Iowa State University

Computation & Construction Lab

Potterbot Ceramic 3D Printer Workflow

Potterbot Ceramic 3D Printer

Hardware

After using these tools please make sure to return them to the gray container labeled Potterbot.

1. Power Supply
2. (A.) 2 Part Extruder Piece (B.) 1 Part Extruder Piece
3. 3D Printed Drill Adaptor
4. Plywood and Acrylic Bases
5. Nozzle Holder
6. 3D Printed Nozzles of Various Diameters
   - 3 mm- Red
   - 3.5 mm- White
   - 4 mm- Chartreuse
   - 4.5 mm- Black
   - 5 mm- Light Grey

   ** A grasshopper definition has been developed to quickly make nozzles of varying diameters. This is located on the CCL Canvas.*
7. Poly-Carbonate Tube
8. Motor + Threaded Rod
9. Threaded Rod Cover
10. USB 2.0 A (Male) to USB 2.0 B (Male)- This cable allows you to connect a PC laptop into the Potterbot to see the configuration settings. *The laptop CANNOT be connected to power while it is connected to the Potterbot!!*

Software

Design Setup

- Rhinoceros + Grasshopper (make sure to export in mm)

G-Code Setup

- Simplify 3D (CCL#1 and #2 Desktops) Prints STL files only.
- Xylinus (Grasshopper Plug-in CCL#1 and #2 Desktops) G-Code can be generated directly from grasshopper. It allows for the printing of curves and polysurfaces.

SD Card

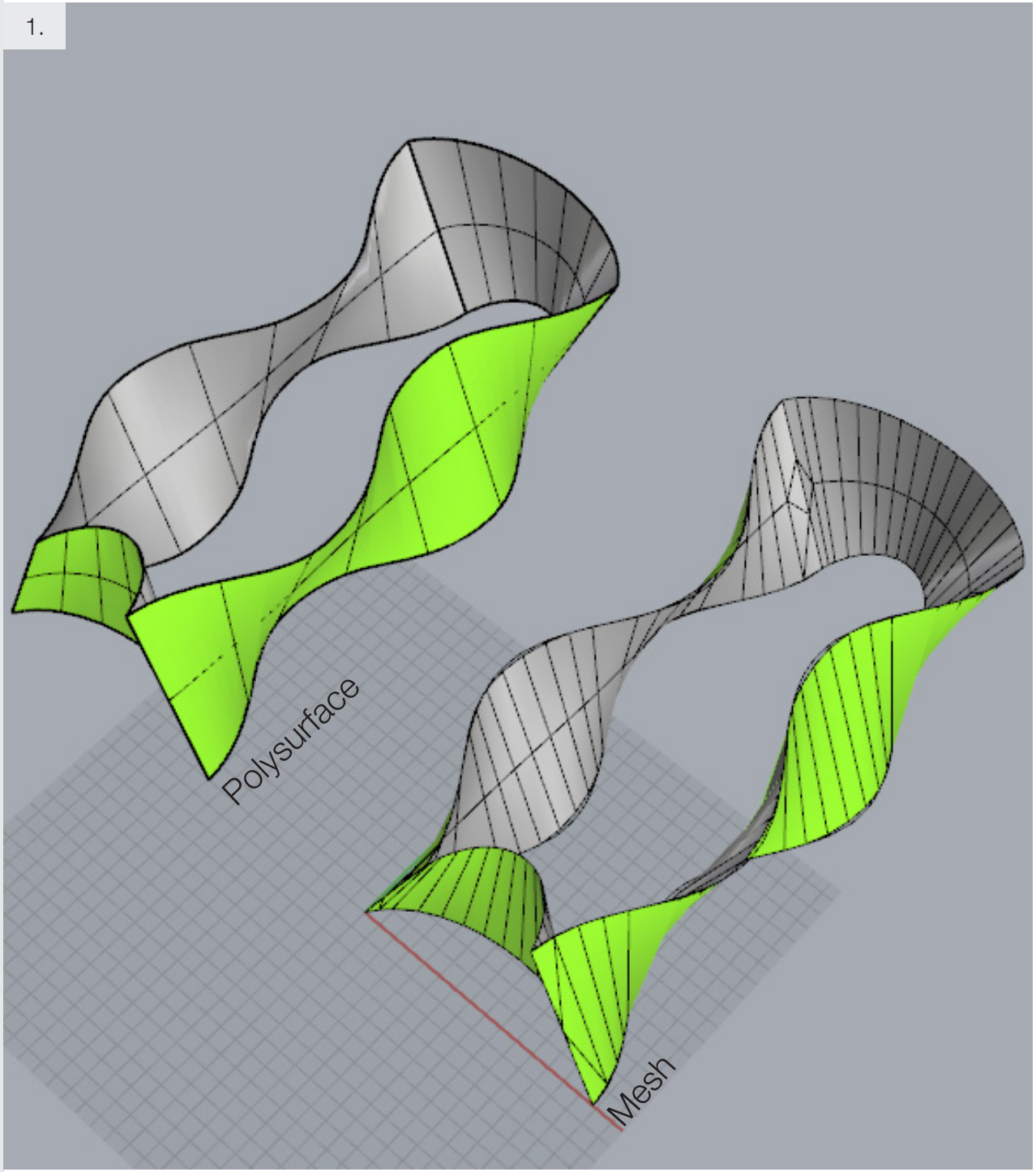
- Place G-Code file on SD card.

Simplify3D

Use Simplify3D on the CCL#1 desktop. You can buy it but that is not necessary.

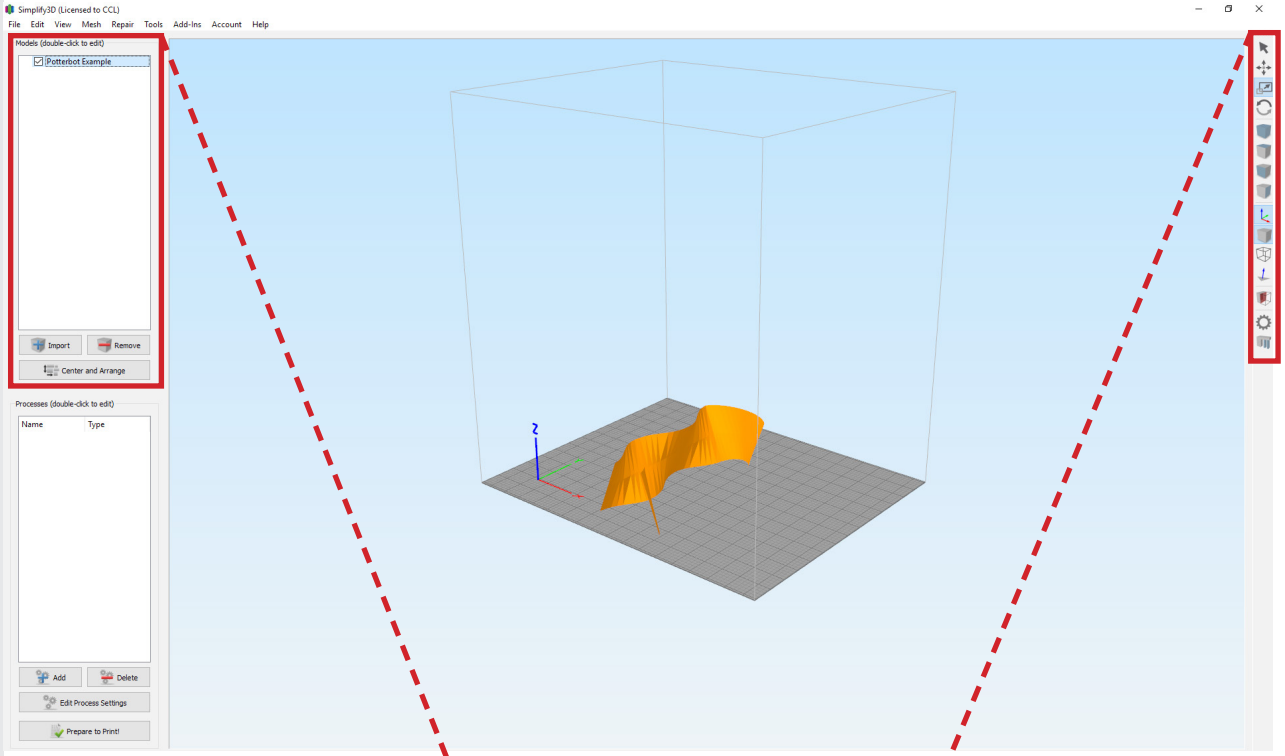
1. Your file should be in millimeters! In Rhinoceros you will export the walls of your polysurface without a base or a top. Be sure to mesh your polysurface prior to exporting as an .stl

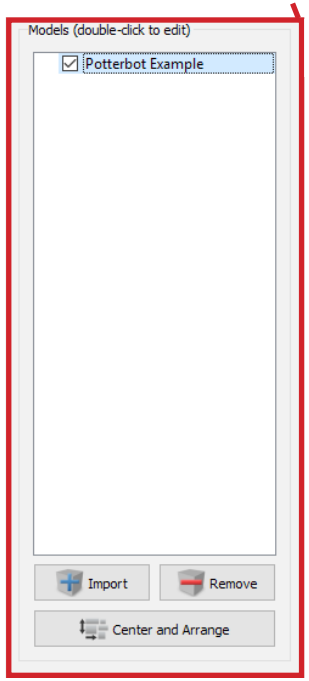
1.



2. First import your .stl file by opening Simplify3D and clicking 'Import'. The file's name will be located in the white box with the title 'Models (double-click to edit)." This will allow you to quickly center or remove your model.
3. There are an array of tools on the right toolbar. One can change the view, rotate, scale and move their object. Do NOT scale outside of Rhinoceros!!

In Simplify3D occasionally walls of the model will not render on screen. They are there do not be concerned. This can be seen on screenshot in the image to the right. In Rhinoceros on the prior page you could see the entire form. In this image two sides are not rendered. If you orbit around the model they should render at different angles.

