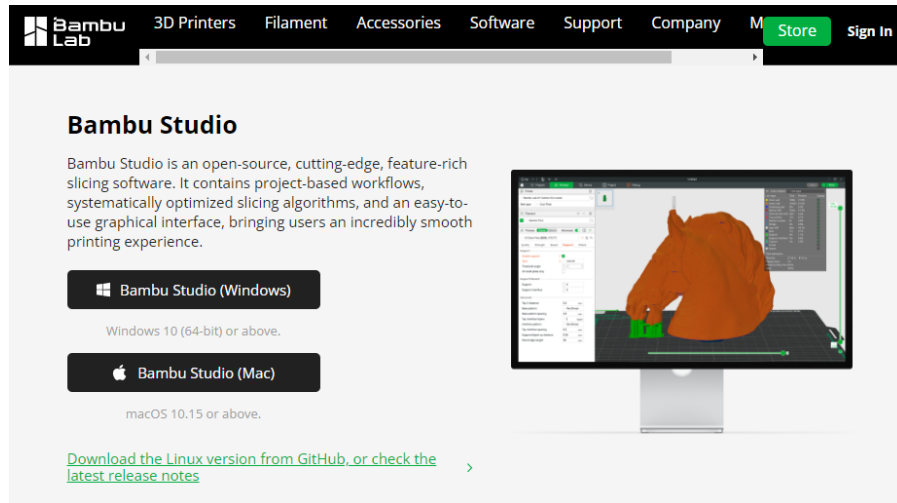


How to 3D Print Manipulatives

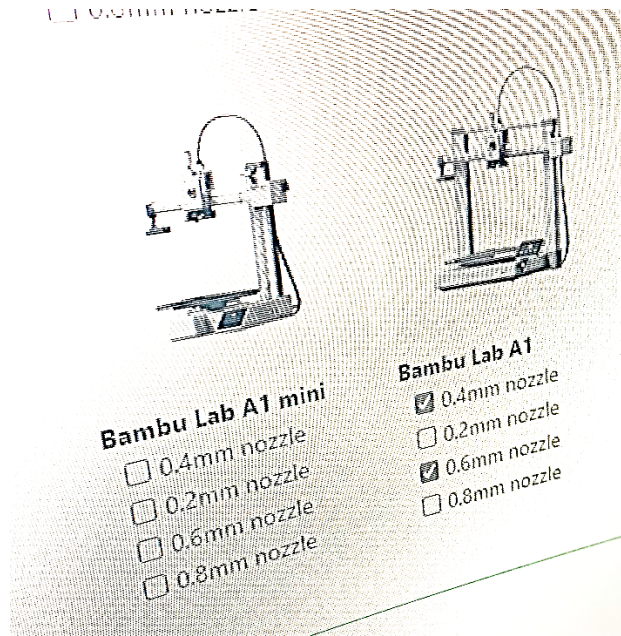
Step 1:

Download and install Bambu Studio: <https://bambulab.com/en-us/download/studio>



IMPORTANT!

During the installation process, you will need to select the type of printer you are using. Select "Clear All" and then select the Bambu Lab A1. Be certain to select both the 0.4mm and 0.6mm nozzles (but ONLY for the Bambu Lab A1).



We will focus on using the 0.6mm nozzle, but should have both selected just in case.

Step 2:

You will now locate the files for the manipulative(s) you will 3D print. There are two main ways to do this, and it's important to know both ways:

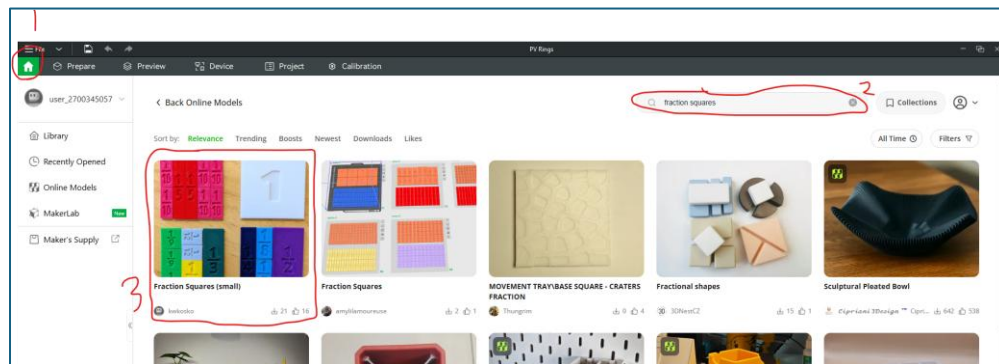
1. Download files from Bambu's "Makerworld" repository – this can be done within Bambu Studio or on <https://www.makerworld.com>; or,
2. Download files from a different source ([printables.com](https://www.printables.com), [thingiverse.com](https://www.thingiverse.com), etc.) and import them to Bambu Studio (these are STL files).

