Assembling A 3D Printer

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Abstract: The purpose of this application note is to explain and identify all of the components necessary to build a fully functioning 3D printer. The tutorial portion will explain what parts you need and why. This will be a more general application note as there are many variations of 3D printers that can be made for a plethora of purposes.
**Keywords**

**ABS:** Acrylonitrile Butadiene Styrene based filament

**Extruder:** Printhead that disperses filament onto the print area

**Filament:** Printing material

**PLA:** Polyactic Acid based filament

**Rails:** Extrusions that the support the axes and also allow them to move.

**Stepper Motor:** Motor that moves mechanical components
Introduction

3D printing technology is very new and has only been around since the 1980’s. In recent years it's commercial success has been primarily driven by hobbyists who have used 3D printers to make everything from art to firearms. 3D printing is a subset of additive manufacturing.

Choosing A Frame

A 3D printer’s frame or housing acts as a support system as well as its workspace. The frame must be robust enough to support itself as well as any objects will be used to created and its electrical components. Frames consist of rails for the axes to move along, as well as some type of endstop structure to act as a barrier to prevent any of the axes from running off of the rails during object creation. There will typically be 3 axes, X-axis, Y-axis,
and the Z-axis which mean you will need at least 4 rails since 2 will be used to set the boundaries of either the X or Y axes. These are of course the 3 directions necessary to create any type of 3D object. Figure 1 above shows a Shapeoko 2 CNC milling kit which provides an excellent frame for a 3D printer. In this figure, the rails are the silver extrusions and all the silver and black portions are a part of the frame. The Shapeoko 2 is an excellent choice for a frame because its rails are connected only by screws which means that you can buy as much rail as you need and connect more and more rail as needed. You can also proceed to cut it if you find that you have too much excess rail. There are also kits such as the Ordbot that come with electrical components already in tow. You are not limited to these 2 options only as there is always the choice to build your own frame from scratch if you are not satisfied with options that are currently available on the market. However, keep in mind that the frame should be some type of metal since it will encounter high temperatures and needs to be able withstand added weight of electrical components and objects that it will create. You will also need to provide wheels, attachment fixtures, belts, and custom housings for electrical components as well.

**Choosing a Print Surface and Heatbed**

After the frame is built, you will need to attach a print surface for your objects to be printed on. You will want to choose some sort of base material first. This needs to be sturdy, durable, and flat as it will be the primary support for your print area. Plywood and perfboard are good materials to use for this as they are relatively inexpensive. Next you will need an actual print surface. The best thing to use for a print surface is glass. It can be
cleaned easily after use, is smooth, and is easy to find. You will want to consider oven glass as it can withstand high temperatures if you are using a heat bed underneath the print surface. No matter what you choose to use as a print surface, you will want to make sure above all else that it is smooth and flat as even the slightest deviation in the surface can affect the accuracy of your 3D printed object.

Once your printing area is fully constructed to your liking, you may need to also include a heatbed that will rest underneath the print area. PCB heatbeds (Figure 2) are readily available on the internet and are viable heat sources. Griddles have even been suggested as heatbeds in certain cases. Your heatbed will need to properly heat the print surface evenly which should be taken into account when considering what heatbed to purchase. The use of a heatbed is optional depending on what type of filament that you are using. PLA filament does not require a heated print surface while it is suggested that ABS filament is printed onto a heated surface. The purpose of a heatbed in any case, is to keep the object at a higher temperature to offset any warping or imperfections that may occur in the object during printing.

![Figure 2: PCB Heatbed](image-url)
Choosing an Extruder

The extruder is can be considered the most important piece of a 3D printer. There are plenty of ready-made extruder kits that will provide all the parts that you need for this component. The type of extruder that you choose determines what kind of filament that you use and vice-versa. In turn, the extruder will also determine the type of objects that you will be able to create. All extruders do not work with all available filaments. For example, an extruder that can utilize PLA filament usually will not work with ABS filament. You will want to pick what type of filament and commit to it as you cannot just switch back and forth between types of filament easily. Once you have done this, it is good practice to also purchase a cooling fan for the extruder head as to avoid extruder jams. It is possible to use 2 extruders in the case that you would like to use one to output a base material and the other to output a support material. However, this is not required and is usually not necessary at all.

Figure 3: 3D Printer Extruder
**Electrical components and Power Supply**

Upon completion of building the mechanical portion of your 3D printer, you will need to incorporate the electrical components in order to actually use the printer. Firstly, you will need stepper motors to drive the movement of the 3 axes as well as one for the extruder. Figure 4 shows a NEMA17 stepper motor which is a common motor to use and works with an Arduino Microcontroller. The actual amount of motors that are required vary with the needs of the user and size of the printer, but you will need at least 4. Keep in mind that your chosen stepper motors must be compatible with your chosen microcontroller and stepper motor drivers kit. Stepper motors vary in the number of “steps” they have which in turn affects the resolution. A higher resolution does not necessarily entail a more detailed and precise image.

![NEMA17 Stepper Motor](image)

*Figure 4: NEMA17 Stepper Motor*

You will also need to choose stepper motor drivers and a microcontroller. The microcontroller is the brains of the 3D printer. It communicates with the stepper motor
To control the stepper motors, you will need to use stepper drivers and a microcontroller. It is recommended to choose the microcontroller based on your stepper motor and driver kit. The Arduino Mega is a popular choice due to its compatibility with the RAMPS 1.4 stepper drivers kit and NEMA17 stepper motors. Once you have chosen your components, you will need to wire them correctly. The RAMPS 1.4 connects directly to the Arduino microcontroller, and the motors can be wired directly to the RAMPS kit. To connect your microcontroller to a computer, you will need a viable power source capable of providing enough power to run your microcontroller, stepper drivers, and motors. A good choice for this would be a laptop power supply with a 12V-24V output. Using a higher voltage will provide more torque to the motors. Additionally, you will need approximately 10 amps of current from your chosen power source.

![Figure 5: Arduino Mega 2560](image)
Conclusion

3D printing is a new technology that is still in a rather infantile stage. There are many different models and kits that can be used for 3D printing. This note should only be used as a guide or checklist and not taken as an absolute path to construction of a 3D printer. Parts, needs, technologies and capabilities will determine what specific components a person needs in order to make their own 3D printer. There are endless possibilities and configurations. I did not outline any of the software requirements but be mindful that moderate coding knowledge and some firmware programs such as Marlin or Repitier will be needed in order to work the 3D printer as well as a CAD program to create the 3D
objects and a GCode generator to convert those images into a language that the printer can understand.
References

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http://reprap.org/wiki/RepRap