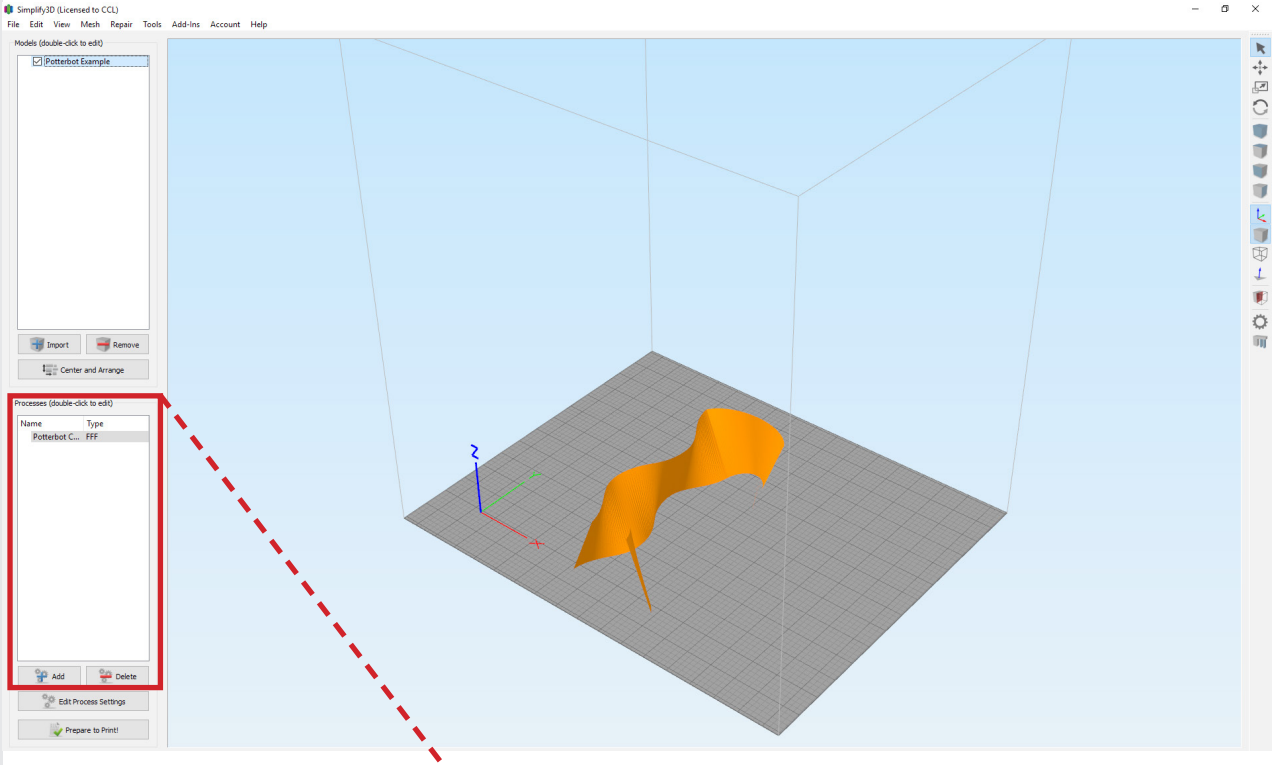


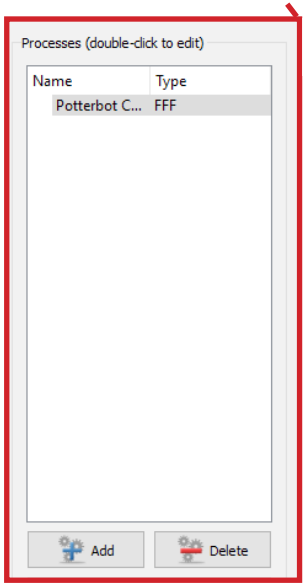


2.

3.

4. If there is already a Potterbot Ceramic Printer Process, click ‘FFF.’ If not click, ‘Add.’

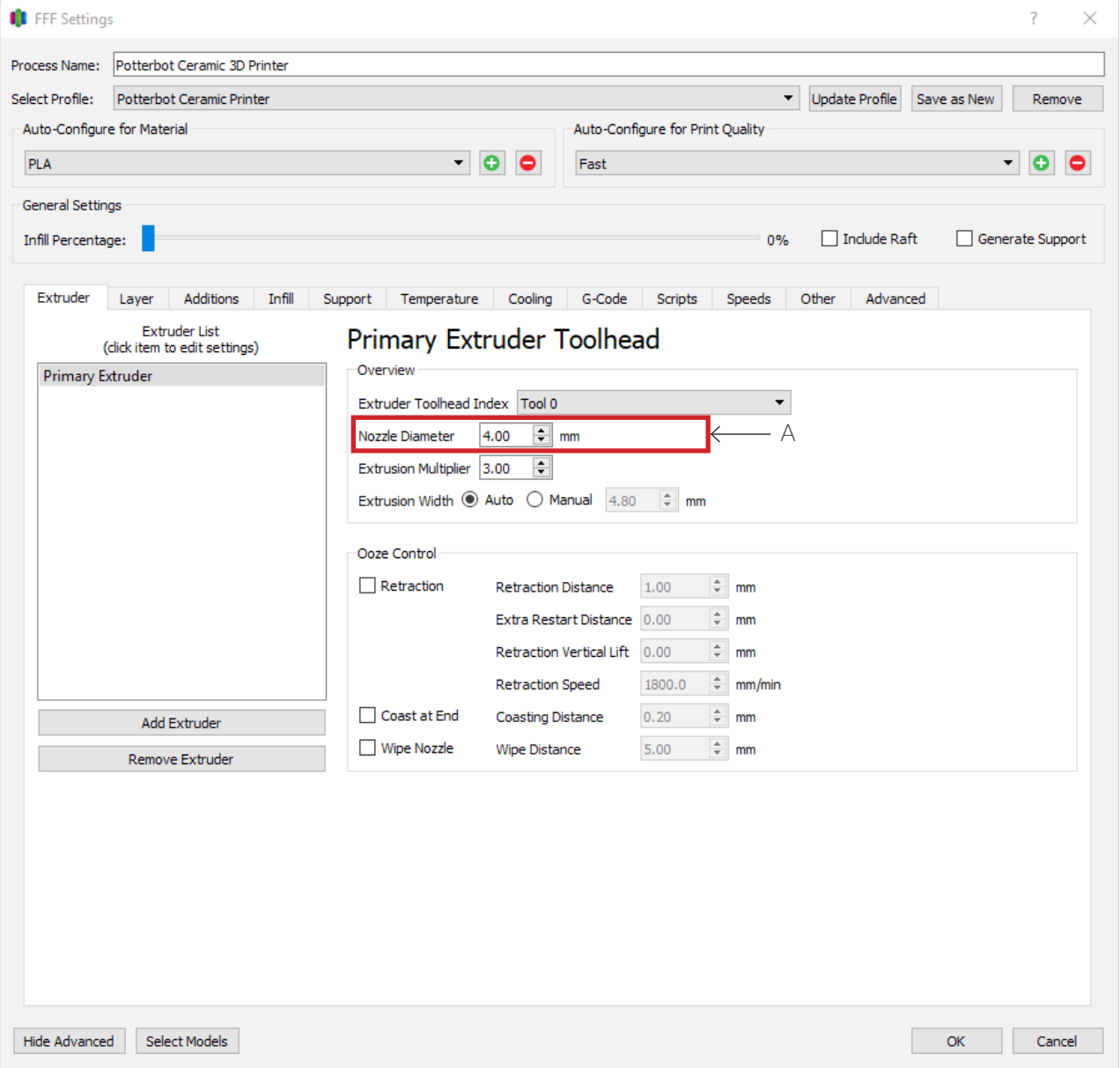




4.

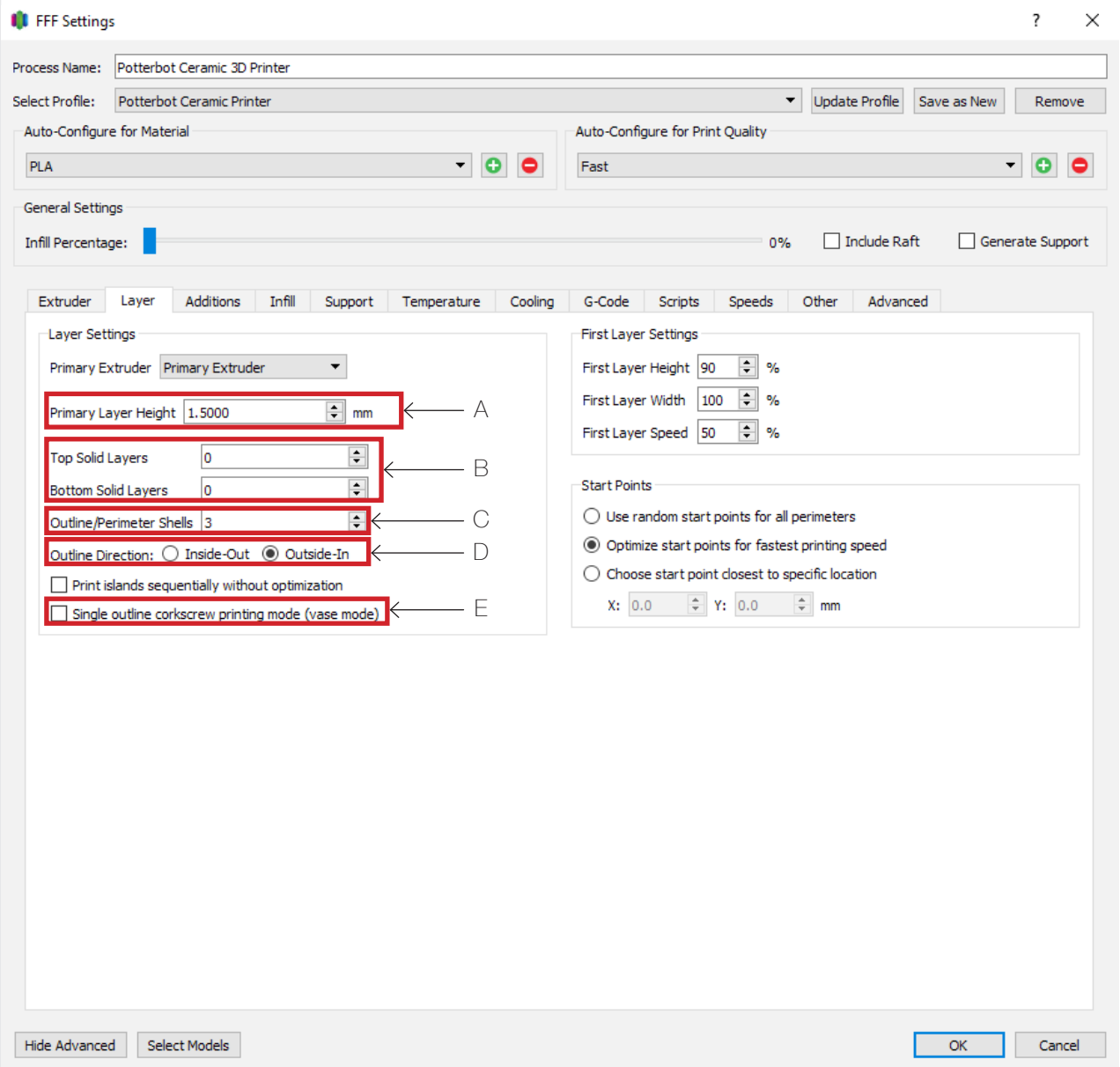
5. The FFF Settings should open up to the Extruder tab. (A.) Change the nozzle diameter and extrusion width to match the nozzle you will be printing with. The rest of the settings should remain the same.

5.