It is *easier* to download files directly within the Bambu Studio application, BUT not everything worth printing is always available there. We will look at BOTH ways below:

Downloading files within Bambu Studio / Makerworld:

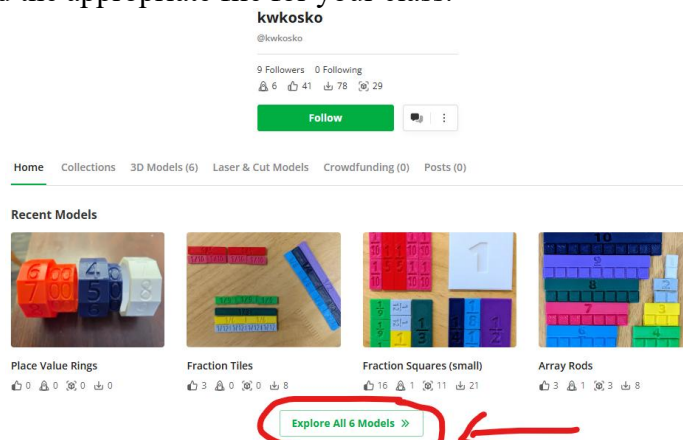
To search for manipulatives (or any teaching material) in Bambu Studio:

1. Click on the Home button at the top-left;
2. Type in what you want to search for (the illustrated example is for [fraction squares](#));
3. Click on an object to explore it as an option.

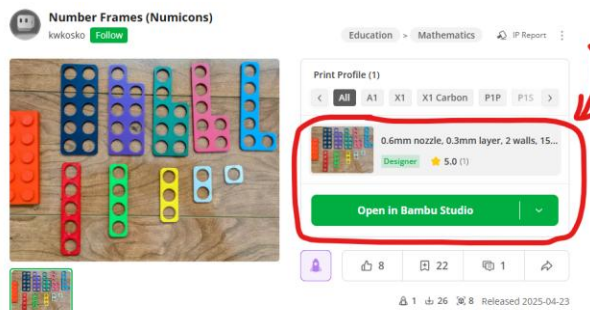


IMPORTANT

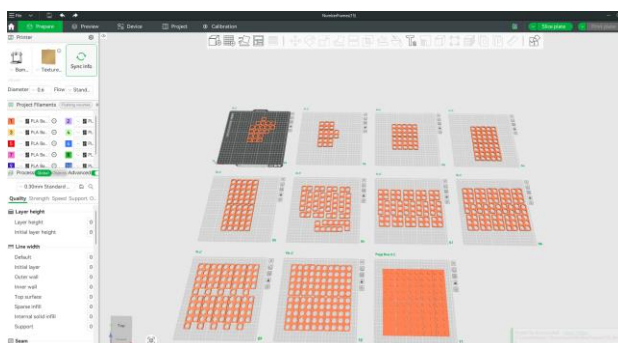
Because there are often more than one option, and we want to make sure you print from a reliable source (*some options you may find won't print well because of poor design*), we want you to print from a specific source. To do this, open your web browser and go to: <https://makerworld.com/en/@kwkosko> Once here (see below image), click "explore all models" at the bottom and find the appropriate file for your class.



When you click on the right file, you should see the page below.



Next, click “Open in Bambu Studio” to transfer this to Bambu Studio (you will be prompted to “sign in” to Makerworld, and this is the same account as Bambu Studio). Note: if there is more than one profile available, select the one that is 0.6mm nozzle (this is the size of nozzle we use in the IRC to improve the speed of our prints). If you’ve done everything right, Bambu Studio will open and load a screen that looks similar to the right-side image below (we will discuss what to do in the next step).



Downloading files from a different source (Thingiverse as an example):

As with Makerworld, you can go to a different repository to download different objects to print. Here we provide the option of using Thingiverse. As with the above example, you will use the files we’ve verified to make sure everything prints correctly. So, go to the Makerspace Manipulatives page (<https://xr.kent.edu/makerspace/>) and download the files needed for your course. Below are two examples:

Manipulative	Direct Link to Download STL files.
ECED 40303	https://www.thingiverse.com/thing:5897419
Number Frames (Numicons)	
ECED 40404	https://www.thingiverse.com/thing:5897787
Fraction Tiles	

STL files are the basic 3D models for the manipulatives. You can modify or create your own. For this course, you are **not** asked to do so.

