WHAT CAN 3D PRINTING DO FOR WOODTURNERS AND WOODWORKERS?

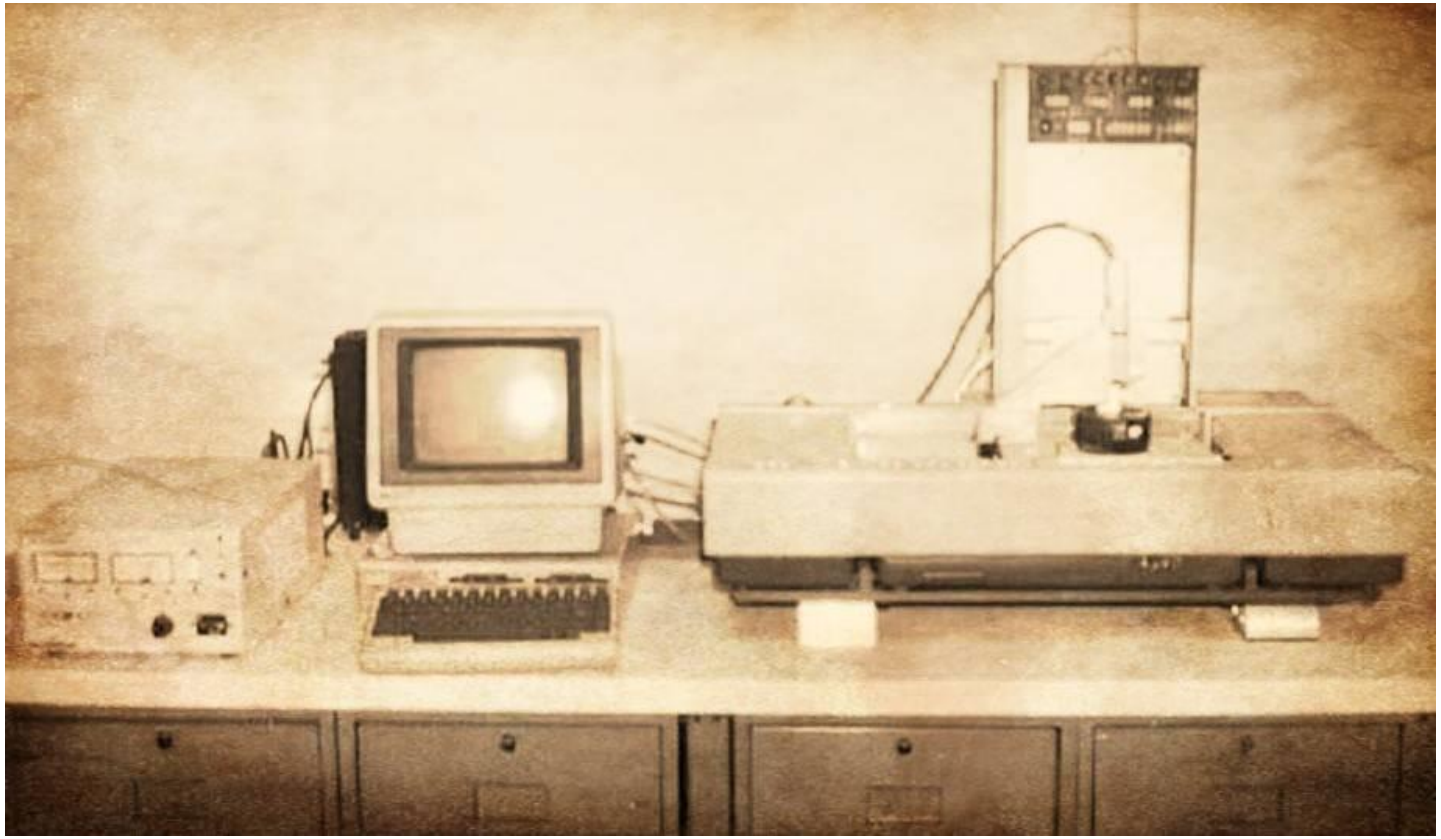
And how do I start?

OVERVIEW

- 3D printing presents a world of possibilities for woodturners and woodworkers as well as an entry into a fascinating branch of modern technology.
- This short guide gives an introduction to 3D printing for the home hobbyist and explores some of the software, hardware and online resources.
- Some ready to use print files are included.
- This presentation is a selection of images and info extracted from the Web and photos of my own prints.

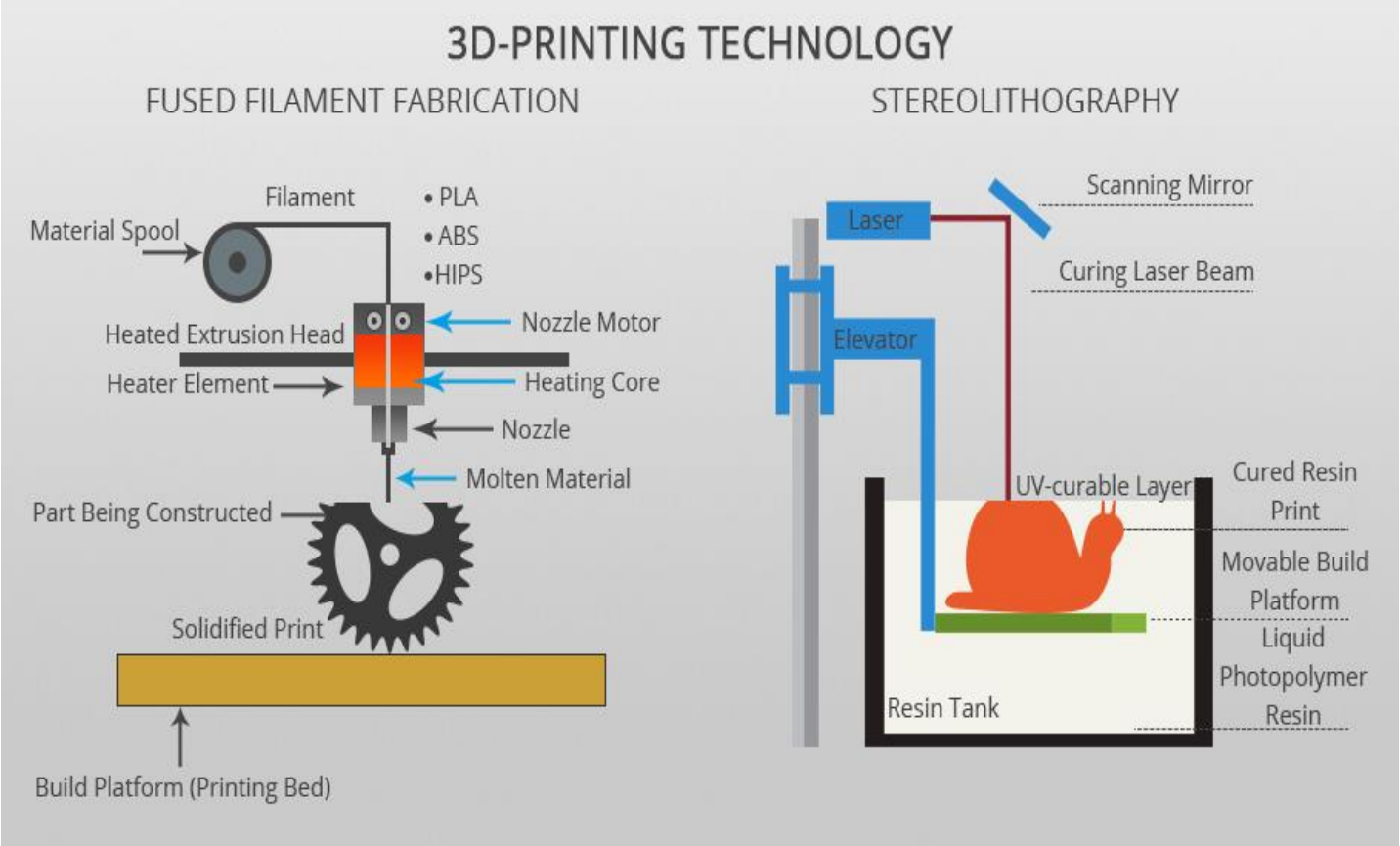
WHAT IS A 3D PRINTER?

- In 1983, Chuck Hull created the first working 3D printer. He also created the STL files format that we still use today. In 2014 he was added to the Inventors hall of fame and sits alongside Henry Ford, Thomas Edison, and many others.
- Normal printers print onto paper, 3D printer prints physical objects. They have been around since the 80’s and entered mainstream popularity in 2016. They are now a commodity item.



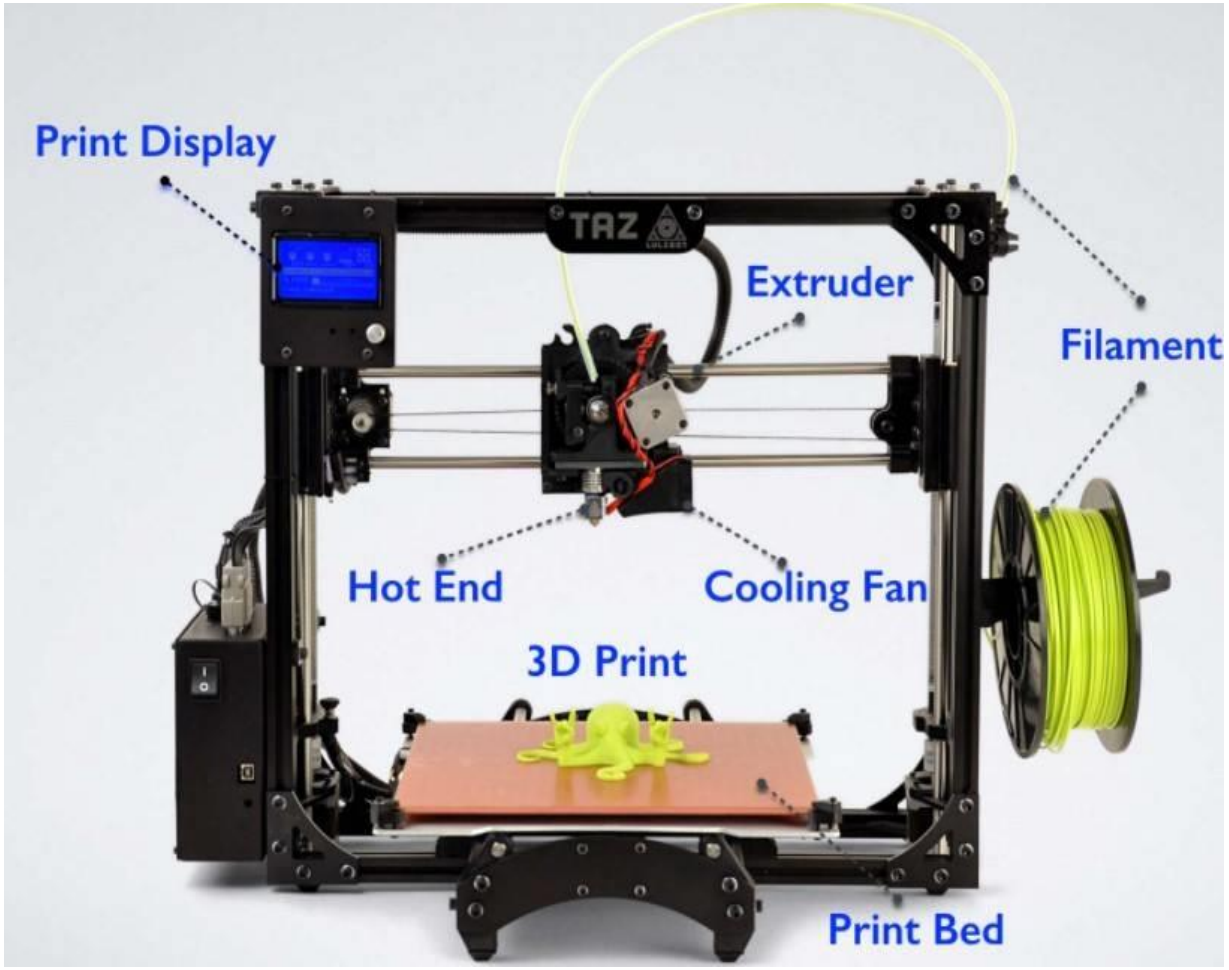
WHAT IS A 3D PRINTER?