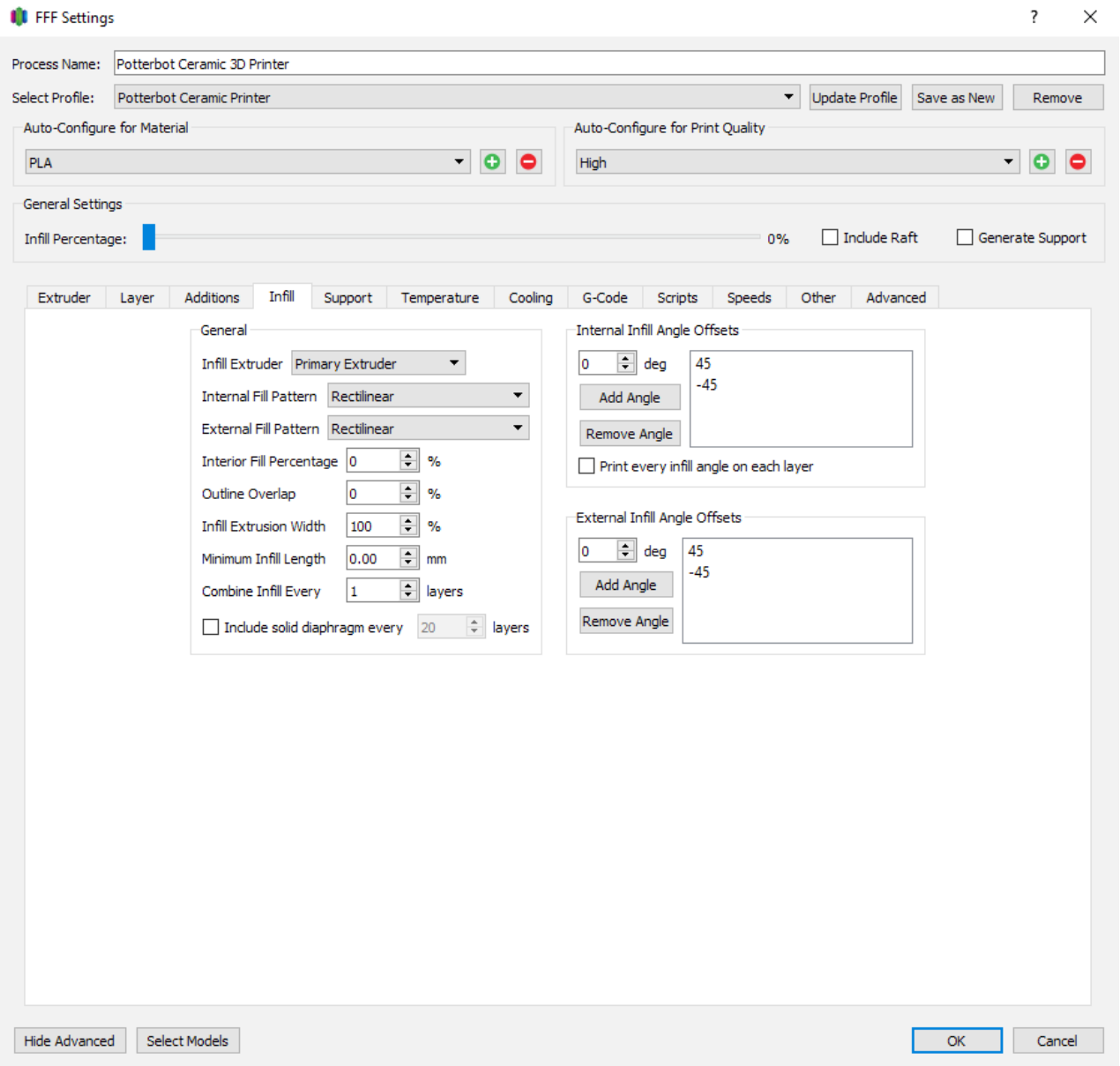
6. Next is the Layer tab. (A.) Choose a layer height, it is recommended to stay between 1 mm -2 mm layer height. (B.) Choose 0 for both the top and bottom layers. (C.) The number of perimeter shells determines the thickness of the print. (D.) Outline Direction determines the printing directions it is best to work from the Outside-In. (E.) Vase mode is an easy way to just print the shell of a polysurface. If this is checked set the Outline/Perimeter Shells to 0. The rest of the setting should remain the same.

6.

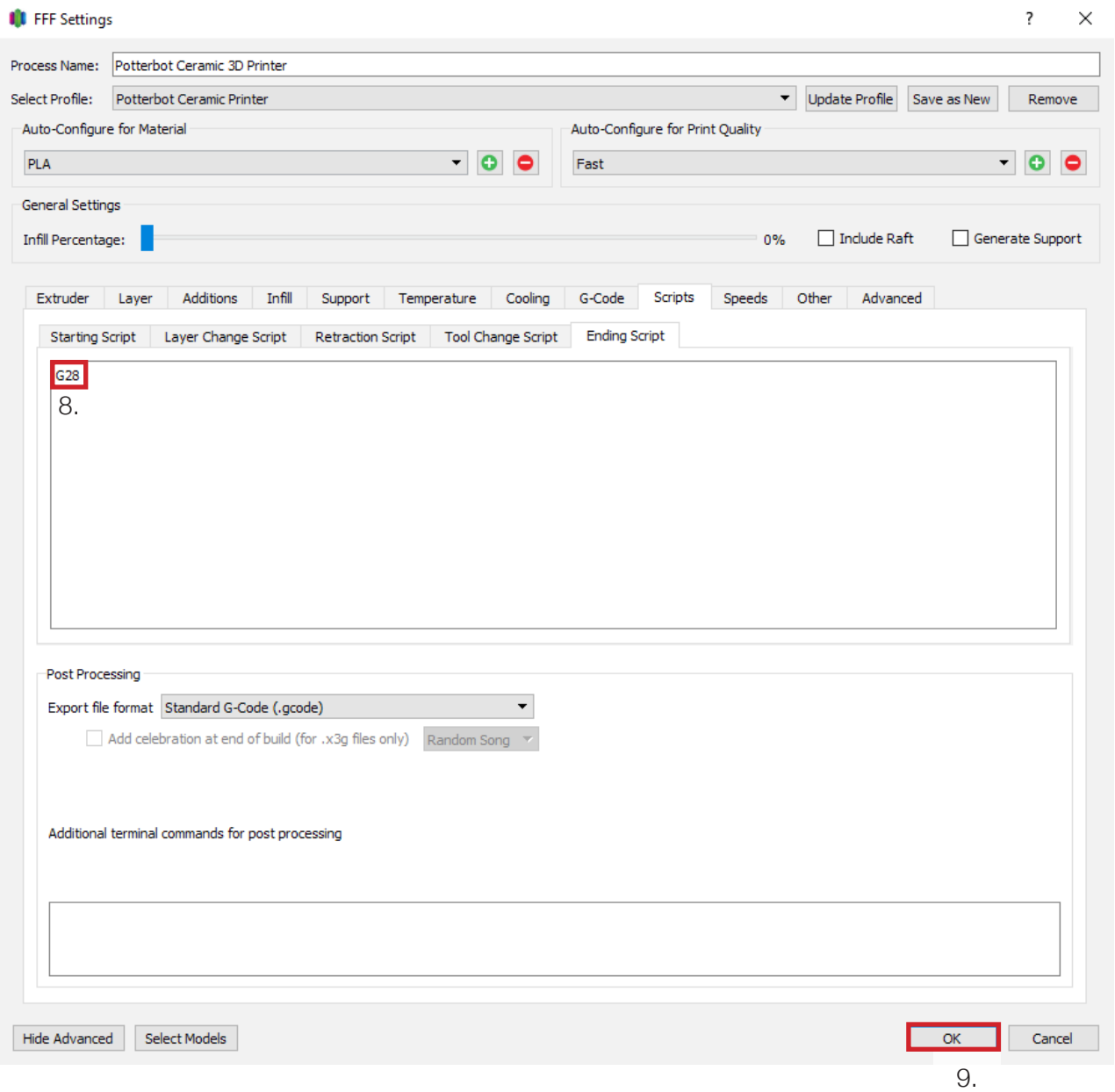


7. It is not recommended to use infill with the potterbot. Be sure that the Infill tab settings match those of the screenshot to the right.

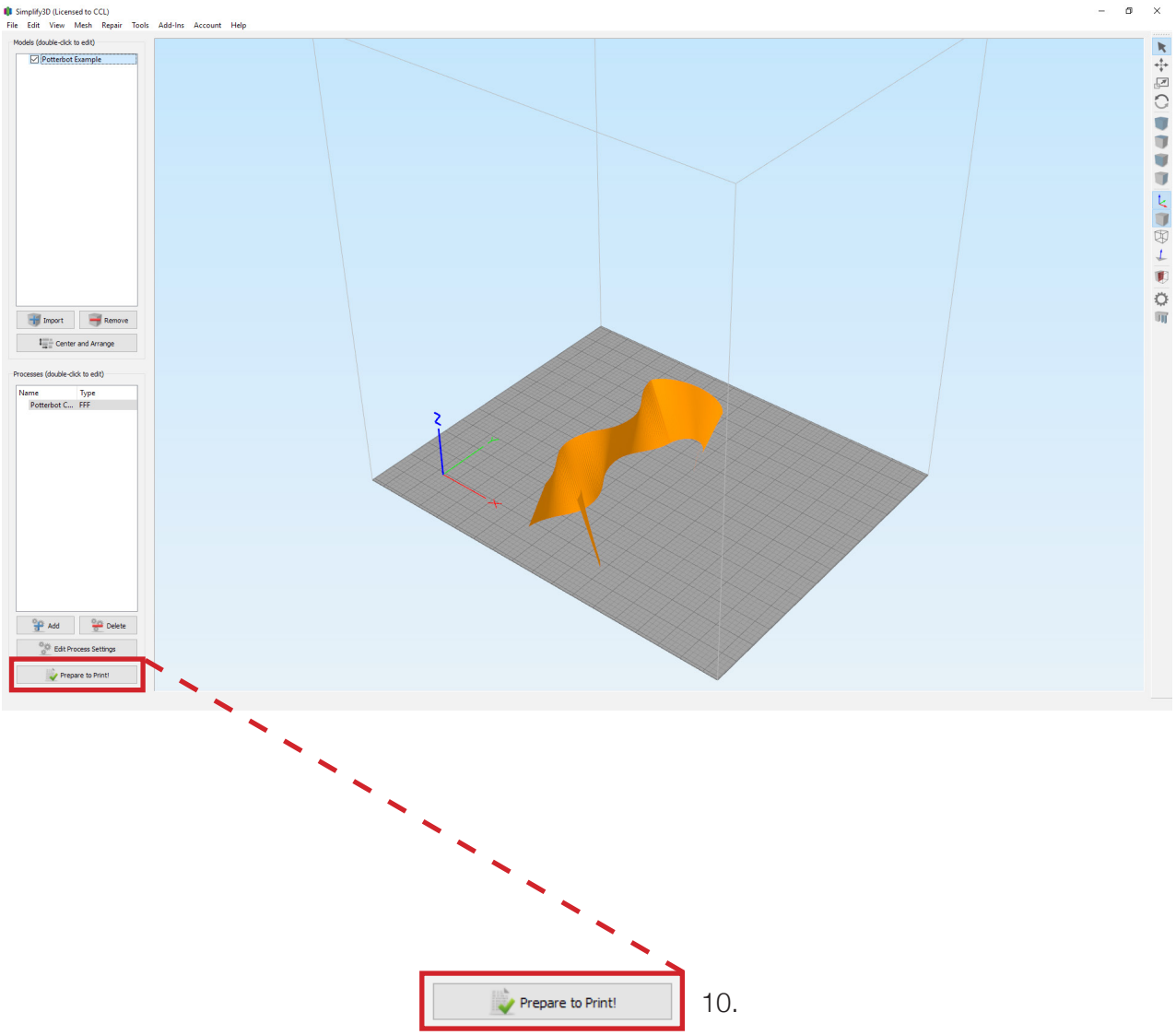
7.