Note #1: *The number frames zip file will contain STL and SVG files. SVG files can be used on a Cricut to cut foam versions of the shapes. You will use the STL files for 3D printing.*

Note #2: *To make use of the STL files (i.e., to actually print something), you will need to “slice” the files in Bambu Studio.*

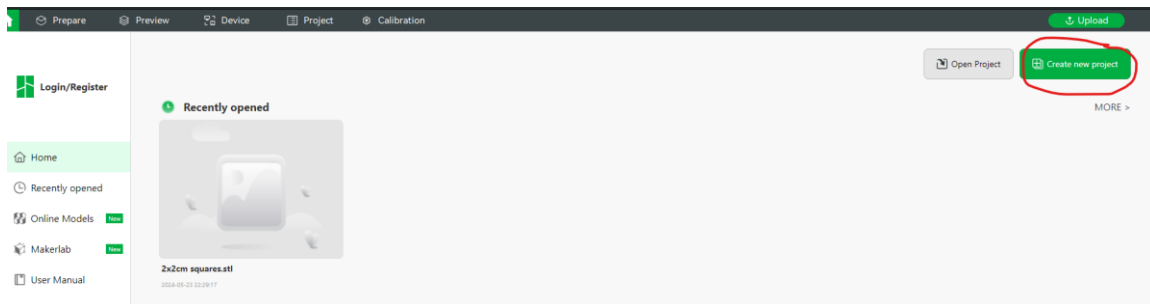
Note #3: *STL files are also often downloadable in Makerworld. These files are the “basic” files for printing and can be used across different manufacturers and software programs.*

Step 3:

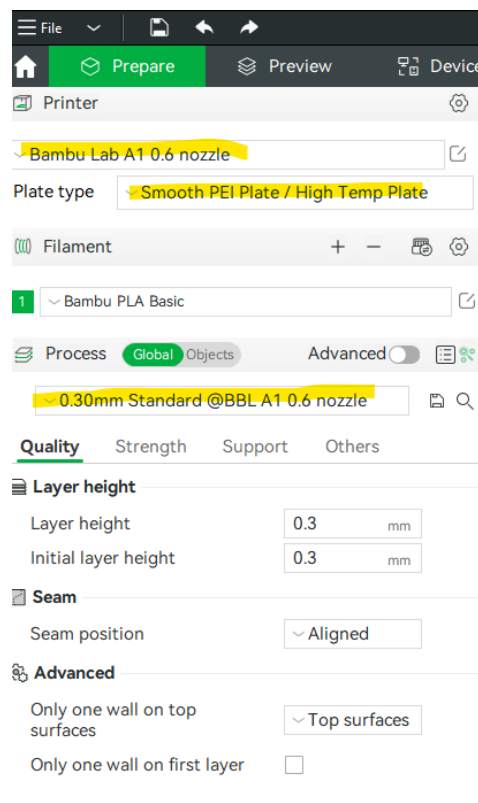
Now it is time to “**slice**” your STL files. Slicing is a process of providing the 3D printer with specific directions of when/where/how to print the 3D object (manipulatives). It’s called slicing because you are printing layer-by-layer and the program “slices” the 3D object into these layers.

IMPORTANT: If you used Bambu Studio/Makerworld to open the STL files directly into Bambu Studio, you will “skip” some of these first steps [where you need to start will be highlighted]. However, these steps are important to know for when you have an STL file that did not come from Makerworld.

First – Open Bambu Studio and click “Create New Project.”