- There are 2 types of 3D printer generally used by the hobbyist.
- By far the most common is the FDM (Fusion Deposition Modelling) printer where a filament of plastic material is extruded from a heated nozzle onto a bed.
- The second is the SLA (stereolithograhpy) or resin printer where the model is built up from a resin bath with the detail being formed by the intersection of X and Y beams of light. These are capable of fine detail but require post processing to finish the printed item.



PRINTER BASICS

- Regardless of type the core functionality of a 3D printer consists of:
  - A frame for the X,Y and Z drives
  - A control board and power supply that controls the movement of the component parts driven by “gcode”, a CNC standard language.
- From here the two types diverge, I will concentrate on FDM printers
  - An extruder mechanism that feeds the raw material
  - A “hot-end” that melts the material and extrudes it through a fine nozzle
  - A baseplate or bed that may be heated to help adhesion of the extruded material



TYPICAL 3D PRINTER

- 3D printers commonly have a print volume around 220 x 220 x 250 mm and basic models are under £200.00 with some closer to £120.00 on sale.
- The lower cost models usually need a bit of tinkering to get them to work reliably.
- The model shown is a Creality Ender 3 Pro, a very popular model. The construction, using standard aluminium extrusion is typical of that end of the market at approx. £220.00

MATERIALS USED TO PRINT

- Most users of 3D printers start by using PLA (Polylactic Acid) filament as the printing material, derived from corn starch, a renewable source. The most common other plastics used by 3D printers in the hobby environment are PETG, ABS, Nylon and some flexible varieties. There is also a water-soluble plastic used for supports. This is by no means an exhaustive list, there are metallic, wood-like, carbon fibre and many only used in high-end industrial printers.

PRINT MATERIALS

- Each manufacturer produces the basic PLA with additional additives and colours so PLA can behave differently depending on the maker. The standard spool contains 1Kg of material, 1.75mm diameter.
- The range of colours is huge and there are “silk”, “shiny”, “matte” and normal ranges available with more coming on the market every month
- Costs range from £14 for budget up to £300 for special metallic.

HOW IT WORKS

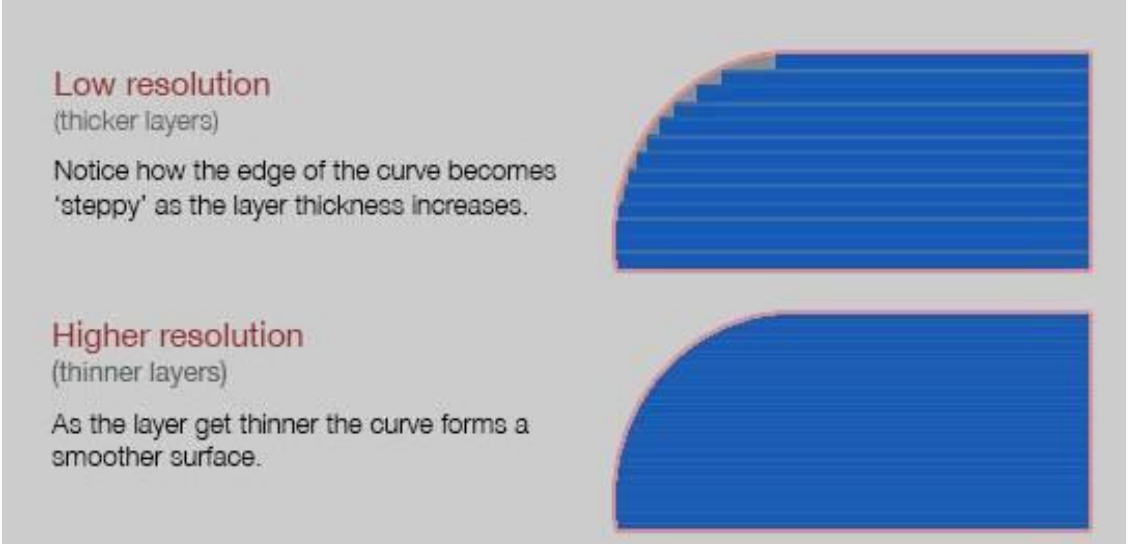
- The print process starts with a "stl" file that contains the design.
- STL files can be produced from CAD (design) programs for technical designs or from 3D modelling programs for more artistic or sculptural work
- These STL files must be processed through a "slicer" program to produce a layer by layer sequence of CNC commands using the "**gcode**" language.
- The **gcode** is translated by the print controller into a series of heating, movement and extrusion commands.
- The majority of 3D printers use the cartesian co-ordinate format. X, Y and Z axes, with several different configurations to achieve this.
- The most common is a bed that can be moved in the Y direction. The print head is on a frame that allows travel in the X direction. This frame is raised up layer by layer in the Z direction.
- Generally there is one extruder head but some multi-extruder systems exist for multi-colour or multi-material printing

BASICS

- 3D printing is not a fast process, print time depends on how the print is configured and the material used.
- Layers are related to the nozzle diameter, the max recommended layer height is 80% of the nozzle diameter.
- Standard nozzles are 0.4 mm but sizes ranging from 0.2 mm to 1.0 mm are readily available. Normal layer heights with a 0.4 mm nozzle range from 0.12 mm to 2.8mm, both having advantages depending on the function of the printed item.
- 3D prints have a grain structure similar to wood based on the successive layers. Use the slicer to orientate the object.

The speed of printing depends on two variables.

1. **Size:** The larger or more complex the design, the longer it takes to print.
2. **Detail:** Higher resolution prints look better but take longer to create.



IMPORTANT PRINTING PARAMETERS I

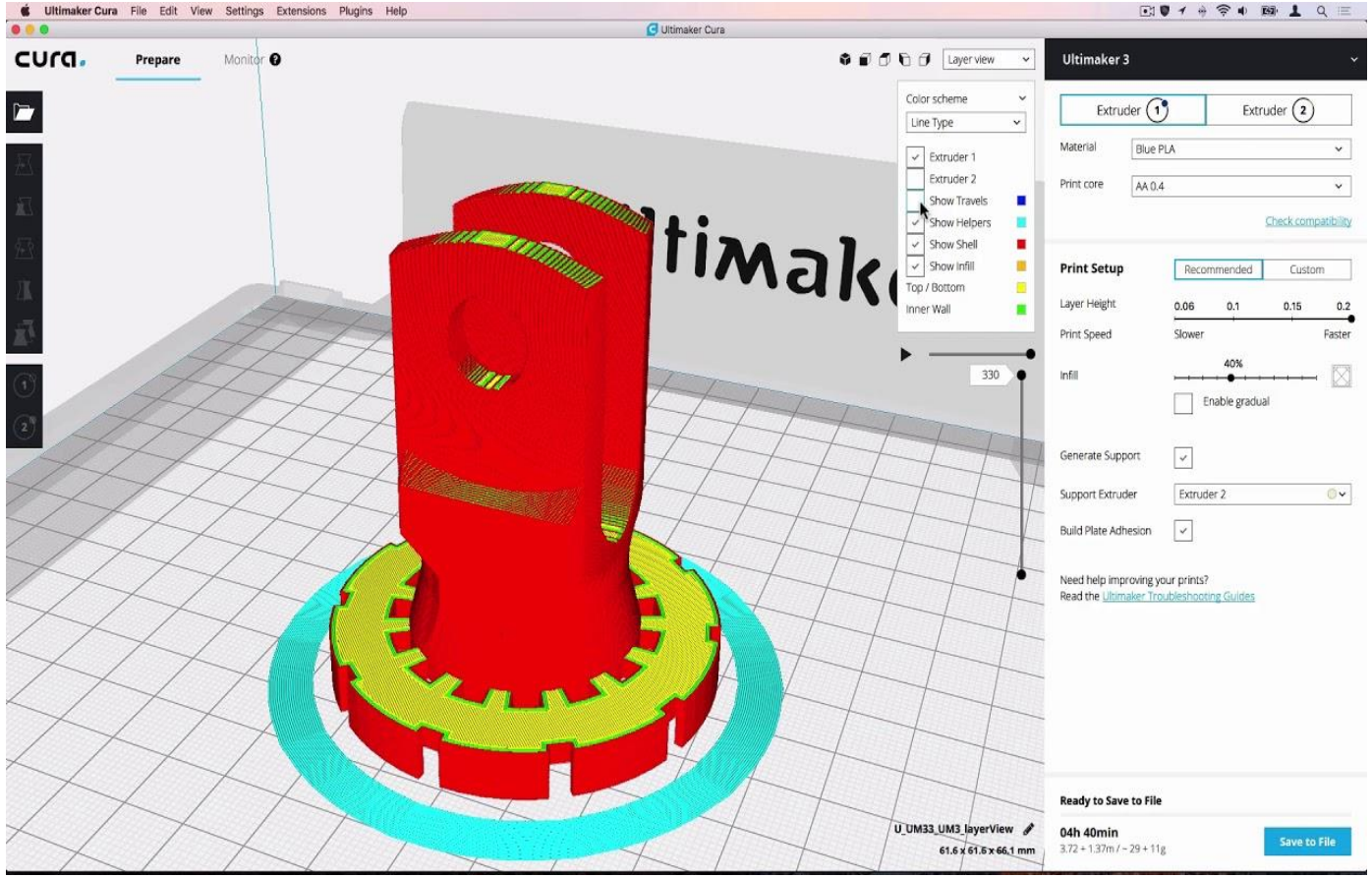
- **Bed Levelling.**
- The bed must be levelled using the adjusting screws.
- Bed height detectors are available that simplify the process.
- **Bed adhesion**.
- Extruded material must adhere to the bed else the model shifts and destroys the print or warps.
- There are many types of bed material and adhesion techniques.