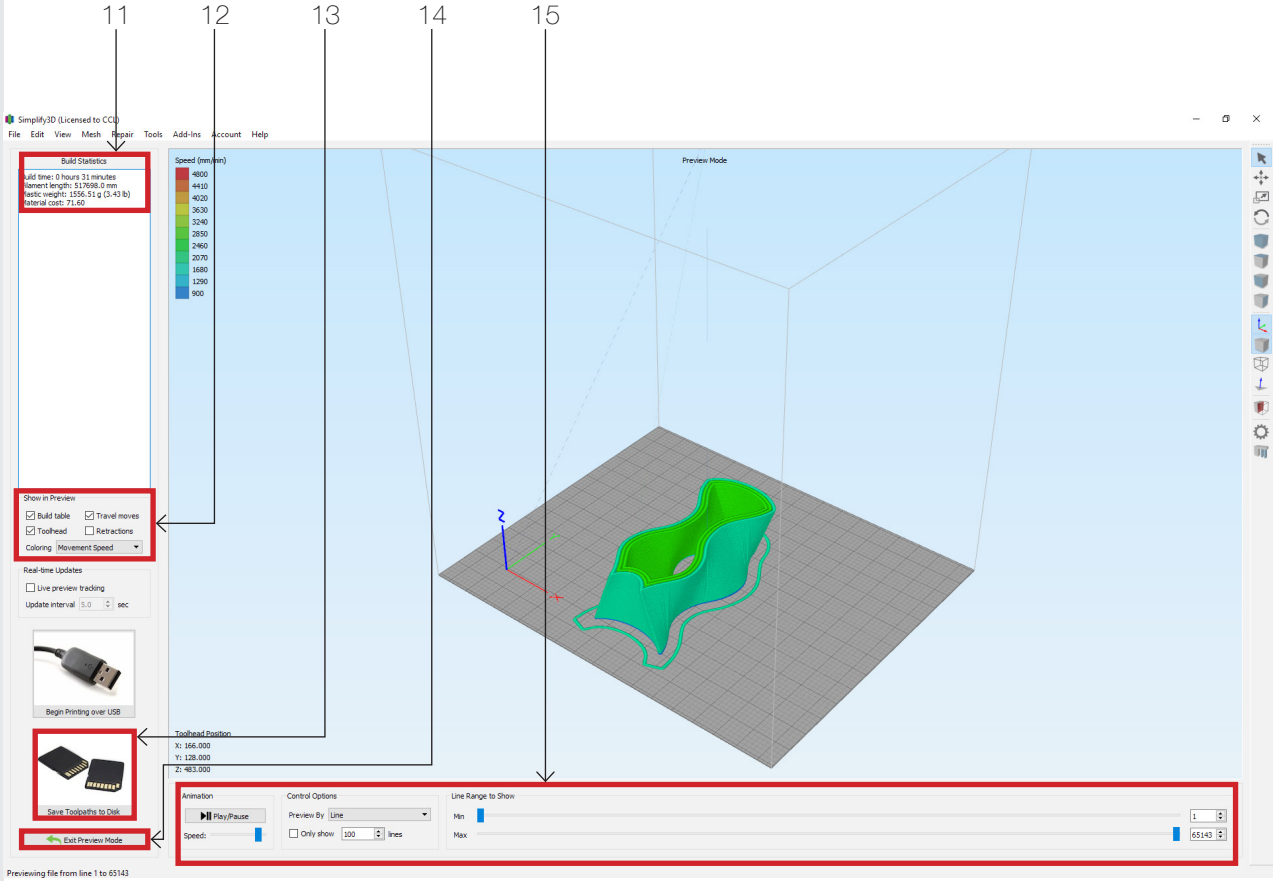
8. Under the tab Scripts, in the sub-tab Ending Script type G28. This will home the potterbot in all three axis after the print is complete.
9. Then click 'OK.'



10. Click ‘Prepare to Print!’



11. The build time estimate in the upper left-hand corner is not accurate.
12. Show in Preview gives you control over what you see.
13. To save the file insert an SD card into the computer and click 'Save Toolpaths to Disk.'
14. To go back to the previous mode, click 'Exit Preview Mode.'
15. To preview or view your print layer by layer one can mess around with the Animation, Control Options and Line Range to Show panels in at the bottom of the window.

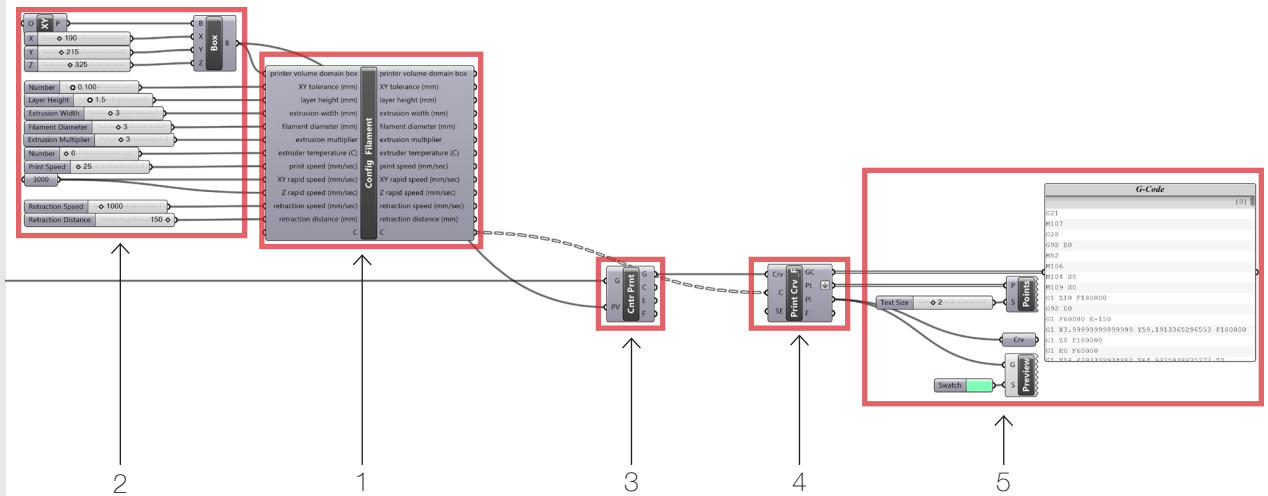


Xylinus

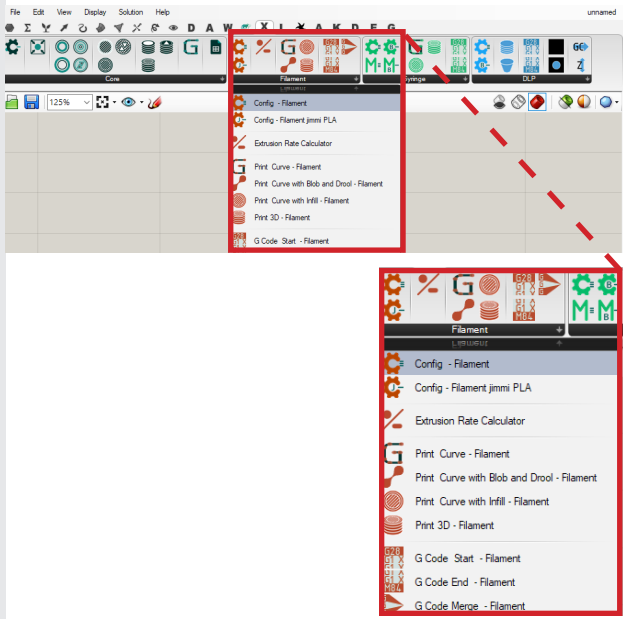
Download Grasshopper and the plug-in Xylinus. Be sure that your units in Rhinoceros are set to Millimeters! These following steps will instruct you on how to print curves. You can also print polysurfaces in Xylinus.

1. To create G-Code using Xylinus you will need to use a few components. First is Config-Filament. This component holds all of the primary configurations needed for printing on a 3D printer. It can be found in the Xylinus plug-in tab in Grasshopper. Drop down Filament and click “Config- Filament.”
2. Once you have this component you will need to give it a myriad of inputs. Most can be set with sliders, number components or directly within the Config Filament component.
    - First in the Potterbots print volume with a center box. The print volume for the potterbot is X-190 mm, Y-215 mm and Z-325 mm
    - XY tolerance- 0.1 mm, Layer Height- Varies with nozzle diameter a good range is 1.0- 2.0 mm.
    - Extrusion width/Filament Diameter- nozzle diameter
    - Extrusion Multiplier- 3
    - Extruder Temperature- 0
    - Print Speed- 25 mm/sec
    - XYZ rapid speed- 3000 mm/sec
    - Retraction speed- 1000 mm/sec
    - Retraction Distance- 150 mm

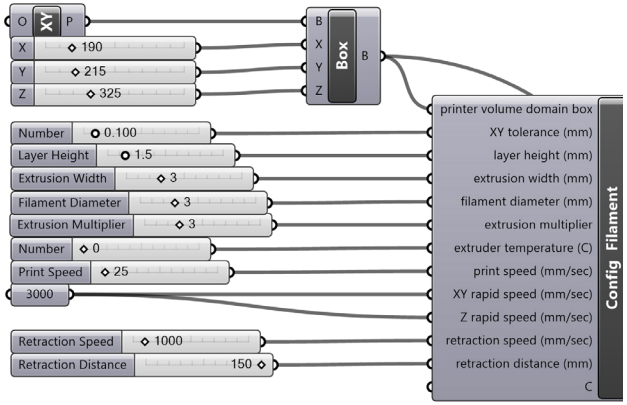
Overview



1.