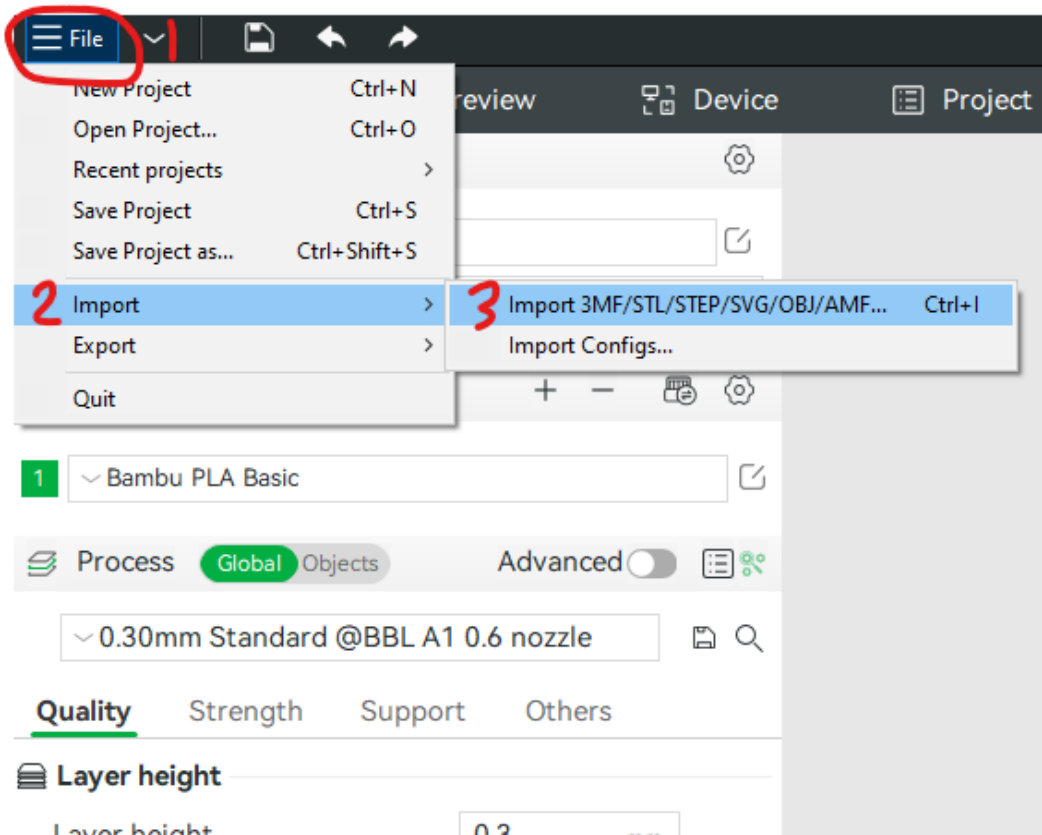


Second – Make sure you have the below settings selected. You will have to select the 0.6 nozzle first. Then the Smooth PEI Plate should be selected. The last highlight should come up automatically.



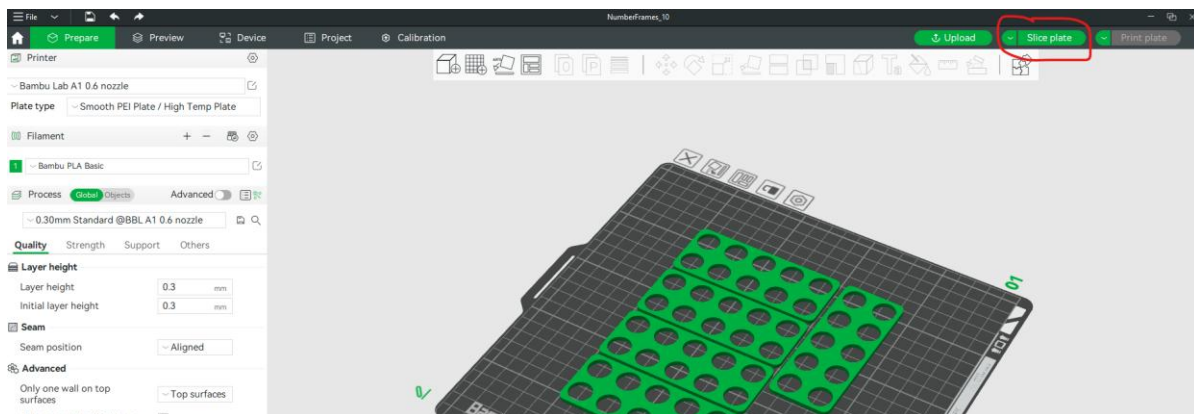
Third – export the STL files from the zip file onto a space on your computer (Bambu Studio will not read the files from a zip folder).

Now you will import your first STL file. To do so, click on the three bars on the top-left, select “import” and then select “import 3MF/STL/STEP/SVG/OBJ/AMF...” (see pic below). Alternatively, you can drag-and-drop an STL file onto the build plate on the program.

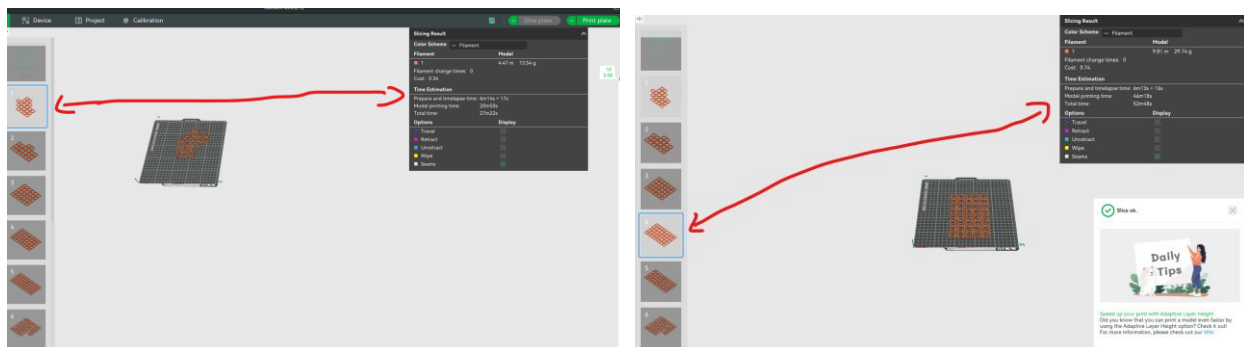


IF YOU USED MAKERWORLD, YOU BEGIN HERE

The above steps are used for when you have an STL file from outside of Makerworld/Bambu Studio. Now that your file(s) is/are imported, you can now click “Slice plate” at the top-right.