IMPORTANT PRINTING PARAMETERS 2

- **Layer height** is related to the resolution and nozzle size
- **Temperature** is governed by the material being printed
- **Print speed** is governed by the material properties and the printer setup
- **Item orientation** affects the bed adhesion, print grain(strength in a particular direction) and the necessity for support structures.
- **Support structures** help to prevent collapse of areas that are printed with no underlying printed material.
- All of these are controlled as parameters in the **slicer** software – some examples of which are shown next.

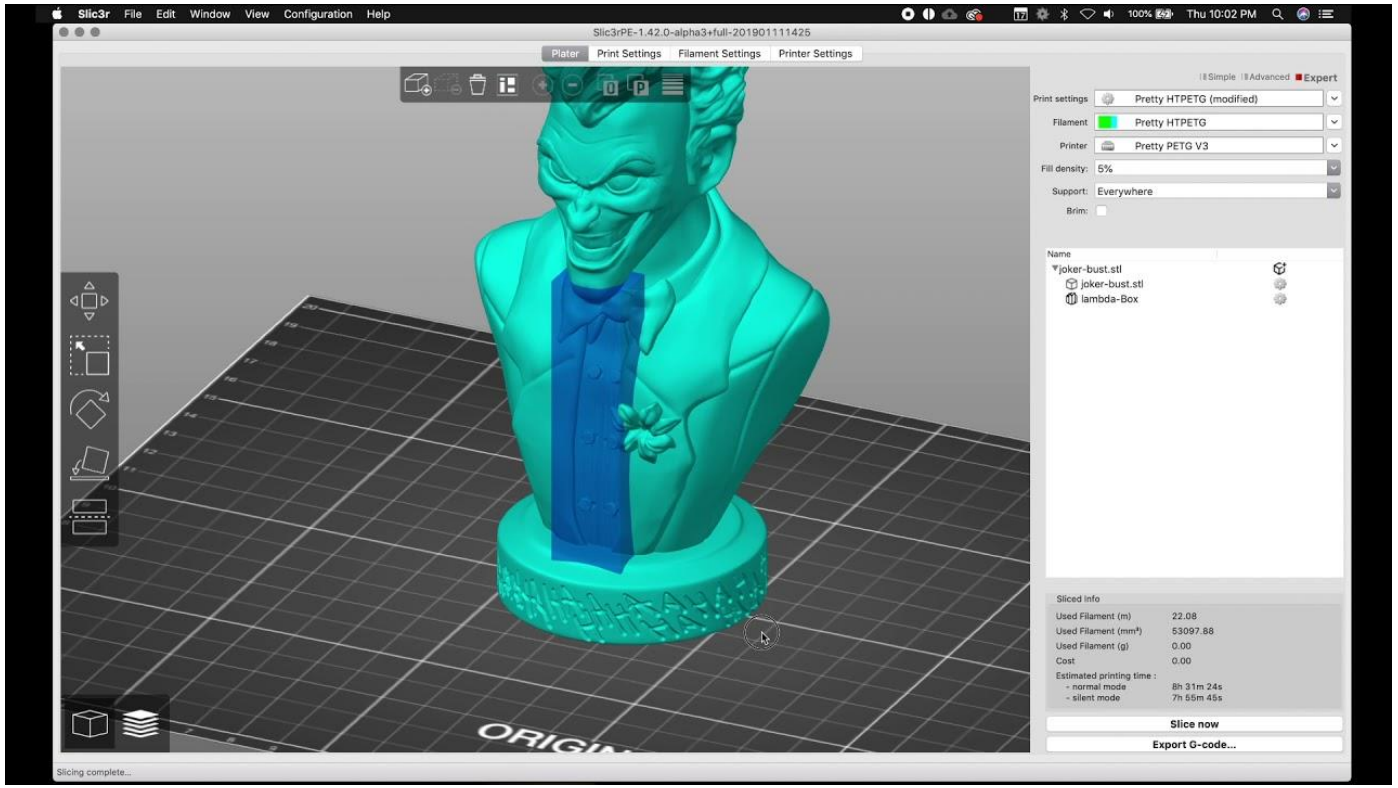
SLICER SOFTWARE 1

- **Slicer** programs are configured for specific combinations of printers and materials.
- The most widely used is **Cura,** a freeware package developed by Ultimaker, which comes with a multitude of pre-configured printers and material types.
- There are over 100 parameters that can be controlled but in most cases the user can accept the defaults.
- The defaults are very conservative so by careful tweaking the print process can be adjusted to allow faster, stronger or different resolution.



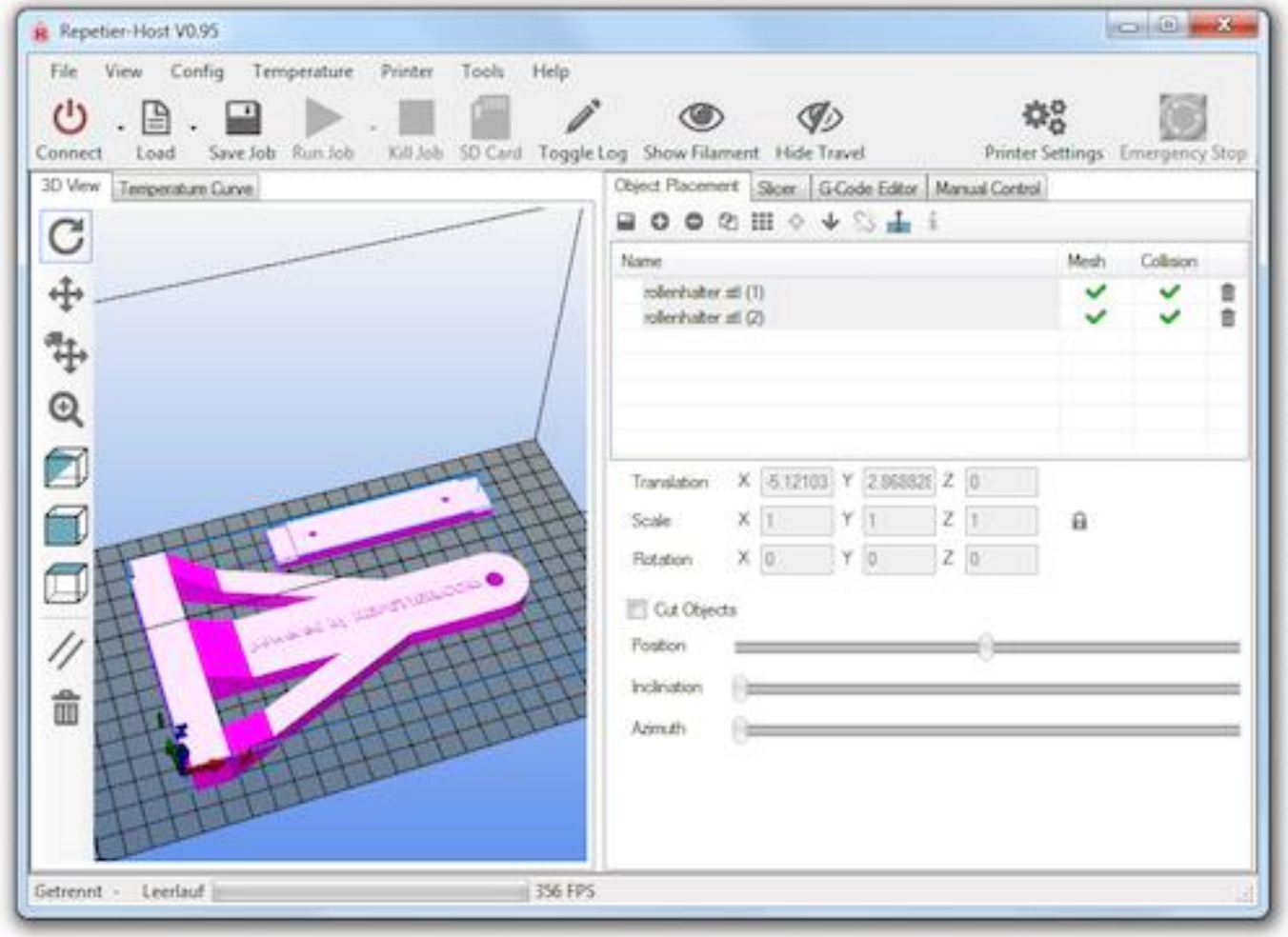
SLICER SOFTWARE 2

- **Slic3r** is a 3D slicer that champions the open source philosophy alongside RepRap 3D printers. It's a completely nonprofit project, which is very commendable considering it is definitely one of the best 3D printer slicer options out there.
- It has a wide variety of features that advanced users will enjoy, including effective, strong infills and many different preview views for ensuring you're happy with your model before you press print, **Slic3r** is versatile enough to handle almost anything you throw at it.