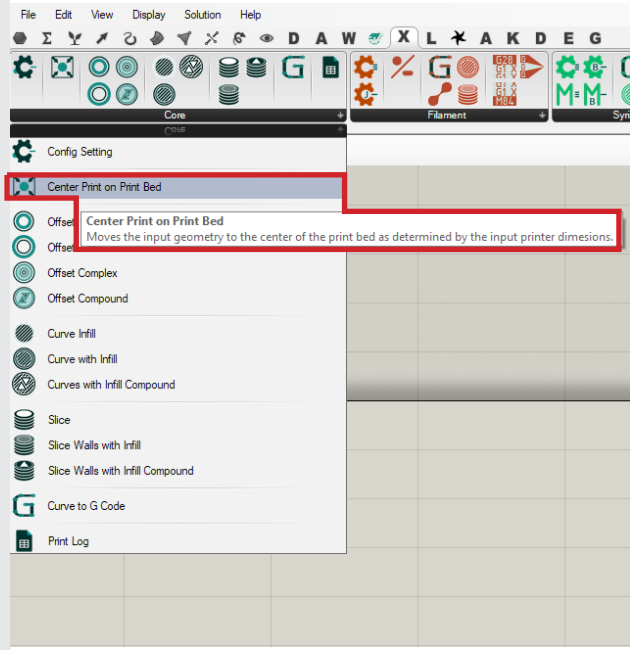


2.

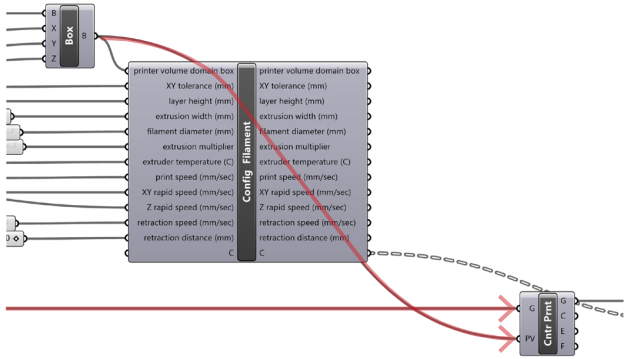


3. (A.) The second component is Center Print on Print Bed. Find this component in the Xylinus tab in the Core Components. (B.) You will need plug the output from the print volume/center box into the PV (print volume) input. Then plug your geometry you are printing into the G (geometry) input.
4. (A.) The third component is the Print Curve-Filament component. This component will generate the G-code. (B.) Plug the G output from the Center Print on Print Bed Component into the input Crv. Then plug the outup C from the Config- Filament into the C input.

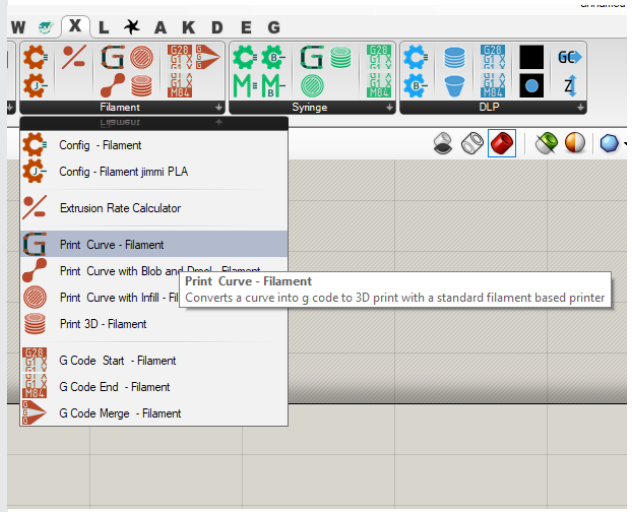
3A.



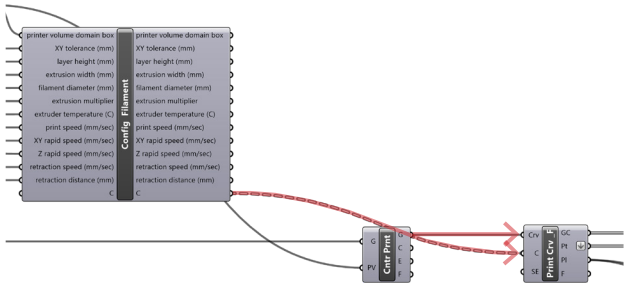
3B.



4A.

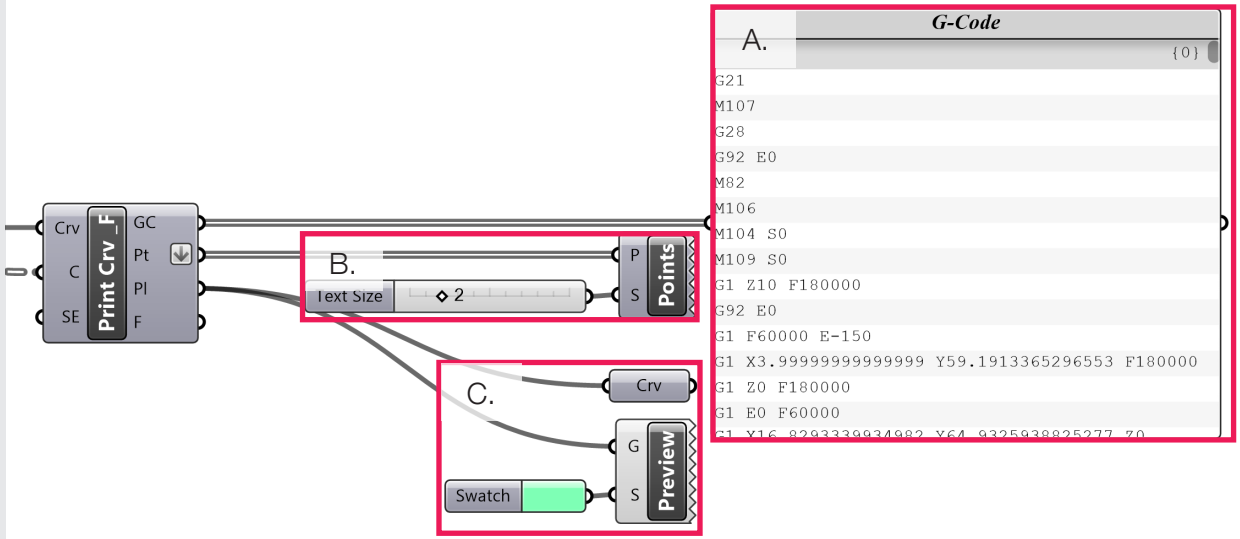


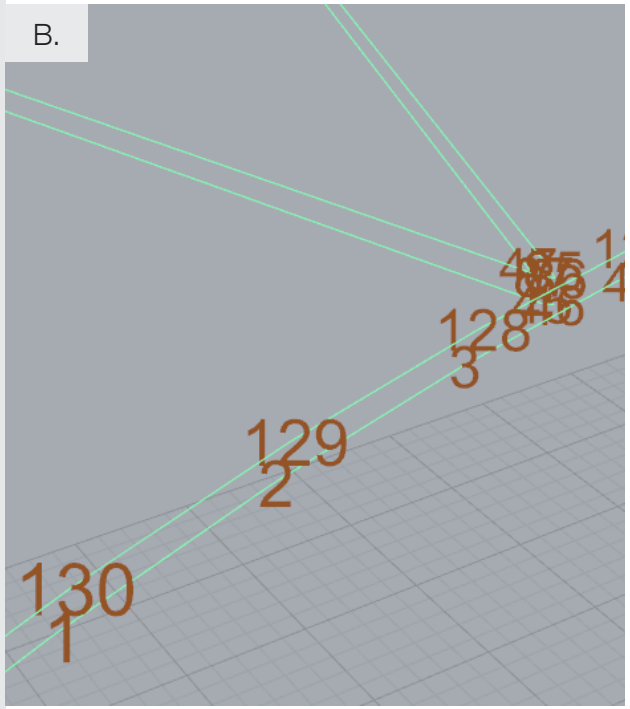
4B.

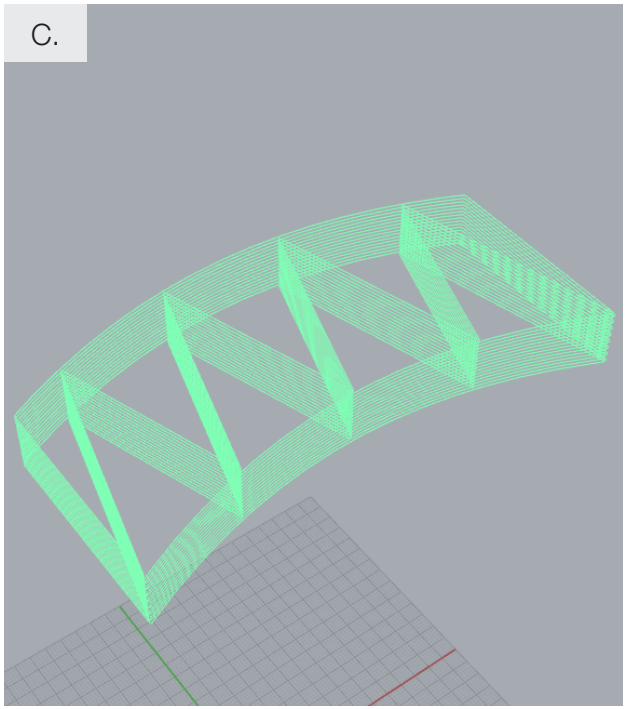


5. (A.) Plugging a panel into the GC output will allow you to view the generated G-Code. (B.) The pt output will allow see the points in order when you plug it into a point list component. (C.) You can see the curves two ways by plugging in a crv component. This would allow you to bake the curve into Rhinoceros. You can preview the printer's path by inputting the Pl output into the P of a preview component. A swatch can be used to change the color of the preview. This preview will be viewed in Rhinoceros

5.