If you have “multiple plates” in your file, Bambu Studio will slice EACH plate, but you would print these separately (and only those you wish to print). Click on the relevant plate to see how the information on the right changes ([total time estimation](#) & [grams of filament](#) used are the most useful).

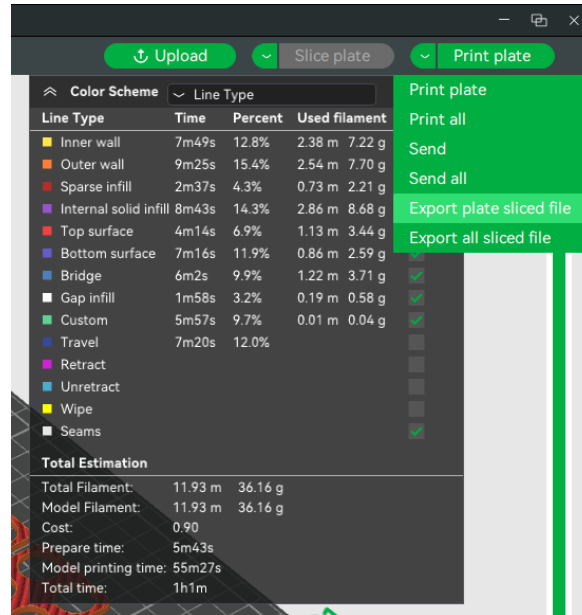


Fourth – it is time to print. Here, you have two options:

1. Print using an SD card [useful if your school building won't allow for the printer to connect to the internet];
2. Print directly via the internet [easiest option].

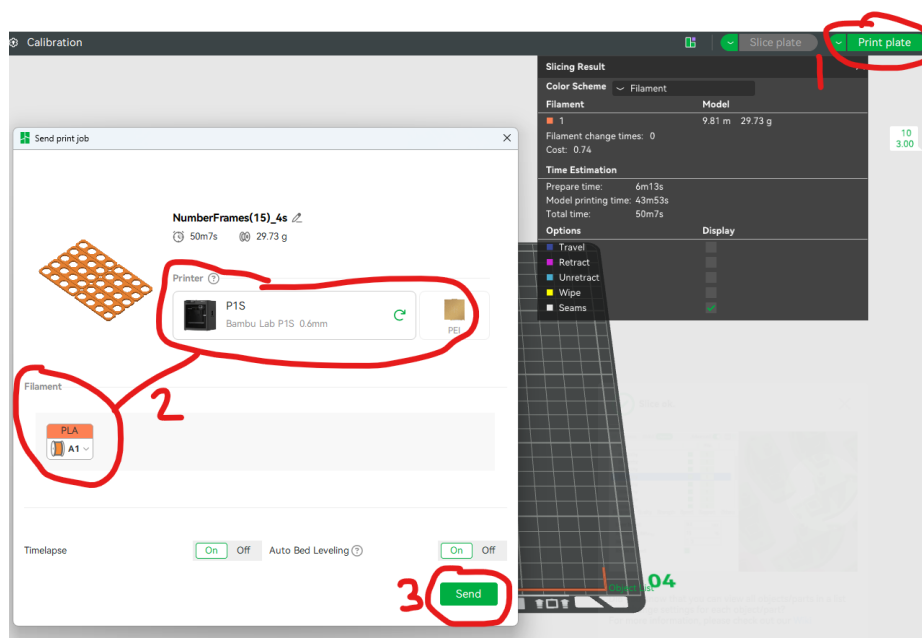
Print using an SD card:

Make sure the SD card is connected to your computer. You will then select “Export plate sliced file” onto the SD card (see pic below). This will export the printable file as a **.3mf** file. Save it in the “models” folder on the SD card.



Print via Wifi/Internet:

This step assumes you have already “linked” your printer with your Bambu Studio account. First, click “Print plate” at the top-right. Next, make sure you are connected to the correct printer and using correct filament [although you will use an A1 that has only one filament option, the below screenshot is of a different Bambu printer that has four different filaments connected]. Last, click “Send” and the file will be sent to your printer to print.