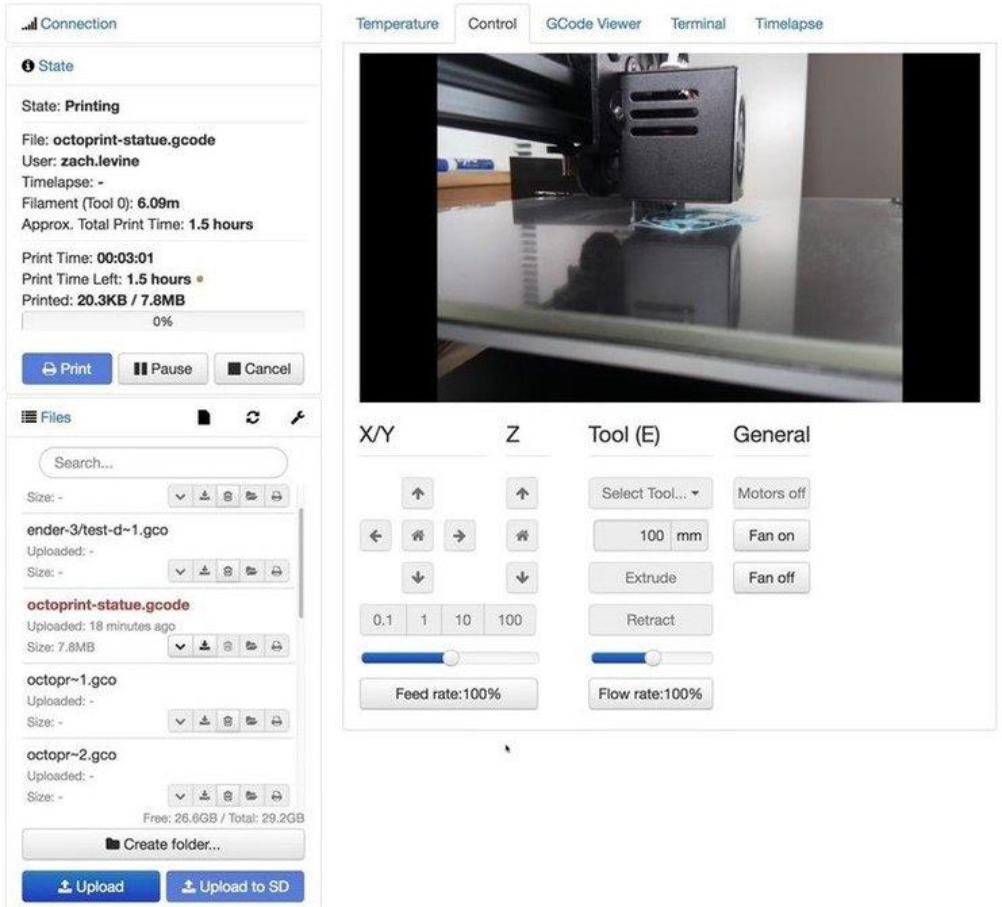
SLICER SOFTWARE 3

- **Repetier Host** is a slightly different program in that it can directly drive the 3D printer control card and you can embed your favourite slicer



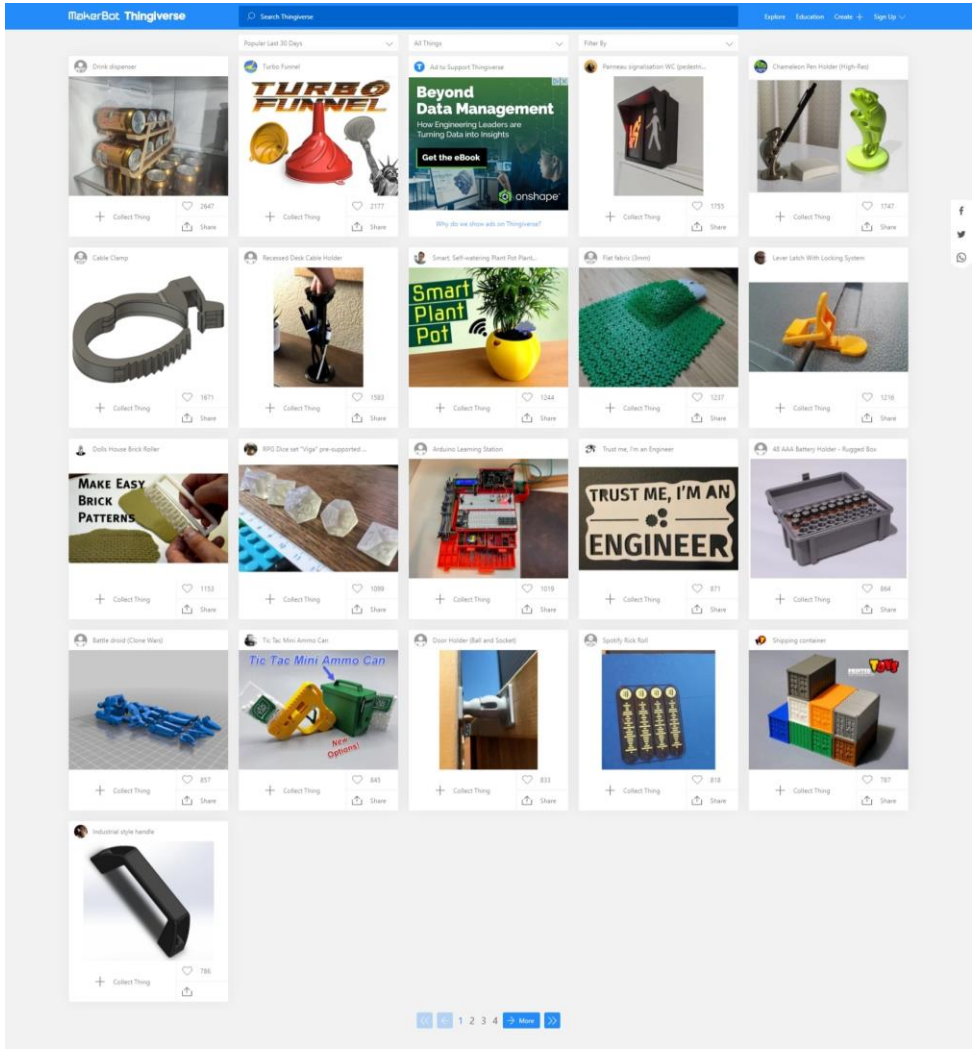
SLICER SOFTWARE 4

- **Octoprint** is a Raspberry Pi based package. Although not a specialized 3D slicer, **OctoPrint** does feature a slicing tool for slicing STL files in addition to its incredible main features. **OctoPrint** acts as more of a slicing software platform and host, allowing for simple and effective remote monitoring of in-progress printing, so you could be in a different city and seamlessly check on how your 3D print is going.
- You can monitor your print's progress, temperature, estimated remaining time, and install a webcam to get video footage of the print to check if any errors have occurred. And if they have, you can remotely pause or stop the print to save on wasted filament!



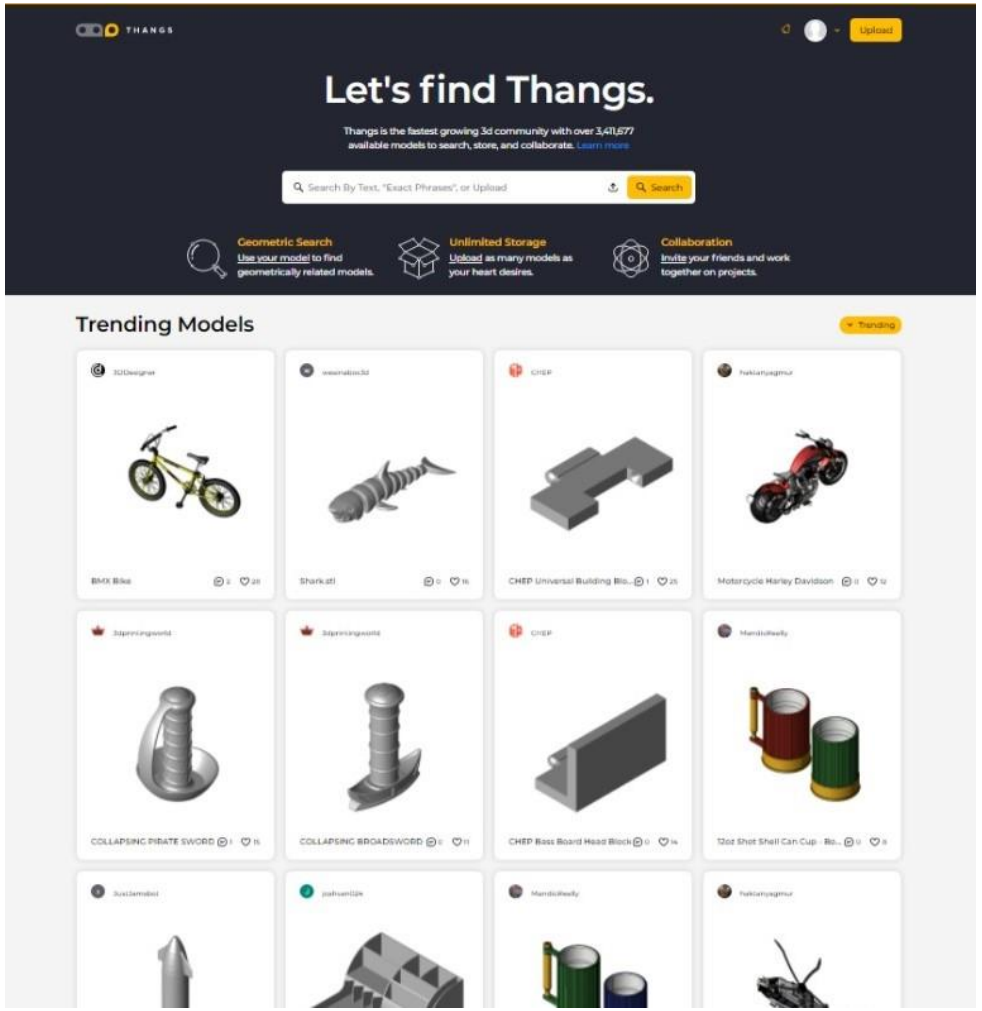
WHERE CAN PRINT FILES BE FOUND?

- There are a great number of freeware/open-source programs available for every step of the design process through to the final **gcode** generation, some of which are covered in the attached documents.
- The biggest online resource is **Thingiverse** with over 2,000,000 3D models. Some of these have the original design files which means you can either feed in your own parameters or re-design. The search facility is a bit erratic as the file names are set by the contributors but finding by the **Thingiverse** number is fast.



ONLINE RESOURCES FOR STL FILES

- **Thangs** is another popular site that also points to content of other web sites
- Searching on “woodturning” brings up some useful objects, currently 18 files.