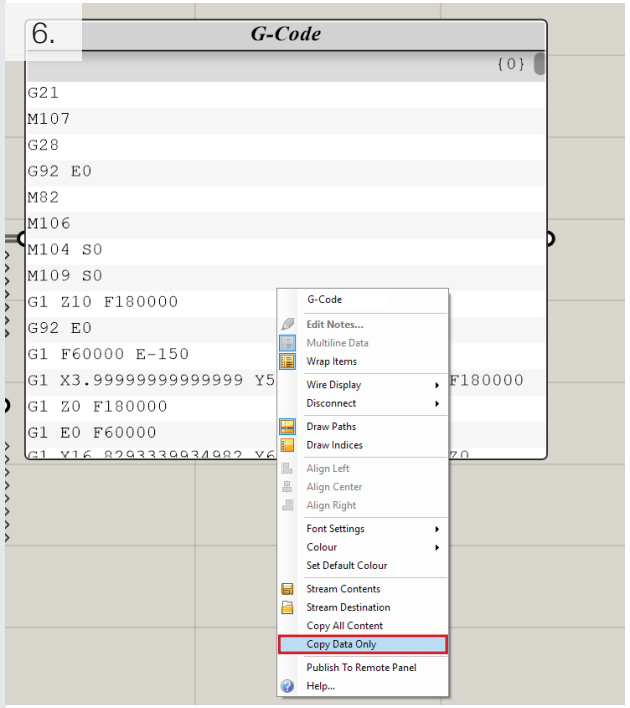




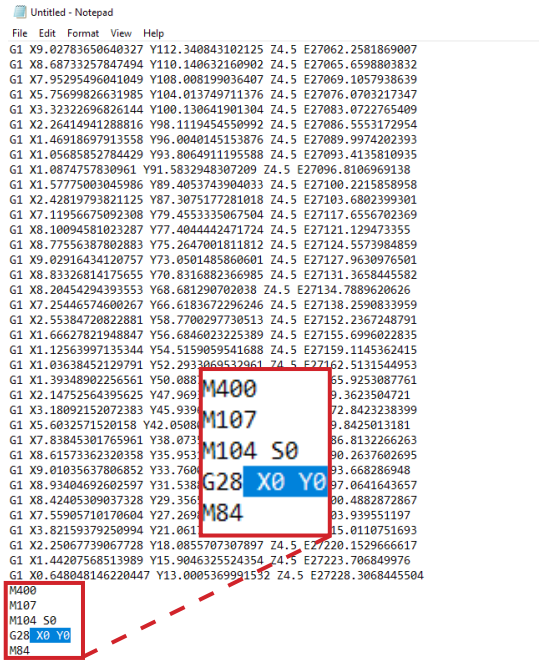


6. Right click the panel. Then click “copy data only.”
7. Open Notepad and paste the data into the text document. Scroll to the bottom of the G-Code and delete X0 Y0 from behind the G28 so the printer homes in the X, Y, and Z axis. If this seems tedious, you can permanently change the end G-Code panel in the parent Print Curve- Filament component by double clicking on the center of the component where the component name is located.
8. Click “File”> “Save” Save the file onto an SD card. File_name.gcode

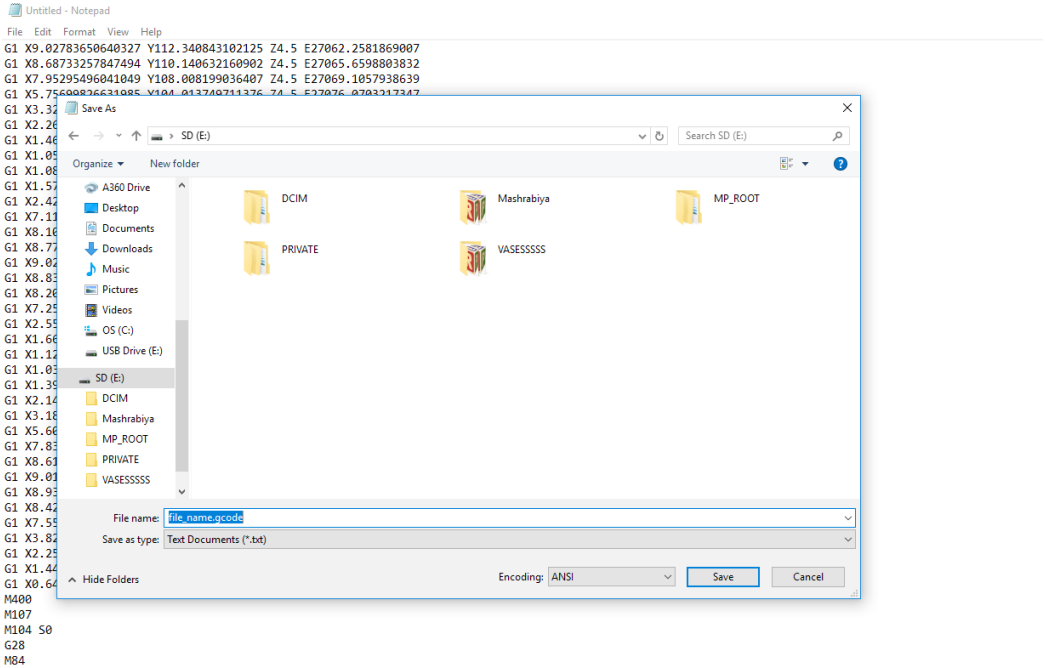
6.



7.

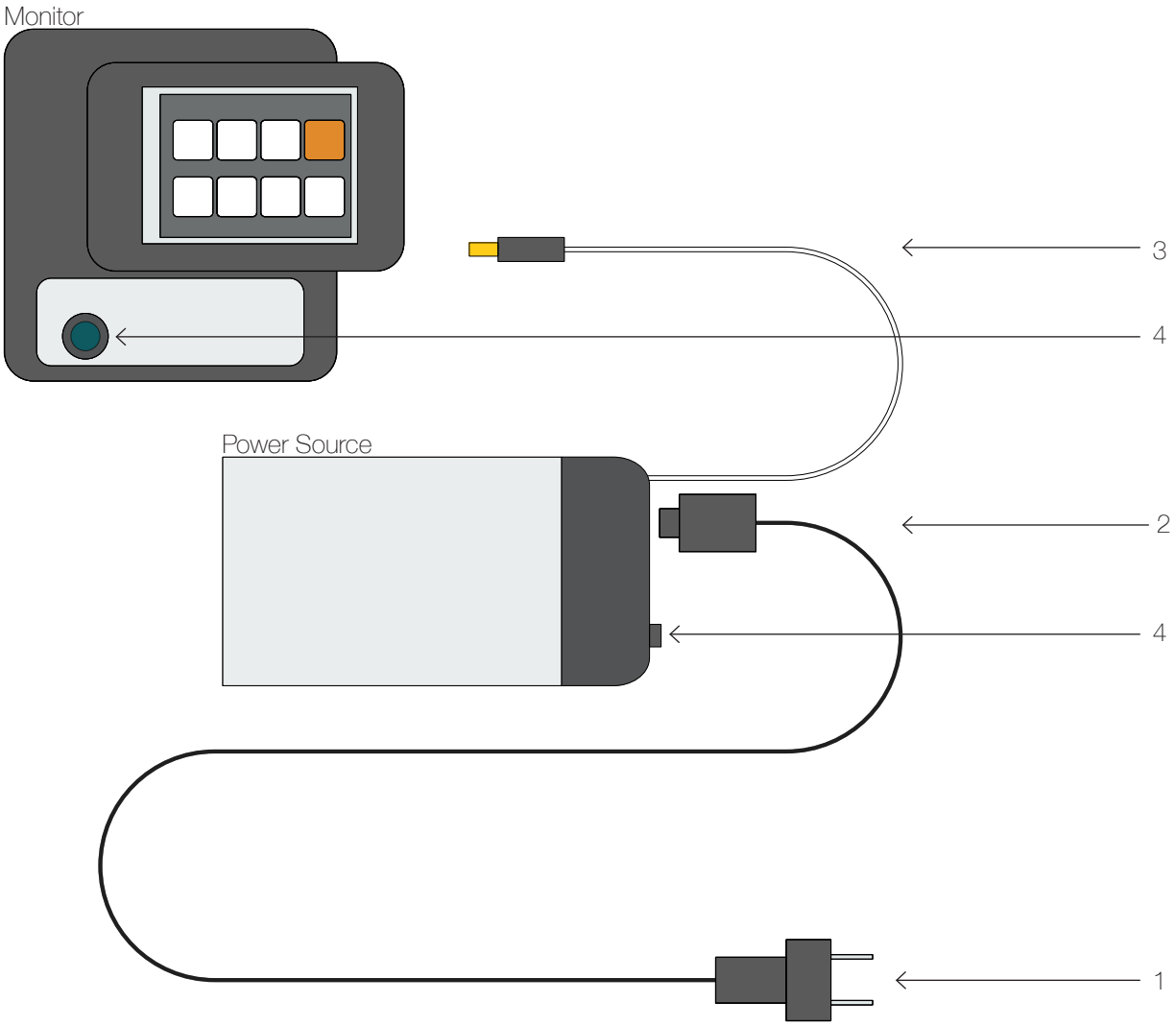


8.



Powering the Potterbot

1. Plug the potterbot into a wall outlet or a surge protector.
2. Plug the cable from the wall into the power source.
3. Plug the white cable from the power source into the back of the Potterbot's Monitor.
4. Turn on the power supply by flipping the switch. Be sure to turn this off when you are finished using the machine.
5. Turn on the machine by pressing the green power button.

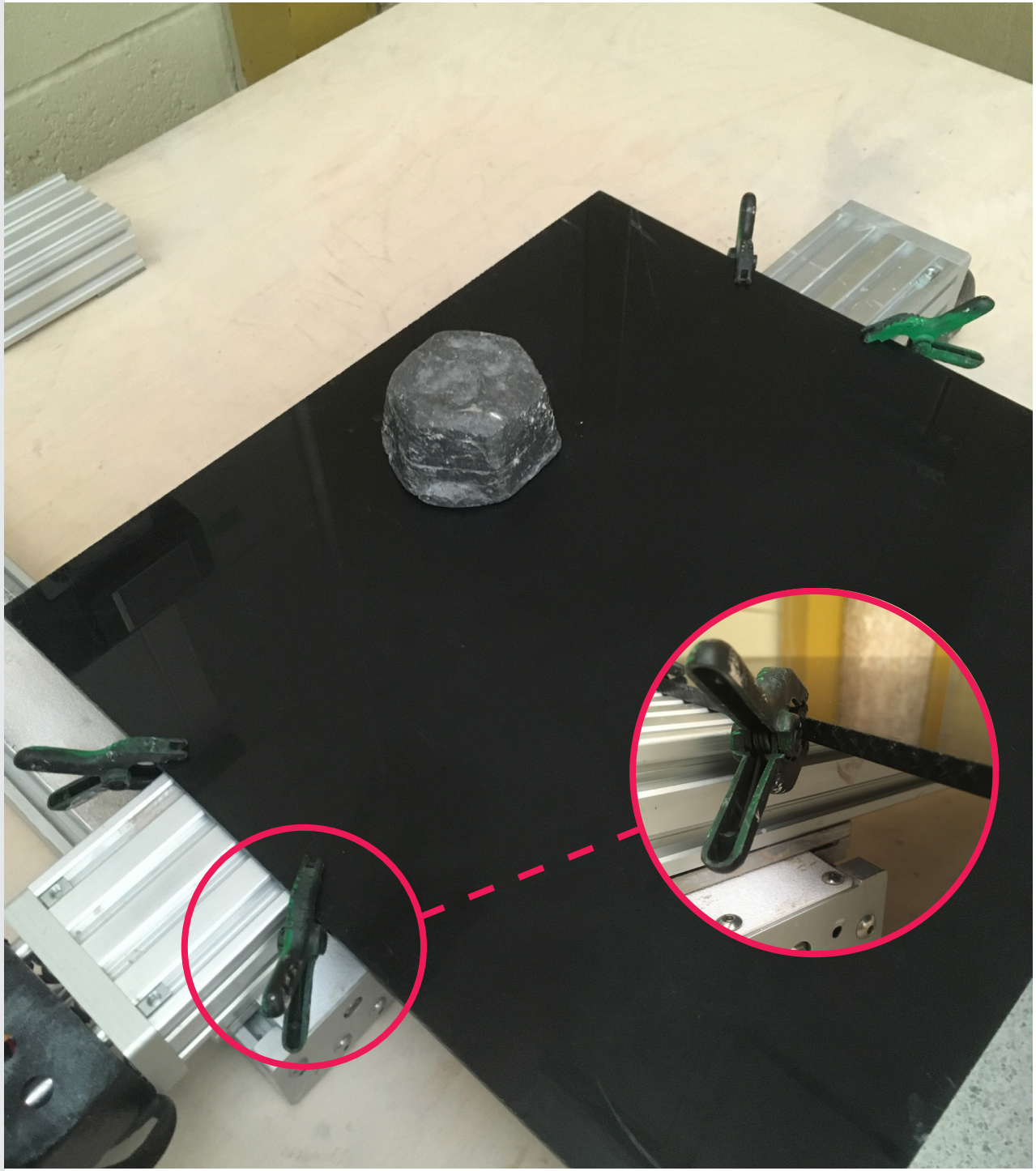


Securing the Bed to the Frame

Clamp the bed to the x-axis frame of the potterbot using clamps. Be sure to get the bottom of the clamp into the grove in the frame. See call-out. You may also want to add a weight to the bed to help level it.