USING THE 3D PRINTER

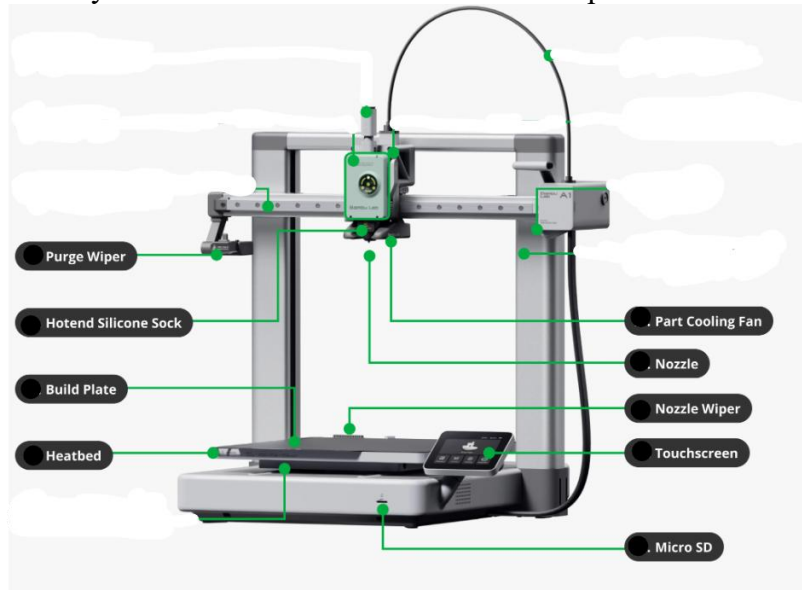
There are a few key terms you need to know when using the 3D printer itself:

Filament: This is the material for 3D printing and usually comes in a 1Kg spool of plastic. We typically use PLA (Polylactic acid), a bioplastic made from renewable resources (corn, cassava, sugarcane, etc.) that are also biodegradable. There are many vendors that sell PLA, but we use [IIID Max](#) due to its low cost (more expensive versions are better for structural devices).

Nozzle / Hotend: These terms are sometimes used interchangeably but are technically different components. The *hotend* melts the PLA at $\sim 250^{\circ}\text{C}$ [482°F] and the *extruder* (set of gears) pushes this melted plastic through the *nozzle*. The nozzle is moved around by the 3D printer to ooze this melted plastic at specific locations, layer-by-layer. A nozzle may have different diameters (0.2mm, 0.4mm, 0.6mm, etc.) with smaller diameters taking longer but providing more precise/detailed prints. For concrete manipulatives, 0.6mm provides enough precision and better speed than the standard 0.4mm option.

Build Plate: This is the surface that a 3D printer builds the object it is printing. In more modern printers, it is usually heated (by a heatbed) to around 60°C [140°F] during the printing process to keep the build sticking to the plate. The build plate is usually made of thin metal and designed to bend so that a print can pop off and be removed more easily after 3D printing is complete.

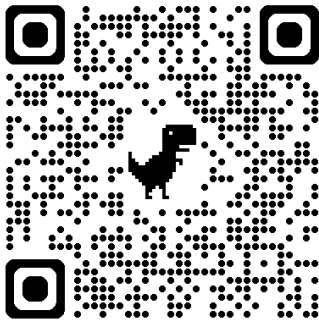
Below is a diagram of some key components for the Bambu Lab A1 to help illustrate the above terms. There are some highlighted components that are specific to this printer. For example, the purge wiper discards any extra filament from the nozzle to keep it from interfering with the print.



Knowing some of these components is useful if one ever encounters a problem with the 3D printer. For specific guidelines, Bambu Lab has provided a wiki for troubleshooting and other details: <https://wiki.bambulab.com/en/a1>

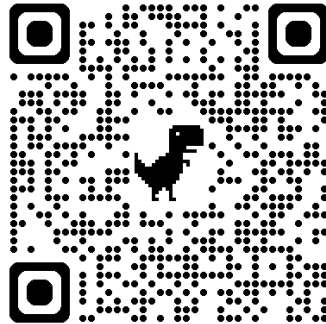
For directions on how to print objects and use the 3D printer, there are a series of videos (linked below by topic). Most of the time, the 3D printer will already be on – simply tap the screen to wake it up. If it is turned off, the “How to Print an Object” video will show where the power button is (back-left of machine base).