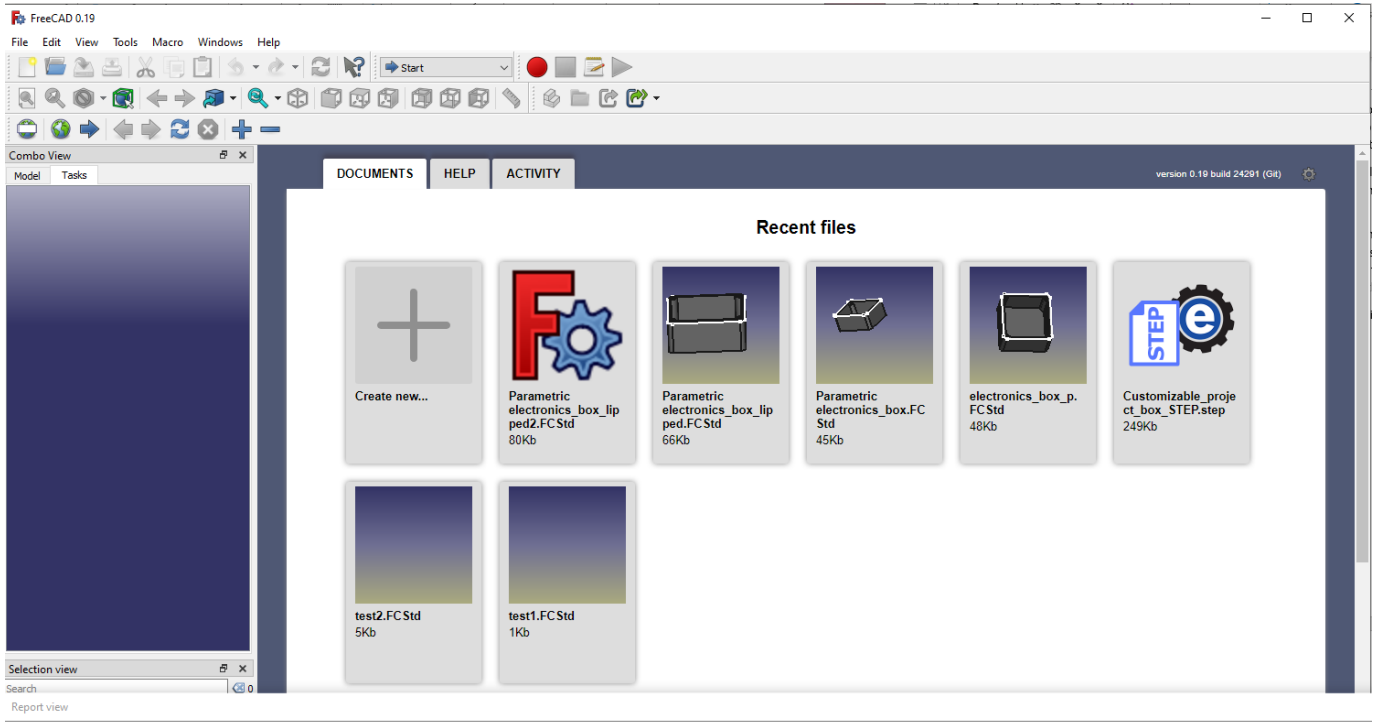


DESIGN SOFTWARE

- Once you have explored 3D printing and the available **stl** resources the next step is to design your own parts or modify existing designs.
- I am covering the engineering/technical resources rather than freeform 3D modelling which is a massive subject in its own right.
- Very simple models can be made in the easier to use online packages like **Sketcher.**
- The examples listed are all free to use, I started using **AutoCad Fusion360** a very powerful package but the subscription model has change recently so students can only use freely for 1 year.
- Some of these packages can import existing **stl** files and edit them. Some of the **Thingiverse** files include the original design files.

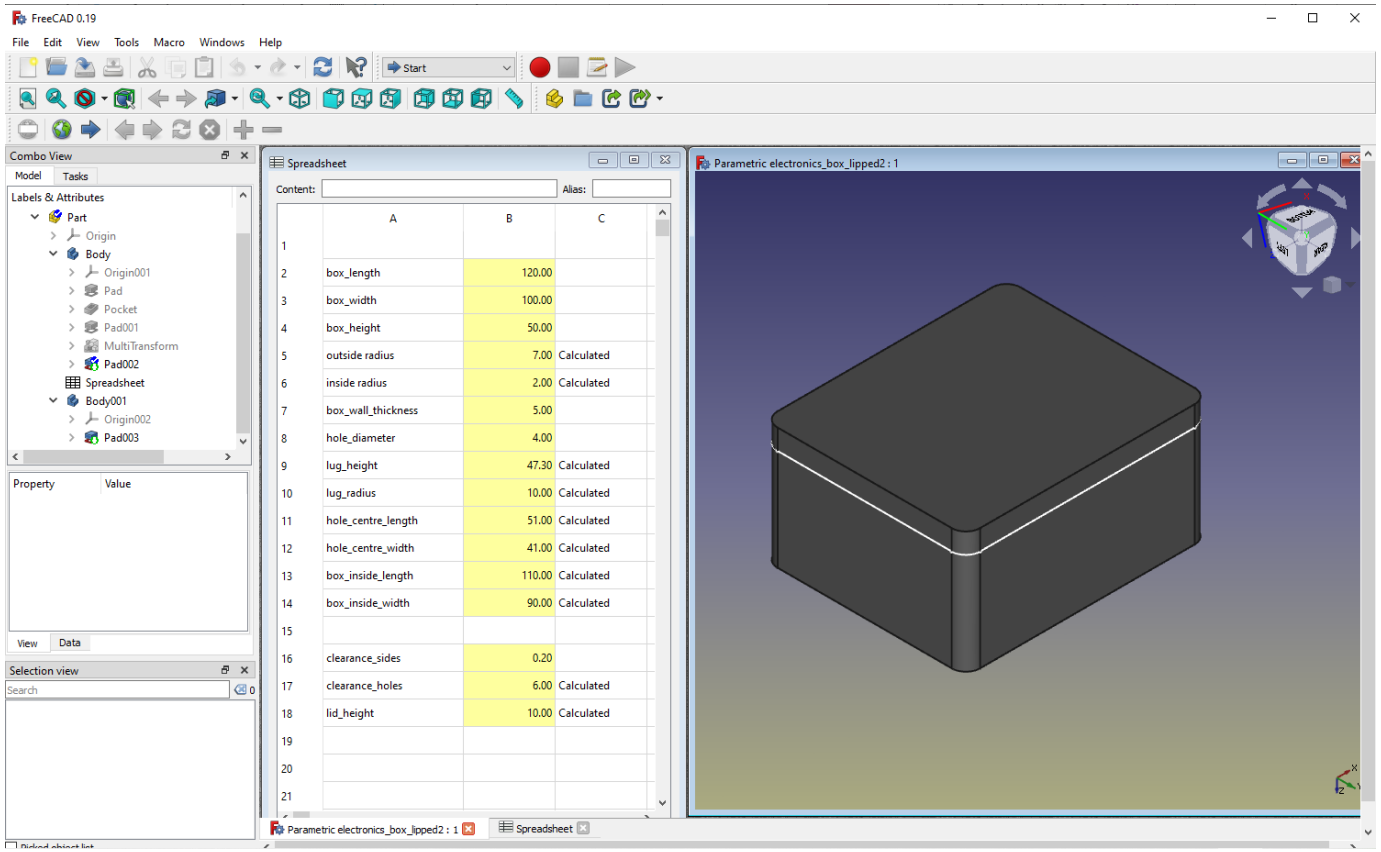
FREECAD

- Excellent design program supported by worldwide developers. Since Fusion360 changed the subscription costs this looks like a freeware successor. There are frequent updates and a large online user community. Even with its small niggles it is a very powerful program.
- **FreeCAD** is made primarily to design objects for the real world. Everything you do in **FreeCAD** uses real-world units, be it microns, kilometers, inches or feet, or even any combination of units. **FreeCAD** offers tools to produce, export and edit solid, full-precision models, export them for 3D printing or CNC machining, create 2D drawings and views of your models.



FREECAD

- All **FreeCAD** objects are natively parametric, meaning their shape can be based on properties such as numeric values, texts, on/off buttons, or even other objects.
- All shape changes are recalculated on demand, recorded by an undo/redo stack, and allow to maintain a precise modelling history. Properties of one object can drive the value of properties of other objects, allowing complex, custom parametric chains that could only exist in your wildest dreams.
- New parametric objects are easy to code. This means that once a design is completed variations of sizes etc are easily made without having to redesign the part.