You can print with an acrylic or wooden base. Sometimes adding a thin layer of clay or wetting the wood base helps the to stick.

A variety of bases can be found hanging on the wall to the left of the sinks.



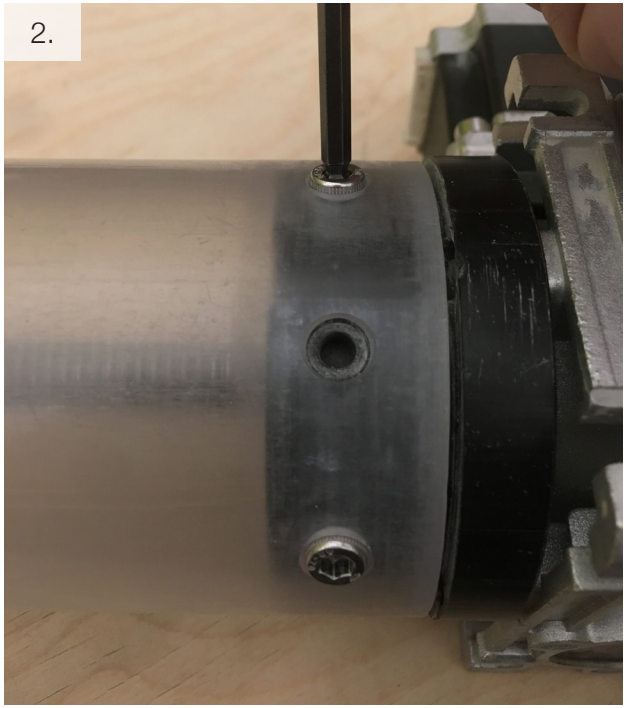
Emptying the Extruder Tube

When removing hardware place into the grey container labelled Potterbot.

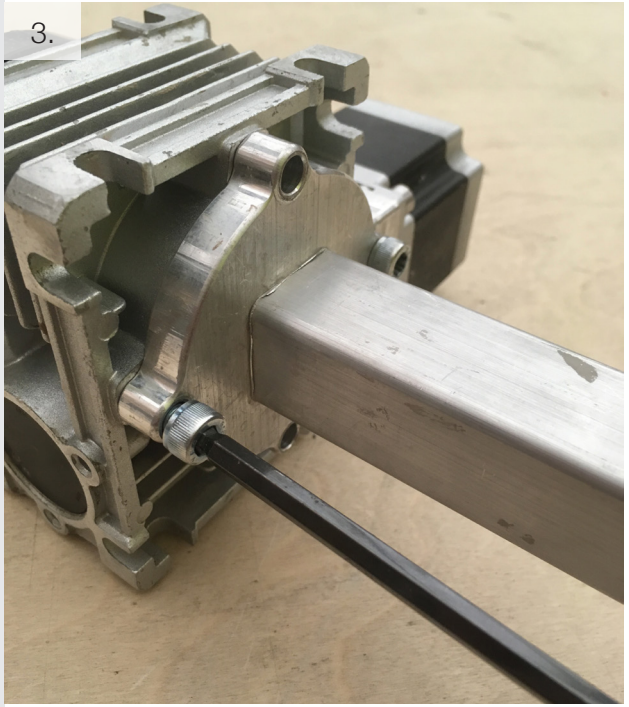
1. Unscrew the nozzle holder from the tube.
2. Remove Screws holding the tube to the motor and threaded rod. Then remove the motor and threaded rod from the clear tube.
3. Remove the two screws holding the threaded rod cover. Then remove the metal cover.
4. Use the PVC pipe to push the extruder piece, nozzle holder, and nozzle through the tube.

1.

2.



3.

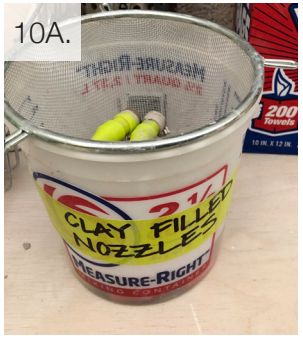


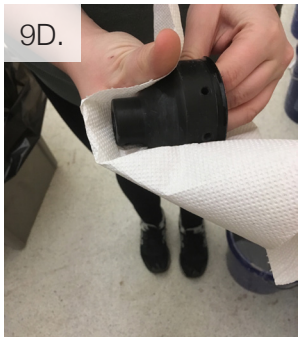
4.

5. Separate the nozzle holder from the extruder piece
6. Place any remaining clay into the 5-gallon bucket labelled Stoneware or Porcelain- depending on the type of clay you are using.
7. Remove the screw holding the nozzle. Put a dowel rod into the nozzle. Hold the nozzle holder and tap the wooden rod lightly on the table. This should push the nozzle through the nozzle holder.
8. Remove the extra clay from the nozzle holder and place in the 5-gallon bucket labelled Stoneware or Porcelain.

CLAY SHOULD NEVER GO DOWN THE DRAIN IN THE WET SINK!! IT WILL CLOG!!

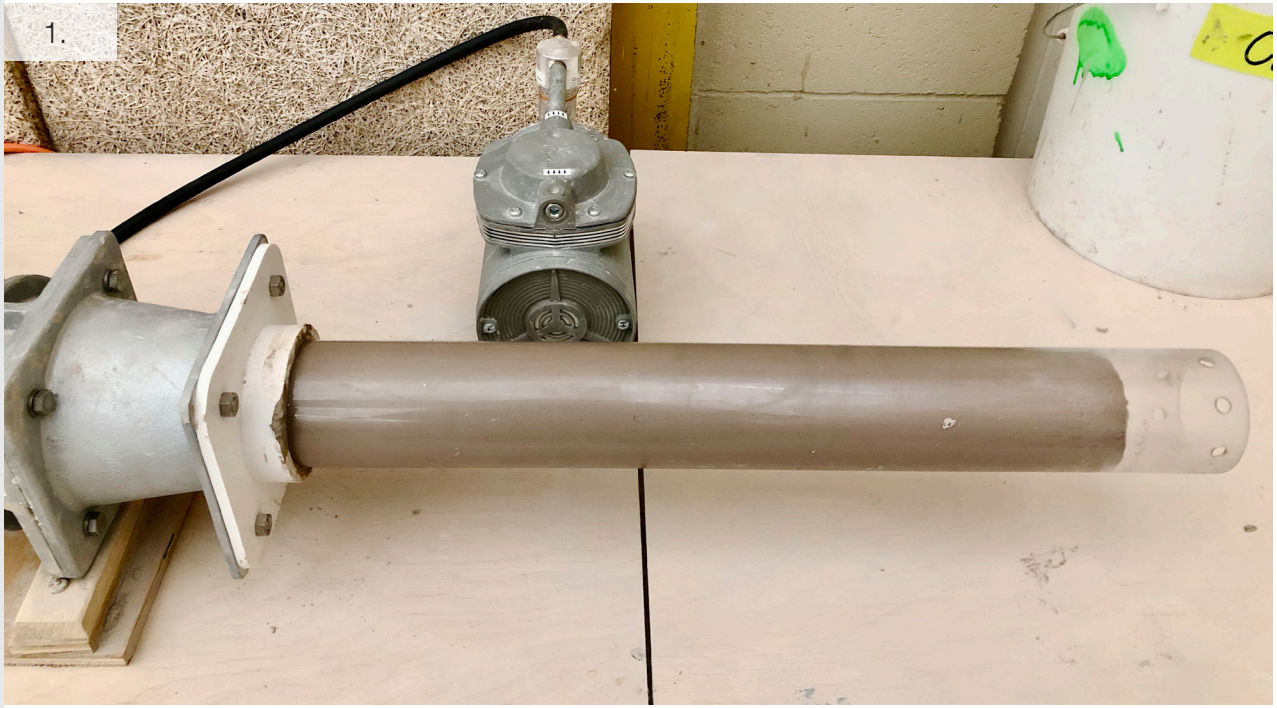
9. (A.) Wash the nozzle holder, extruder piece, and tube in the 5-gallon bucket with soapy water located in the dry sink. (B.) Rinse the them in the 5-gallon bucket with water in the dry sink. (C.) Let dry on the wire rack (D.) Dry with a paper towel.
10. (A.) Let the clay in the nozzle dry on the strainer. (B.) Use a wire rod to push the dried clay out of the nozzle. (C.) Let the nozzle soak in the water to remove any additional clay. (D.) After soaking the nozzle dump the clay filled water from the container into a 5-gallon bucket in the dry sink. Remove any extra clay with a sponge. Then fill the container with water and place strainer on top.
11. Clean any clay or debris off the wood desks with a sponge. If coated in clay clean the potterbot screen with the multipurpose cleaner and a paper towel. Sweep or vacuum the floors. Mop if necessary. All cleaning supplies can be found on or around the dry sink. Once your 3D printed piece has dried wash the wood or acrylic base you printer on. When the water gets dirty please dump the 5-gallon buckets at the southwest entrance to the Communications building. Stir the water prior to dumping it to so the clay does not stick to the bottom of the bucket. Put any tools or equipment back where you found it.

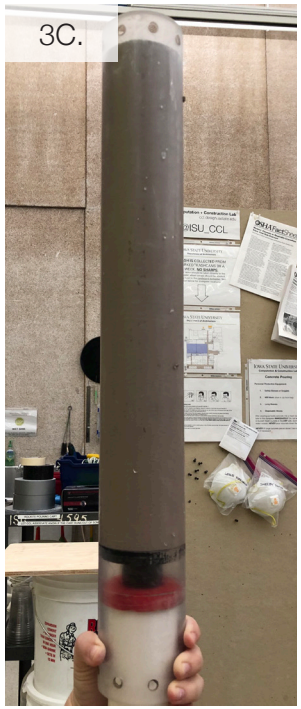


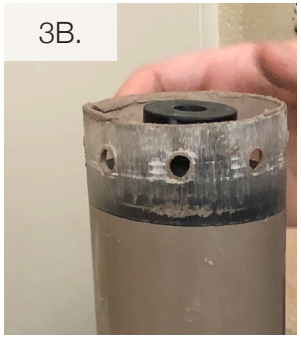


Filling the Extruder Tube + Printing

1. Ask the CCL Associate to use the pug mill and load a tube with clay. Remember to leave around 2-4 inches at the end of the tube free of clay.
2. Place the extruder piece onto the top of the PVC pipe's 3D printed cap. (A.) Make sure the smaller cylinder is facing down. (B.) Make sure that the 5 divots are facing down.
3. Put the tube over the extruder piece and push the tube down on the end that is filled with clay. (A.) Clay will extrude through the holes. (B.) Remove the clay and put into the clay's 5-gallon bucket. (C.) Continue to push the tube down until it reaches the holes at the other end of the tube.