How to Print an Object



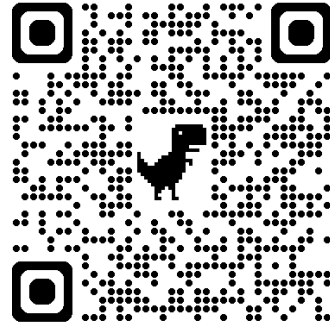
tiny.cc/4n87zz

Removing a Finished Print
from the Build Plate



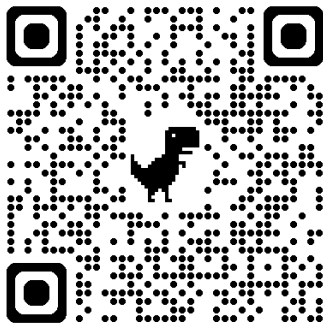
tiny.cc/9n87zz

Changing the Filament



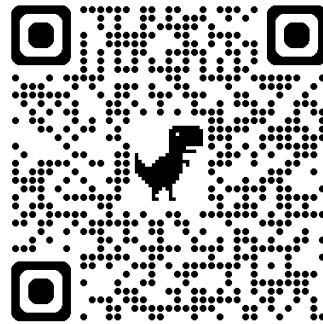
tiny.cc/in87zz

How to Slice an Imported STL File



tiny.cc/01ax001

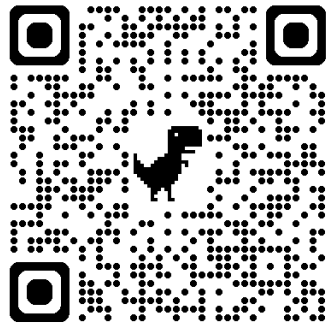
How to Slice within Makerworld



tiny.cc/k2ax001

The above videos should provide enough information for most of what you will need to do. However, additional information can be found in the Wiki below.

