This is Simplify 3D, v4
- You can see several model car parts, placed on the virtual build plate, and a highlighted parts of the user interface



DESIGN SUGGESTIONS

DESIGNING FOR SUCCESSFUL PRINTING (FDM)

- Avoid warping!
  - Warping is caused by the failure of the printed object to adhere to the bed
  - All FDM-printed objects need at least one large flat surface, to successfully adhere
    - If your object does not natively have such a surface, you can create a raft, in your slicer
    - Rafts do affect the surface finish of the object, but if you need one to get your object to stick, don't hesitate
  - Make sure that your heated bed (if you have one) is set to the right temperature for your filament!
  - PVA glue and blue tape can also make the object stick better to your bed
  - Warping is particularly a problem with ABS, and to a lesser extent PET, printing

DESIGNING FOR SUCCESSFUL PRINTING (FDM)

- Avoid unnecessary overhangs!
  - Overhangs are portions of a 3D model that have no plastic below them, and don't sit directly on the build plate
  - Overhangs with angles of up to ~45° are usually fine
  - Arches can help your overhangs to droop less
  - Most slicers have automatic bridging (overhang between two supporting members) detection, and will automatically slow down to help avoid droop
  - Consider rotating your object, to turn overhangs into easier to print vertical objects
  - Use supports, if large overhangs are unavoidable

DESIGNING FOR SUCCESSFUL PRINTING (FDM)

- Understand and properly set up your printer!
  - Every different printer has different strengths and weaknesses
  - When in doubt, print slower, at a larger layer height
    - Layer heights of < 0.2mm are usually only needed for fine details
  - You can mitigate weaknesses through good model design, and by using materials like PVA glue, blue tape, or a variety of build plate surfaces
    - Buildtak
    - PEI

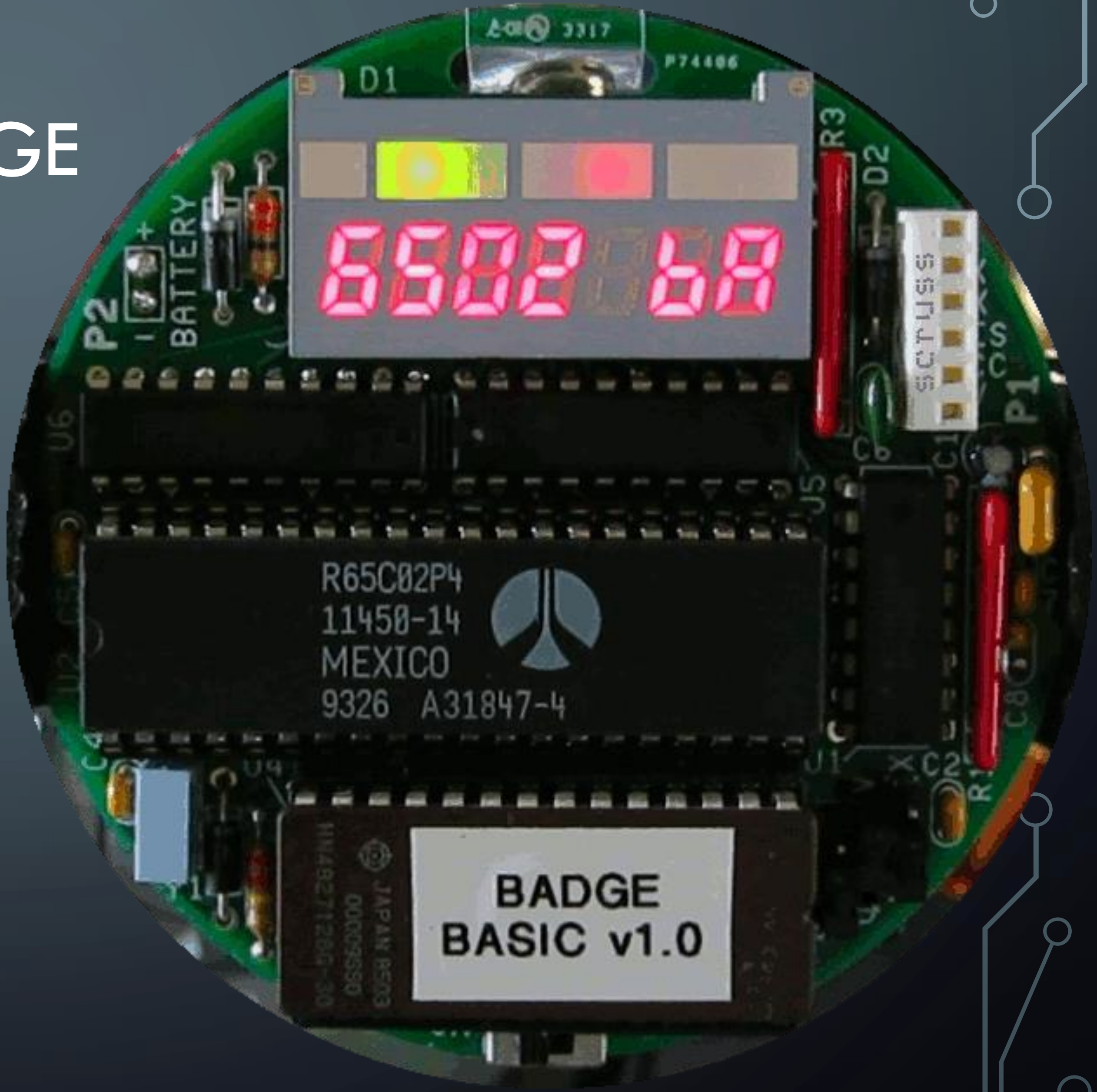
DESIGNING FOR SUCCESSFUL PRINTING (FDM)

