3D Printer Use: *Ultimaker 2+*

Cal Poly Physics Department

3D printing

The physics department has two "Ultimaker 2+" 3D filament printers available for general use. They are housed in 180-634 (the Electronics Lab). With a 3D printer, you can design an object you need on the computer and hold a plastic version of it in your hand in a relatively short time. Here in the department we have found many uses for both research and teaching projects.

The printers have a spatial print resolution of about 0.1 mm, with a build volume of roughly length=8.8", width=8.8", height=8.8". Currently we are using stock spools of a plant-based plastic filament called "PLA." PLA-based objects feel like hard plastic objects and can even be machined to some extent. The stock spool of PLA filament is approximately 3 mm in diameter and, when fed into the printer, is heated to about 210 ^{o}C by a small brass printhead, then deposited, layer-by-layer, to create your object. 3D printing is a slow process and printing something the size and shape of a soda can might take 3-4 hours. 3D printers are safe and quiet, so they can be left alone while printing your object. The printers are *not* controlled by a computer and are self-contained units. To use one, you put your design file (see below) on an SD-card, which is inserted into and used directly by the 3D printer.

Want to give it a quick try?

If you want to see the printer in action, download this file and put it on an SD card. (If you don't have one, there are usually a few near/around the printers.) Turn on the printer (switch on rear left) and insert the SD-card into the slot on the front. Use the screen and click-wheel to navigate to "Print" and then to the file itself (lego.gcode). Rotate or press on the click-wheel to make selections. After about 5 min of warm up, the printer will print a plastic copy of a 2x4 Lego brick (it'll take about 20 min to print and use 4 g of filament).

STL Files

To print an object on the 3D printer, **you must somehow obtain an STL file describing what you'd like to print**. An STL file contains the XYZ coordinates of small triangles that form the volume occupied by a 3D object (STL = "Stereo Lithography").

An STL file can come from a variety of sources. You can find them all over the Internet, which has huge libraries of STL files for objects you can print (iPhone cases, toothbrush holders, chess pieces, tools, etc.). See Thingiverse (http://www.thingiverse.com) for examples. Other examples are here or here (Open Source Optics).

Most likely you'll want to design something yourself, for a project you're working on. In this case, you'll need to create your own STL file. How do you do this? There are a lot of ways (none of them simple). Here are some designing tools you can try:

- TinkerCAD (https://www.tinkercad.com) (web-based)
- Fusion360 (http://www.autodesk.com/products/fusion-360/overview) (web-based)
- Openscad (http://www.openscad.org) (programming approach)
- SketchUp Make (https://www.sketchup.com/download?sketchup=make) (mouse/point-and-click approach) Suggestions:
  - Use the template for millimeters.
  - Also, pull down "Window->Extension Warehouse" and install the STL extension, which gives you the "File->Export STL..." menu.
- AutoCAD (free for educational use)
- SolidWorks (Cal Poly site license, Windows only)
- Mathematica (can output STL files of 3D objects)

We've had good luck with TinkerCAD, Fusion360, Openscad, SketchUP, and AutoCAD. The students tend to like SketchUp and SolidWorks. The default unit for 3D printing is the millimeter, so try to work in such units. If you don't, your object can be scaled later. **When designing, watch the size (dimensions) of your creation.** It's easy to ignore, as you have in past drawing work. Now it matters, since you're designing what will be an actual object!

***** Be sure to save your design as an STL file. *****

Our 3D printers do not print directly from STL files. Instead they use a "gcode" file that contains specific instructions for our printer, describing how to create your object. How do you get a "gcode" file?

Making gcode files and Printing

The final step before printing is to translate your design, contained in the STL file, to the capabilities of our printer itself. To do so, you can download the software (free) "Cura" (https://ultimaker.com/en/products/ultimaker-cura-software). This software is also on some of the computers in 180-634.

- Configure the software for an “Ultimaker 2+” printer. NOTE: Our defaults are 0.4 mm nozzle, PLA filament, 20% fill.
- Make sure the “Generate Support” and “Build Plate Adhesion” options are ticked.

- Select “File/Open…” and load your STL file into the Cura software. Be sure it looks right in the build volume mock-up you’ll see on the screen. You can scale and rotate your object, as needed.
- Put an SD card into the computer and press the “Save to Removable Drive” button in the lower right. This will process your STL file into a gcode file and save onto the SD card. (You can also use “File/Save As…” and select gcode and put on the SD card.)
- Turn on the printer (switch on rear left) and insert the SD-card into the slot.
- Put the SD card with the gcode file into the printer. Use the small click-wheel to navigate and select “Print,” and then select your particular gcode file.
- Initially the printer warms the nozzle and glass platform (about 5 mins), deposits some test material near the front left and then goes to the center and begins printing. (Sometimes it will lay down a support raft that was not part of your design.)
- When it is done the nozzle and the glass build platform will cool (about 5 min) and then a message will indicate to “Remove piece.” This can be done by gently lifting the piece. It was likely printed on a support “raft” which can be peeled away.
- **Do not use a metal screwdriver** to loosen/pry your final object as this will scratch the glass.

Other

- The ability to use 3D printers is cited in Section B.3 of the Phys21 JTUPP report.
- A stock reel of PLA for this printer sells for about $75. Note it is 2.85 mm diameter filament, and is sold in 2 pound spools (like this). At the moment, please feel free to use the reels we have (paid for by the physics dept.). In the future, we may have to track usage and/or develop a usage policy on this. For now, we consider it a resource like “copier paper.”
- If you do a bunch of printing, consider buying a $75 spool and donating it to the dept. (like this).
- Interesting documentary on 3D printing: “Print the Legend.”