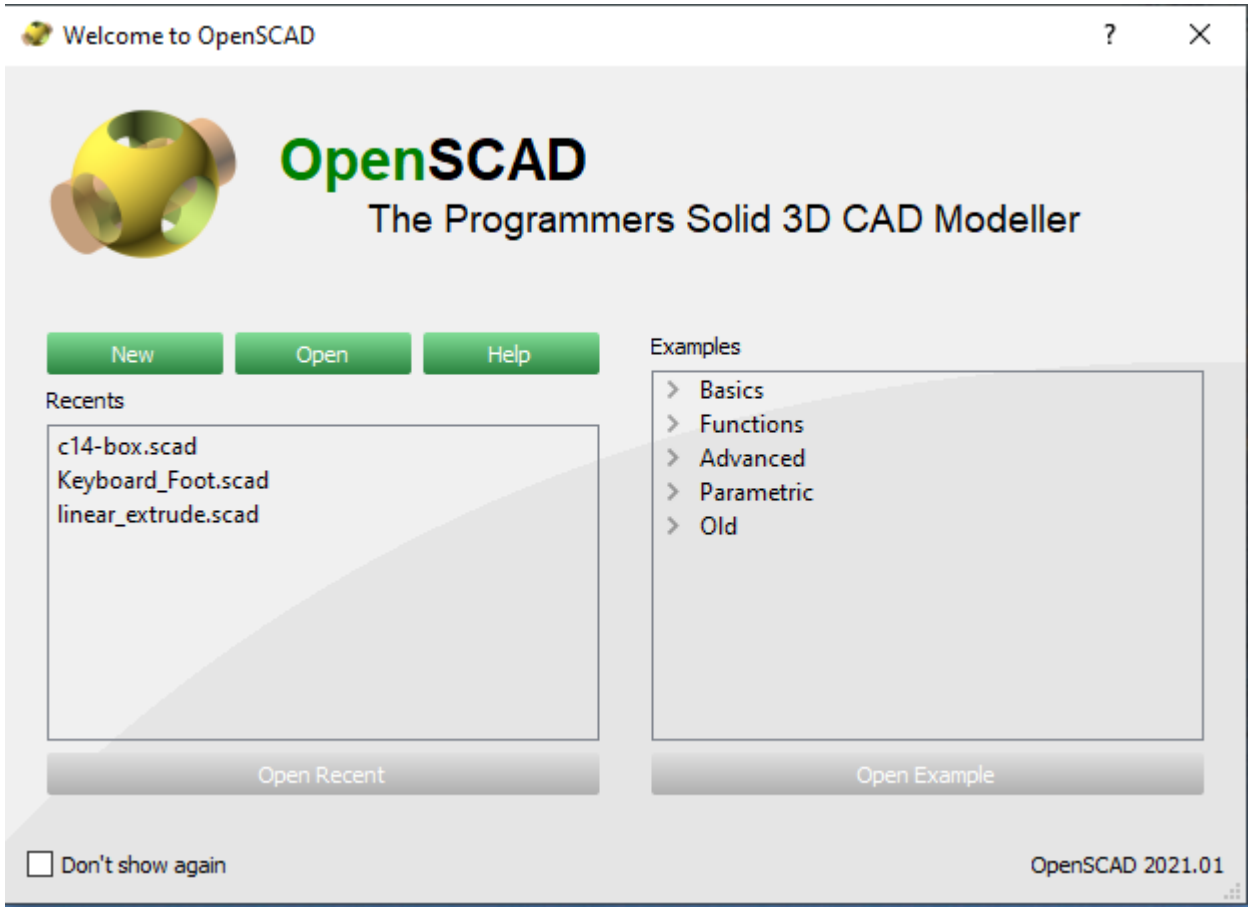


FREECAD

- **FreeCAD** supports dozens of different file formats such as STEP, IGES, OBJ, STL, DWG, DXF, SVG, SHP, STL, DAE, IFC or OFF, NASTRAN, VRML, OpenSCAD CSG and many more, in addition to **FreeCAD**'s native FCStd file format. Add-on workbenches can also add more file formats.
- **FreeCAD** has a huge number of supporting resources on the web, especially in YouTube, but be careful to use those using the latest version, 19 or 20 (developer)

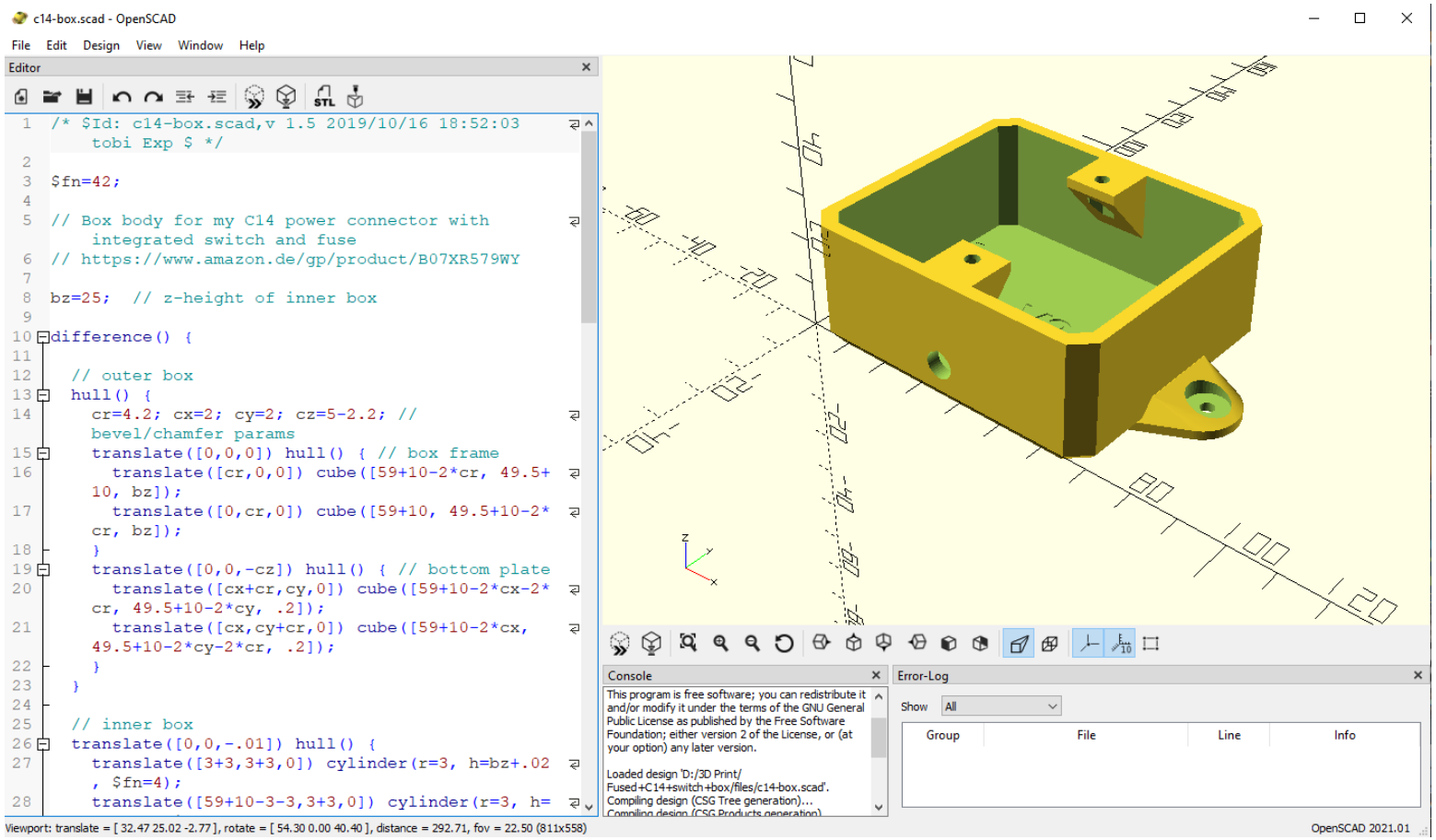
OPENSCAD

- **OpenSCAD** is software for creating solid 3D CAD models. It is free software and available for Linux/UNIX, Windows and Mac OS X. Unlike most free software for creating 3D models (such as Blender) it does not focus on the artistic aspects of 3D modelling but instead on the CAD aspects. Thus it might be the application you are looking for when you are planning to create 3D models of machine parts but pretty sure is not what you are looking for when you are more interested in creating computer-animated movies.



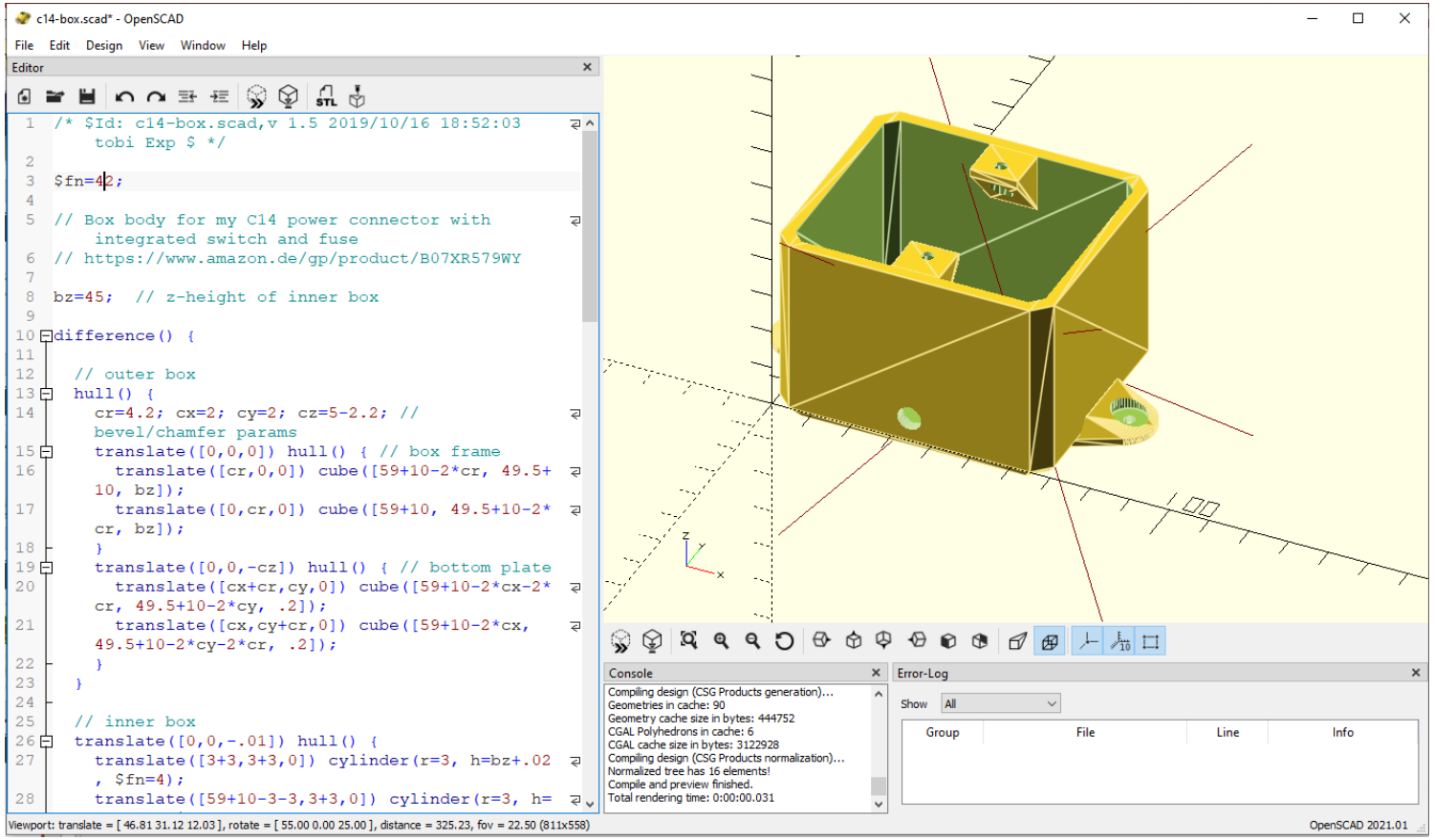
OPENSCAD

- OpenSCAD is not an interactive modeller. Instead it is something like a 3D-compiler that reads in a script file that describes the object and renders the 3D model from this script file. This gives you (the designer) full control over the modelling process and enables you to easily change any step in the modelling process or make designs that are defined by configurable parameters.