- When in doubt, steal!
  - Of course, I mean to re-use work, rather than to roll your own
  - Thingiverse is a wonderful source of pre-created objects that you can modify and re-use
  - Many creators post OpenSCAD or Fusion 360 models of the objects that they share
  - STLs can be edited in TinkerCAD
  - Netfabb online is great for repairing broken mesh

EXAMPLE PROJECTS

VCF MIDWEST 6502 BADGE

- This project illustrates the workflow of OpenSCAD fairly well
- Well-designed OpenSCAD projects make great use of variables and functions, though neither is required
- Initially, all of the functions were code in the main section, but were separated out to simplify the design

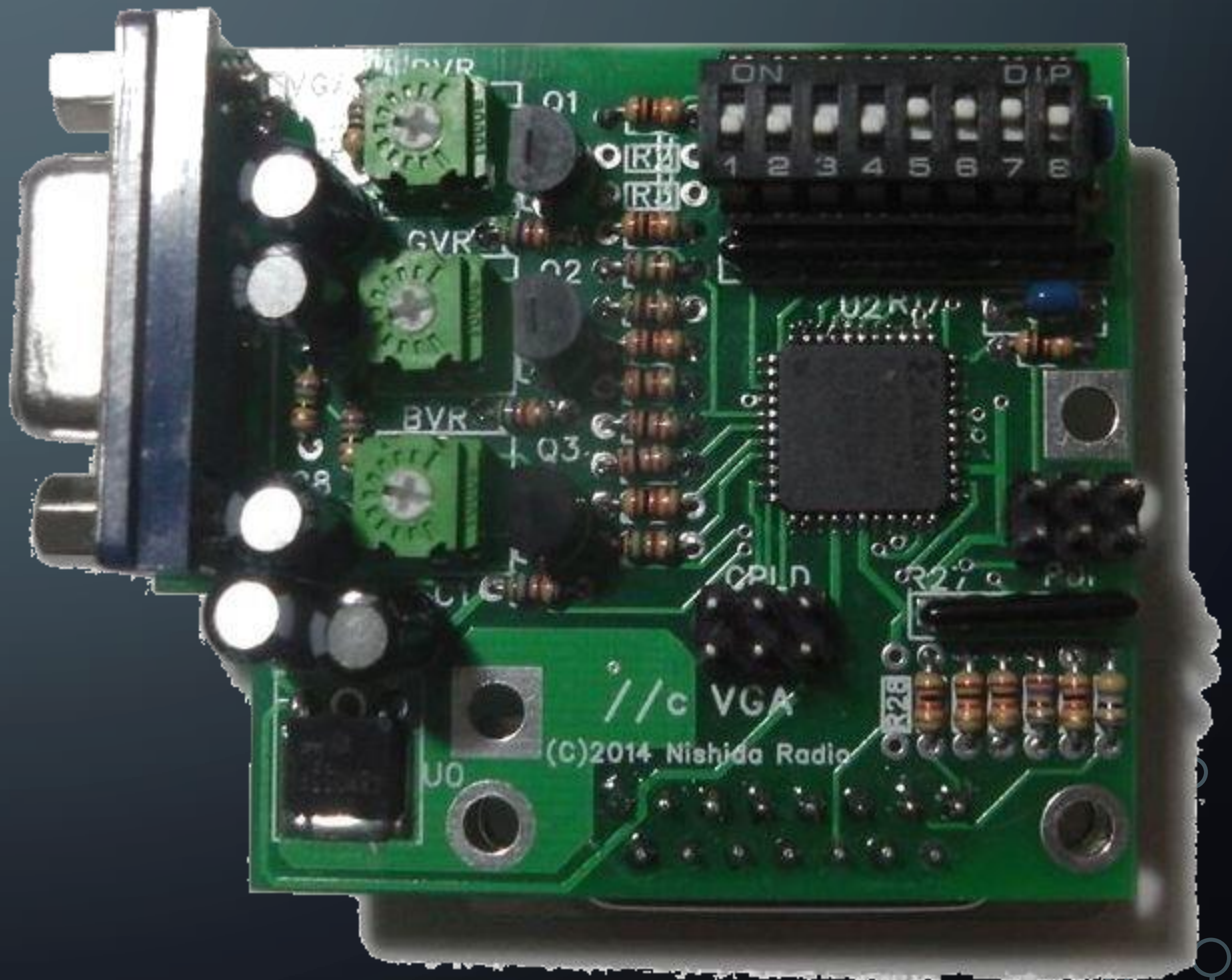


VCF MIDWEST 6502 BADGE

- These are the front and back of the finished badge case
- You can see the surface finish that good contact with a smooth bed can produce
- These were printed with 0.2mm layer heights

IIC VGA ADAPTER (NISHIDA RADIO) CASE

- I created this project to learn Fusion 360 better
- It was completed over two days