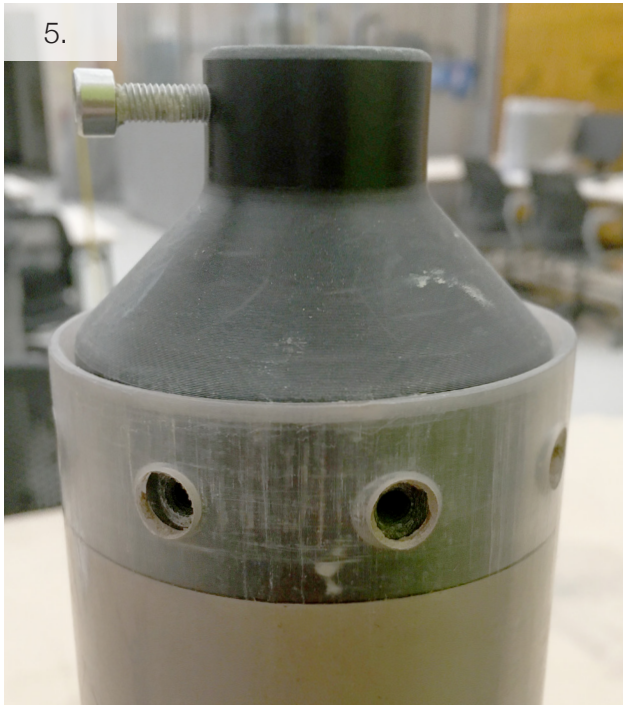






4. Clean any remaining clay from the tube and it's apertures with a sponge and the wire brushes in a 5-gallon bucket in the dry sink.
5. Push the nozzle holder into the tube. Making sure that the holes in the nozzle and the holes in the tube are aligned.
6. Put the screws into the nozzle holder using an Allen wrench.
7. If you are not using the clay immediately, (A.) Cut two balloons. (B.) Place a balloon over either end of the tube to save the clay for another time. This will keep the clay from drying out.


4.

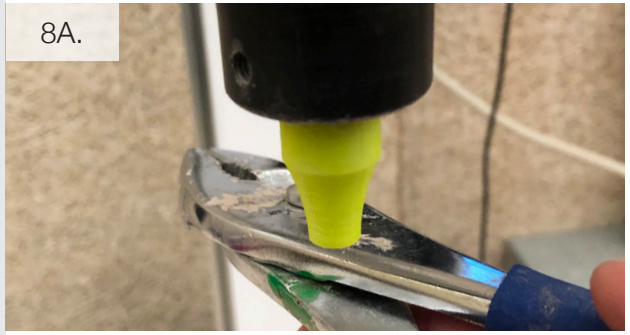

5.

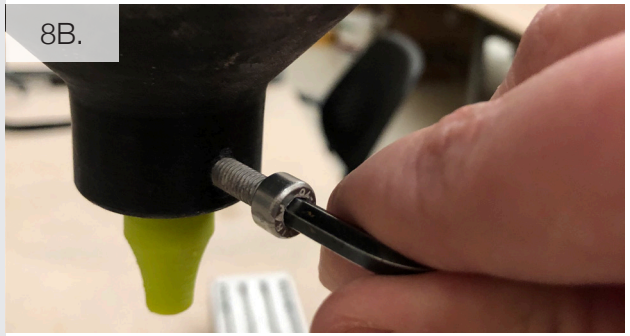

6.

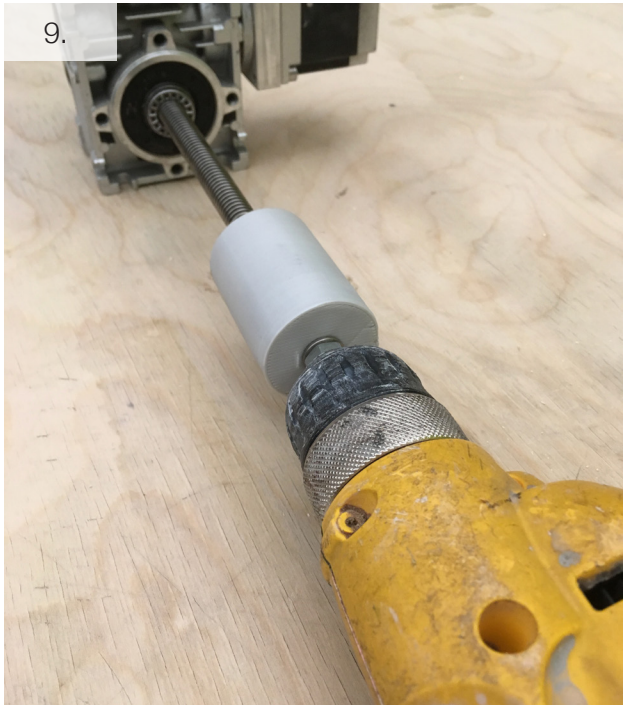

7A.


7B.

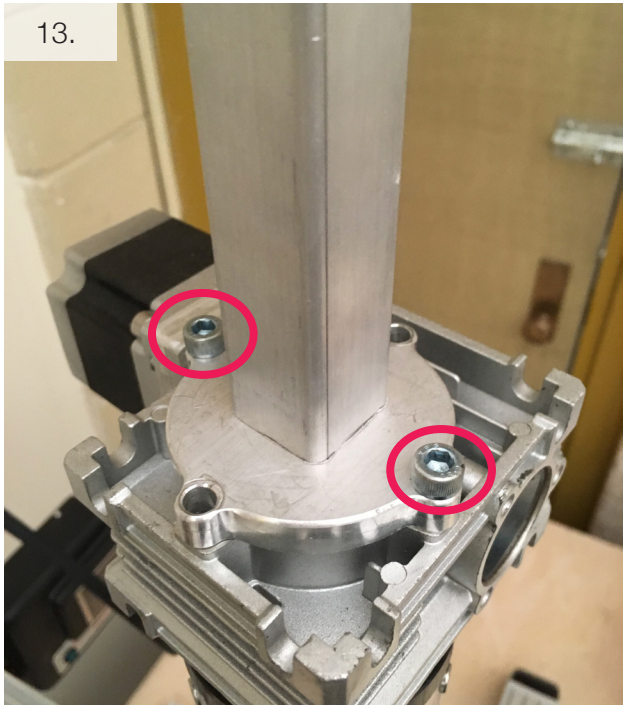
8. (A.) Place a nozzle into the nozzle holder by lightly tapping it with a pliers. A pliers can also be used to remove a nozzle be careful the 3D printed nozzles have a tendency to break. (B.) Put a screw into the side of the nozzle holder to hold the nozzle in place. Do not put the screw in too far or it will puncture the 3D printed nozzle.
9. Use the 3D printed drill adapter to carefully rewind extruder screw.
10. Wind the threaded rod until the black, plastic piece with five screws is inside each corresponding divot. This is not a concern if you are using the one part extruder piece.
11. Place the screws into the tube and black plastic piece to secure the extruder.

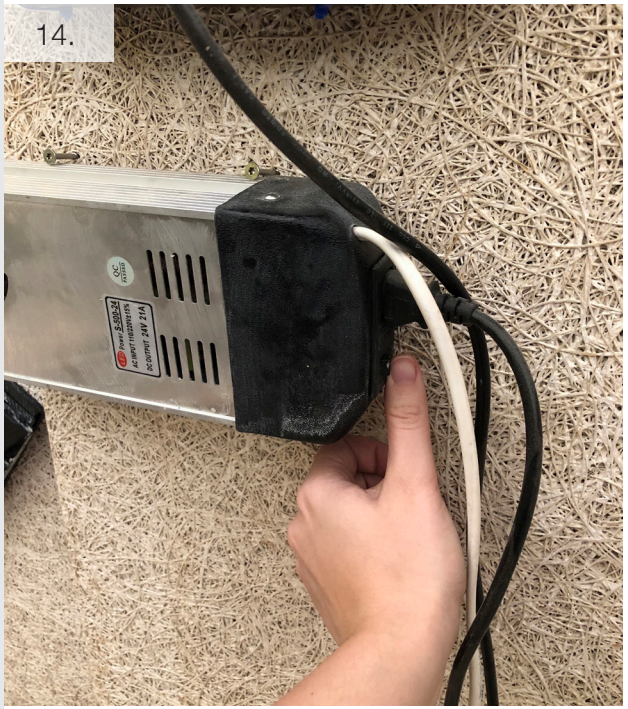






12. Plug the black cord into the stepper motor.
13. Place the metal cover over extruder screw making sure that the two screws align with the holes. Then use two machine screws to lock the cover in place.
14. Switch on the power supply.
15. Press power button.





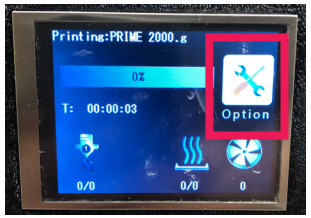
16. Press Printing.
17. First select PRIME 2000. This file continues to extrude and was designed to prepare the clay for printing. Run this file until clay starts to extrude from the nozzle at a consistent rate.
18. (A.) Use the red mixing bowl for Stoneware and the green mixing bowl for porcelain to collect the clay when it extrudes. (B.) Press OPTION > STOP to cancel the print and turn off the printer. Turn the printer back on. Press PRINTING. Use the arrows to find your file. Once you find it select it.

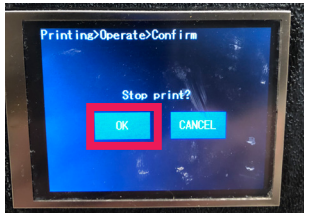
16.

13.

18 A.

18 B.





19. Wait for the potterbot to fully descend in the z axis. Make sure that the nozzle is higher than the printing table so that it does not hit base when it aligns to the proper x and y coordinates.
20. Adjust the distance between the bed and the extruder manually. The nozzle should be around the height of the layers in the file. Loosen the red latch to move the extruder tube. If it is a slight movement just wiggle the tube back and forth and it would move.
21. Wait for your print to finish then carefully remove the acrylic base from the printer and set on a shelf to dry. Let your print dry for at least 12 hours before removing it from the acrylic base.
22. (A.) With a scissors cut off the end of a balloon. (B.) Place the cut balloon over the nozzle and nozzle holder to prevent the clay from drying.