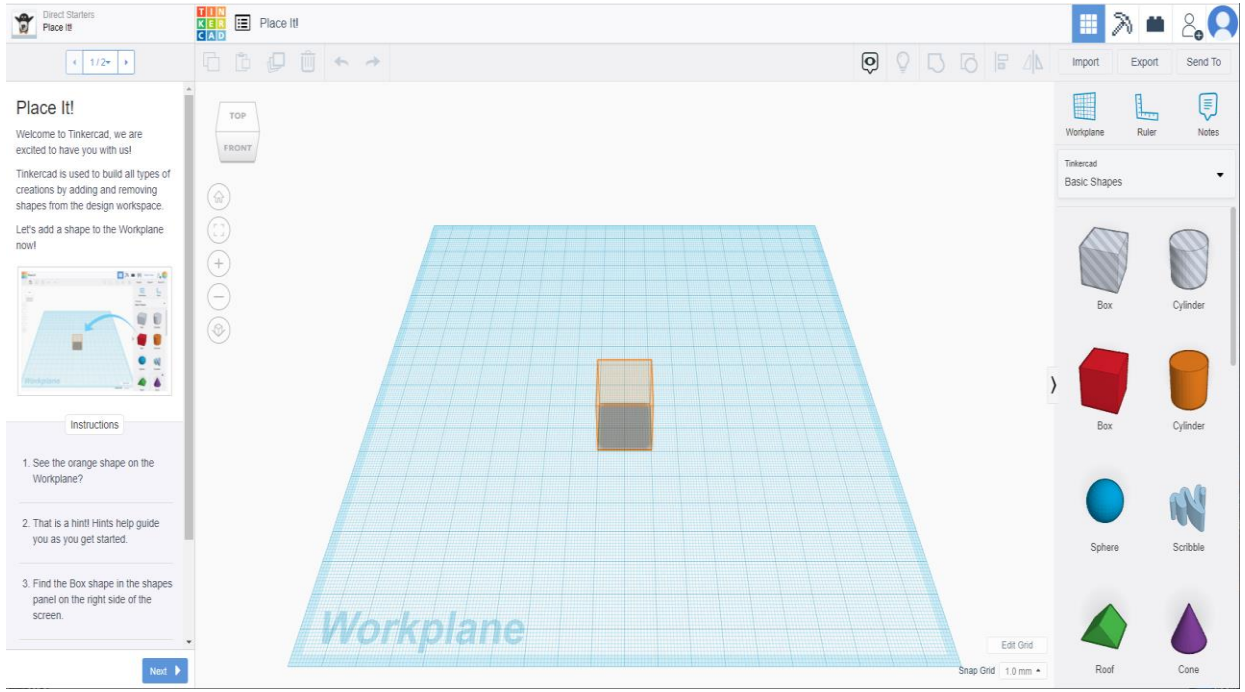
OPENSCAD

- OpenSCAD provides two main modelling techniques: First there is constructive solid geometry (aka CSG) and second there is extrusion of 2D outlines. Autocad DXF files can be used as the data exchange format for such 2D outlines. In addition to 2D paths for extrusion it is also possible to read design parameters from DXF files. Besides DXF files OpenSCAD can read and create 3D models in the STL and OFF file formats.



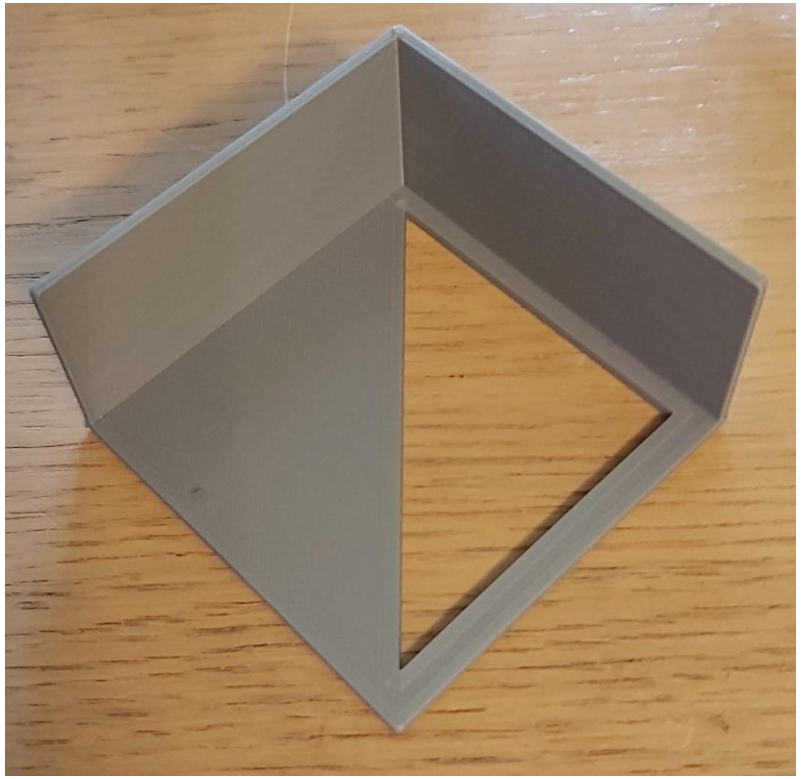
TINKERCAD

- Tinkercad is a web based 3D design package.
- Tinkercad uses a simplified constructive solid geometry method of constructing models. A design is made up of primitive shapes that are either "solid" or "hole". Combining solids and holes together, new shapes can be created, which in turn can be assigned the property of solid or hole.[3] In addition to the standard library of primitive shapes, a user can create custom shape generators using a built-in JavaScript editor.
- Shapes can be imported in three formats: STL and OBJ for 3D, and 2-dimensional SVG shapes for extruding into 3D shapes. Tinkercad exports models in STL or OBJ formats, ready for 3D printing.



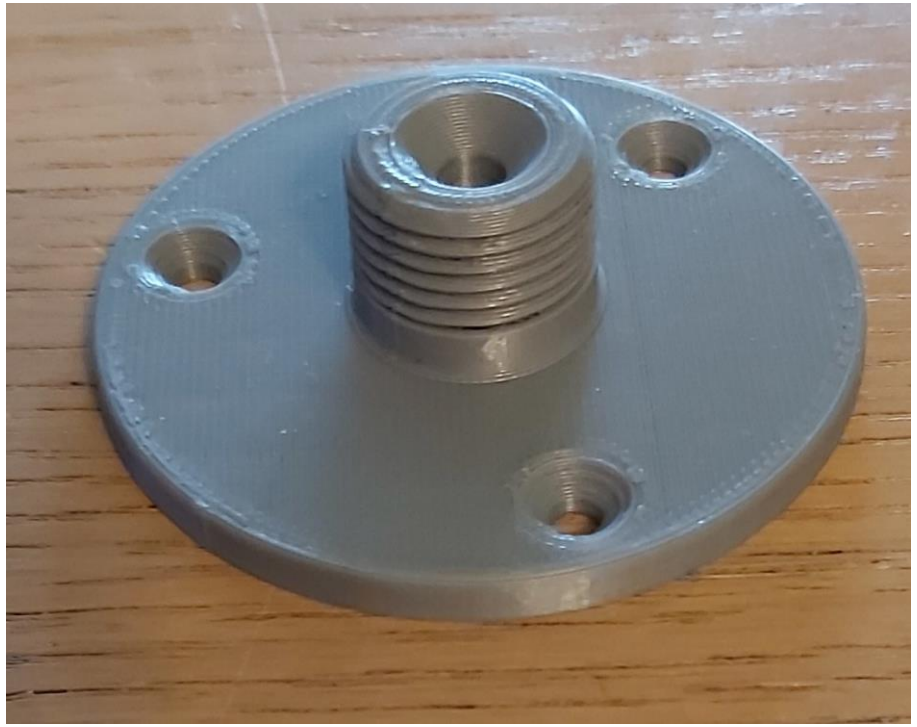
EXAMPLES OF PRINTS

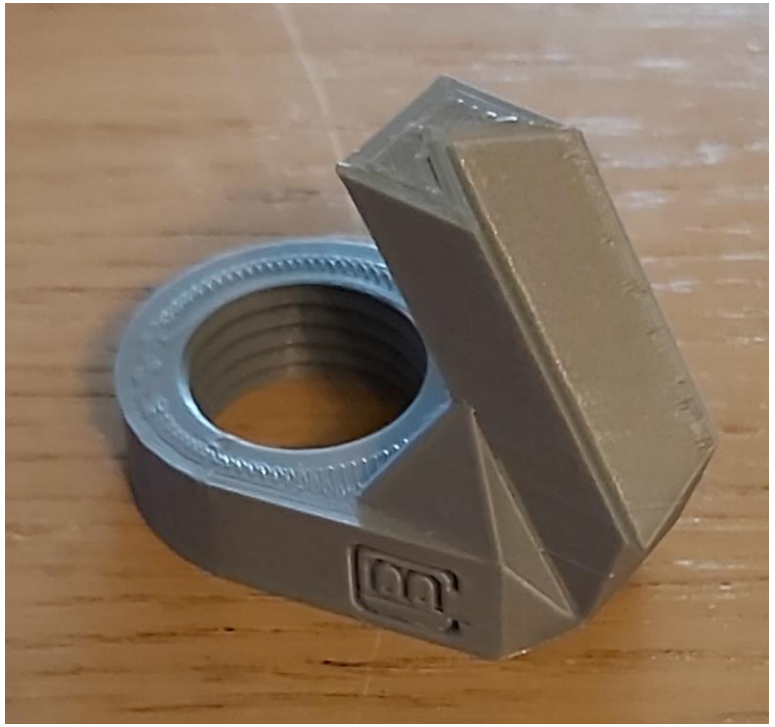
- Here are some examples of printed items I have made
- Two examples of centre finders, one for spindles, one for bowls.



EXAMPLES 2

- Chuck mounting plate ¾ x 16
- Dremel mounted drill sharpener for use with a diamond wheel.