Bambu Lab A1 Wiki

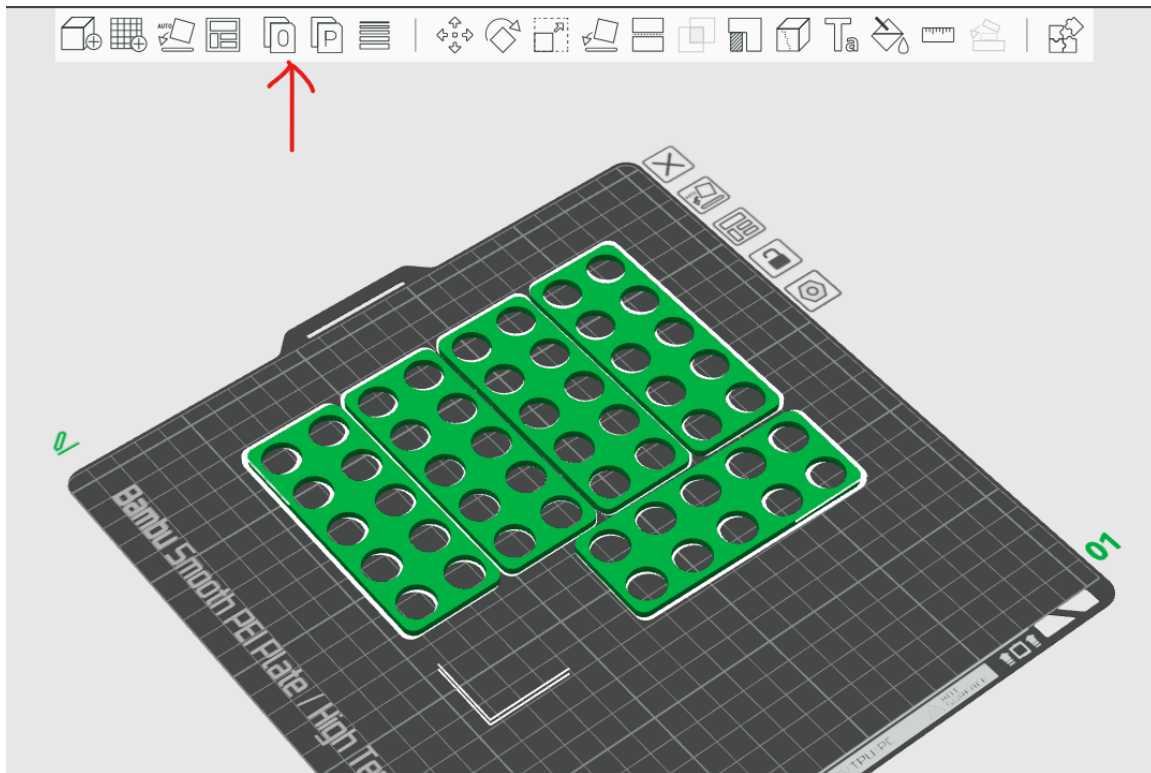


wiki.bambulab.com/en/a1

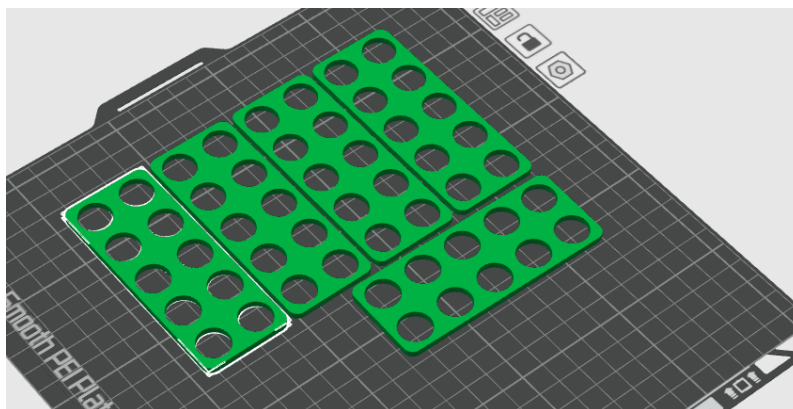
CHANGING ARRANGEMENT OF MANIPULATIVES ON A PRINT

Splitting into Parts

To change the number of manipulatives on a build plate, you will have to move and adjust the file imported. In this example, we need to make each of the 10s individual objects. To do so, click/highlight the file and then select “split objects” (see below pic).



Click on the build plate somewhere other than the manipulatives, and then you should now be able to select only one of the 10s at a time.



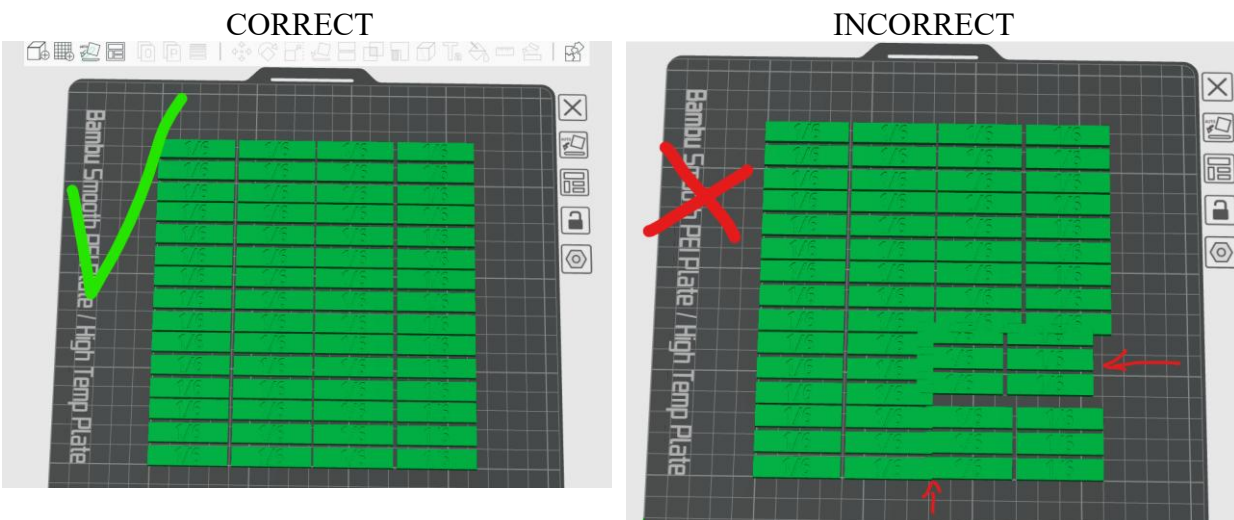
Copying & Pasting

Another way of manipulating what is on the build plate is to copy-and-paste. This is relatively simple to do:

- On a PC, use **Control + C** to copy and **Control + P** to paste any highlighted object.
- On a Mac, **Command + C** to copy and **Command + V** to paste any highlighted object.

The objects will usually paste in a patterned format and you can click and move objects around to the desired place. You can also use a “select all” shortcut to highlight all objects on a build plate to move at once.

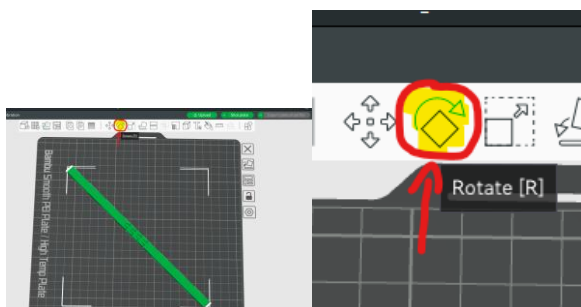
Note: Be careful not to have printable parts touching or overlapping on the build plate or your print may be ruined.



Rotating an Object

At times you may need to rotate an STL file. To do so, highlight the object (click on it), then click on the Rotate, and enter the degrees it should rotate (see pics below).

Click on “Rotate” on the menu.



Pick the appropriate axis (usually Z-axis) and enter the degrees to rotate.