- There is nothing at all complex being done, but it does illustrate how much easier it is to apply operations like chamfers or round-overs to an object in Fusion, as compared to OpenSCAD



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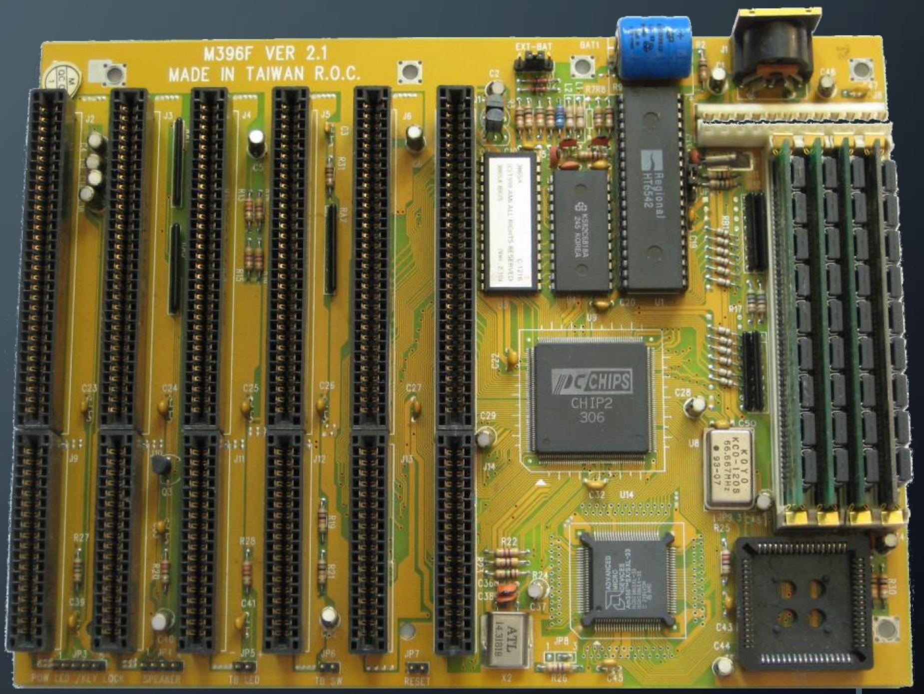
MICRO 386 CASE

- This project was created in TinkerCAD
- I split it up into multiple files in order to make it easier to print
- There were many iterations required to produce the final object
- I find TinkerCAD to be fairly easy to use, because it reminds me of a number of vector drawing programs, like MacDraw, with the addition of 3D objects



MICRO 386 CASE

- The final product fits quite well
- Unfortunately, the Amazon-special power brick failed to regulate the voltage properly, and killed the motherboard, during initial testing
- I plan to finish the project, some time later this year

CONCLUSION

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- “3D printing.” Wikipedia, 11 July 2018, en.wikipedia.org/wiki/3D_printing.
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