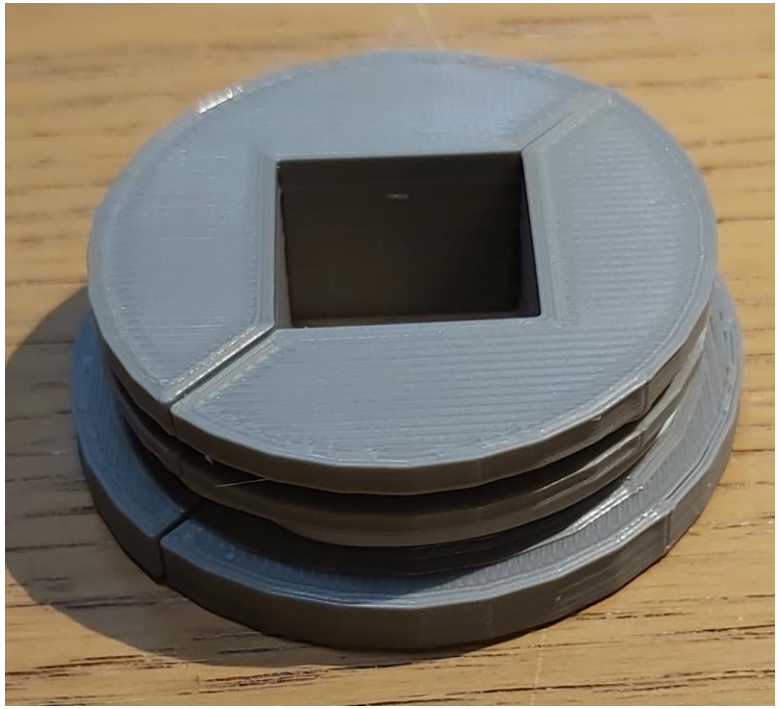


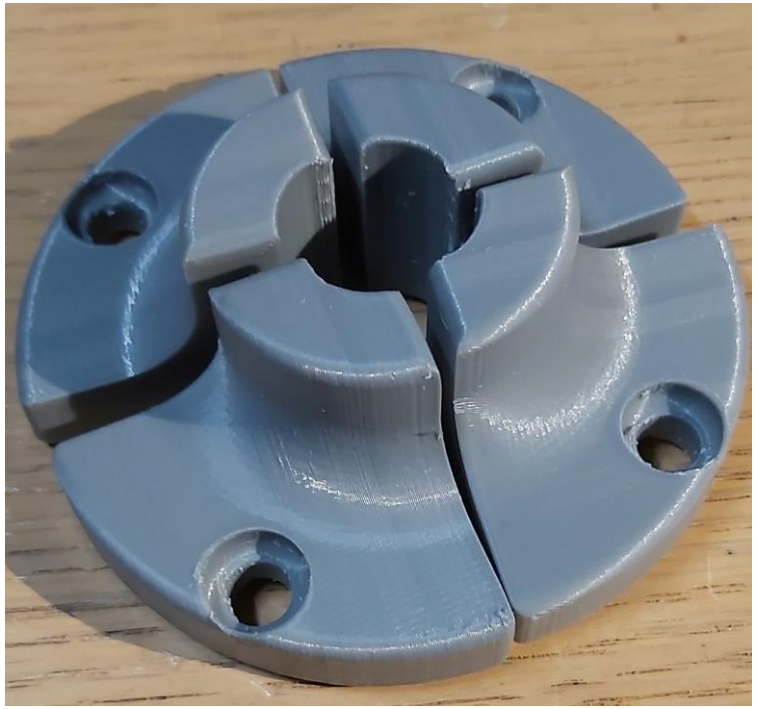
EXAMPLES 3

- ER32 collet holder for 12mm square bar
- There are design files for a variety of ER32 hexagonal and square holders in imperial and metric sizes
- A full range of normal ER32 collets are available as a parametric design

EXAMPLES 4

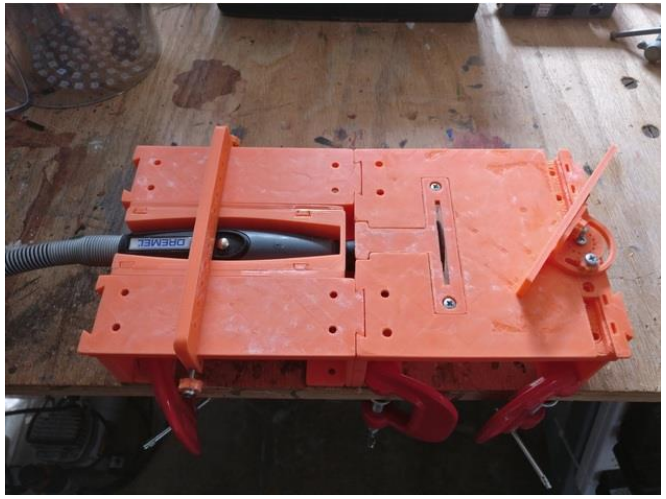
- SuperNova chuck jaws and holders are available in a range of sizes.

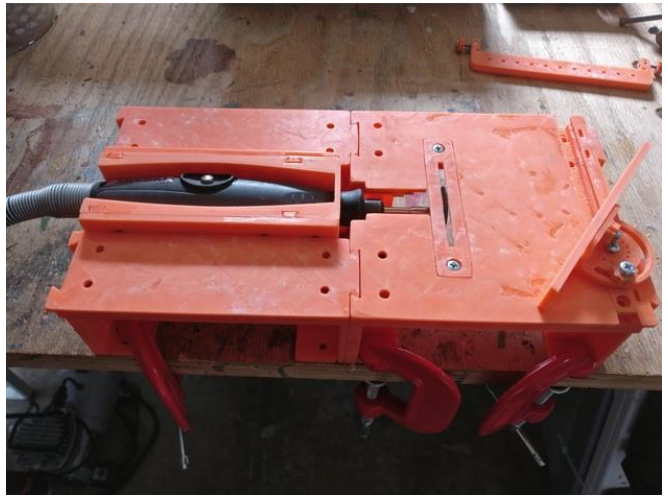


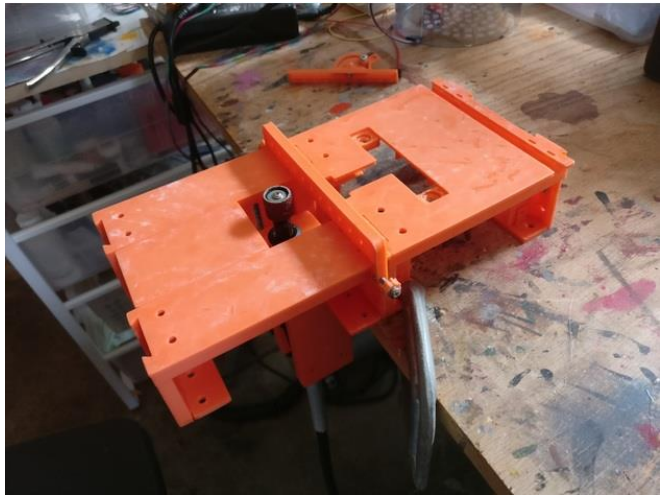


EXAMPLE 5

- This is the most complex item I have printed, a Dremel based work centre/shaper.





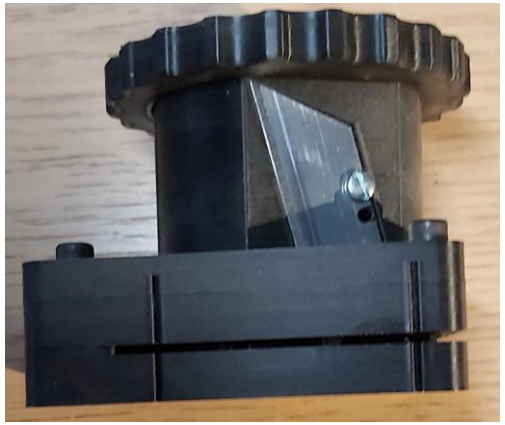


EXAMPLE 6

- This is a holder and water tank for MicroMesh abrasives about 170 x 150 x 100 mm.
- This took about 26 hours to print.

EXAMPLE 7

- Cutter for 50mm sanding disks from a sheet of Velcro type sandpaper.



ONLINE RESOURCES

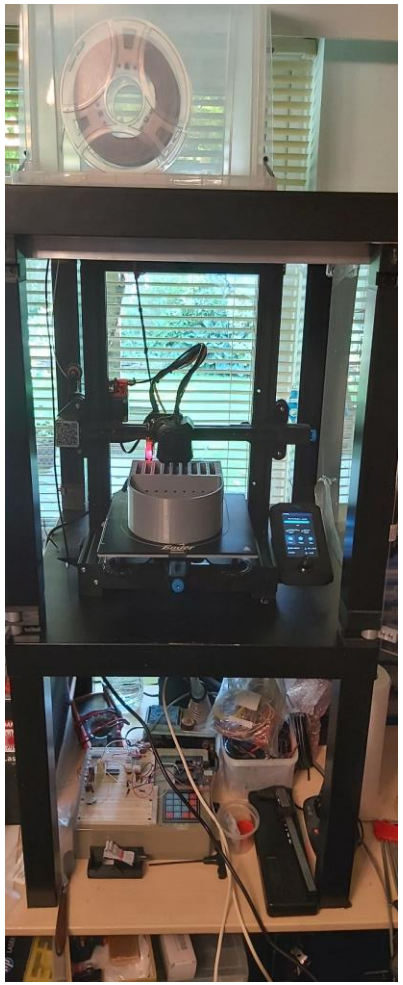
- There are many YouTube makers and online ePublishers regularly making useful content for all levels of users
- One of the best that I use regularly is All3DP.
- https://all3dp.com
- All3DP produce a regular newsletter with reviews and guides.
- Here is a list of other sites well worth a visit.
- https://www.simplify3d.com
- https://3dprintguides.com
- https://www.3ders.org
- Be advised that some of the information on the Web is some years old, 12 months in the 3D printing world is a long time.

YOUTUBE RESOURCES

- These YouTube channels are very good and give unbiased information. When being sponsored they say so up front.
- https://www.youtube.com/channel/UCb8Rde3uRL1ohROUVg46h1A
  - Thomas Sanladerer - **excellent**
- https://www.youtube.com/channel/UCbgBDBrwsikmtoLqtpc59Bw
  - Teaching Tech – **very good**
- https://www.youtube.com/channel/UCWEX2NVlLeIQr3v-cIF9LxA
  - MakeWithTech – **good**
- **Try YouTube search – usually brings up good connections but watch the date.**

MY 3D PRINT SETUP

- My Creality Ender 3 v2 in a self-built cabinet based on Ikea Lack coffee tables using printed parts from Thingiverse. It is fully enclosed with acrylic panels with side and front opening doors. I have already upgraded a number of items on the printer and will install Octoprint when the electronics is finished.
- The box holding the filament will have heater and humidity control.
- The electronics will be in a printed parametric box.
- This is the 3rd 3D Printer I have run.



CONCLUSION AND REFERENCES

- This presentation has only scratched the surface but hopefully it can simplify your entry into 3D printing

- There are a number of related documents on the NWWA web site.
- One has links to free software for CAD design and Slicers.
- Another has links to YouTube 3D printing channels that I have found to be reliable and honest and other web based resources.
- Finally, another has the Thingiverse numbers for the items I printed.
- If you need further help, contact me at mikec@woodstuff.co.uk