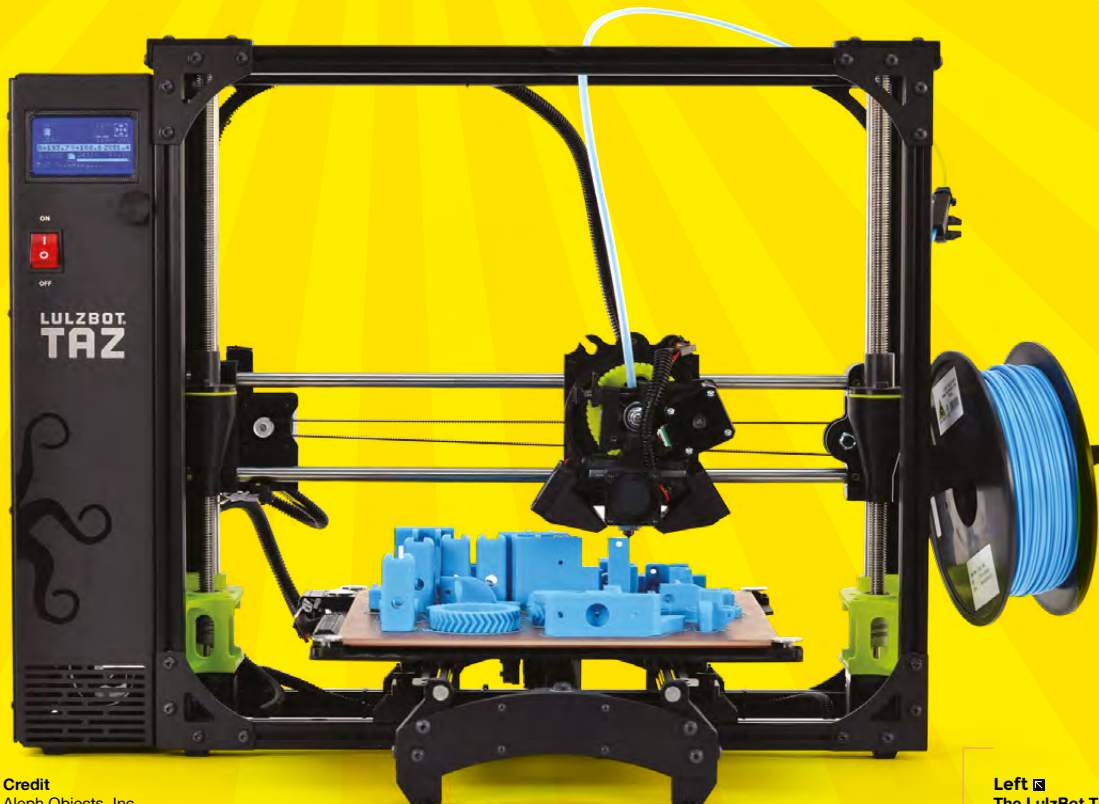# How to Start
3D Printing

Everything
you need to know
to buy your first
3D printer
and start making

By **Cameron Coward**

Credit
Aleph Objects, Inc.

Left
The LulzBot TAZ 6

Congratulations on making the decision to start your journey into 3D printing! You've probably seen online all of the amazing creations people are making, and are eager to dive right in yourself. But, like all hobbies, getting started with 3D printing can seem overwhelming at first. There are hundreds of printer models to choose from, a wide variety of filament types to consider, and even the available software options can be a lot to think about.

Luckily, hobbyist 3D printing has been dramatically refined in recent years, and getting started has never been easier. 3D printers have become very affordable, and even consumer-grade models now rival the quality of professional printers from less than a decade ago. The various software options are stable and reliable, and are now easy to learn, even for a complete beginner. In this guide we'll show you what to look for when purchasing a 3D printer, and how to start using it.

The most exciting part of getting started with 3D printing is choosing the printer itself. But, with so many options out there, how do you know what to look for? While it's true that there are many models on the market, the vast majority of consumer 3D printers are actually quite similar. Virtually all entry-level hobby printers use a process called fused filament fabrication (FFF), and that's what you'll want to purchase.

3D PRINTERS ARE MORE AFFORDABLE THAN EVER

Some brands refer to this as fused deposition modelling (FDM), but the way they work is the same: rolls of plastic filament are fed into an extruder, which contains a nozzle assembly called the hot end. The hot end melts the filament, and the molten plastic is then laid down in layers to form the part being printed. There are other types of 3D printers on the market, but most of them are still too expensive for a beginner who is just getting their feet wet with the hobby.

Consumer FFF and FDM 3D printers can still vary dramatically in price, however. At the bottom end are models that can cost less than £150, while the more expensive prosumer printers can easily exceed £3000. The large differences in price generally come down to just a few factors: the size of the print area, the quality of the components used, and the non-essential tech goodies that are built in.

SIZE DOES MATTER

The most pressing consideration is the printer's size – specifically the build volume. This is a direct specification for how large a single printed part can be. Generally,

this is also directly correlated with the model's price. It can be tempting to buy something with a huge build volume, but bear in mind that print time increases exponentially with volume, and most people rarely need to utilise all of the available space. That said, we recommend buying a printer with at least a 4″ × 4″ × 4″ (100 mm × 100 mm × 100 mm) build volume.

While most new 3D printers come with them now, it's still important that you purchase a model with a heated bed. Having a heated bed at your disposal will greatly expand the types of filament you can work with, and there is no reason not to get a printer that doesn't have one. Aside from that, the individual components of 3D printers these days are pretty comparable, and you shouldn't have to worry too much about specifications like resolution.

What you do want to pay attention to is the build quality of the machine. Frame rigidity is one of the biggest factors that goes into the quality of the print, so make sure the printer has a sturdy metal frame. Avoid printers that have wood or plastic frames. After that, it just comes down to what extras you want. These can be extras like a touch screen, WiFi, or auto-levelling. None of them is essential, but the convenience might be worth it if you've got a little extra money to spend. →
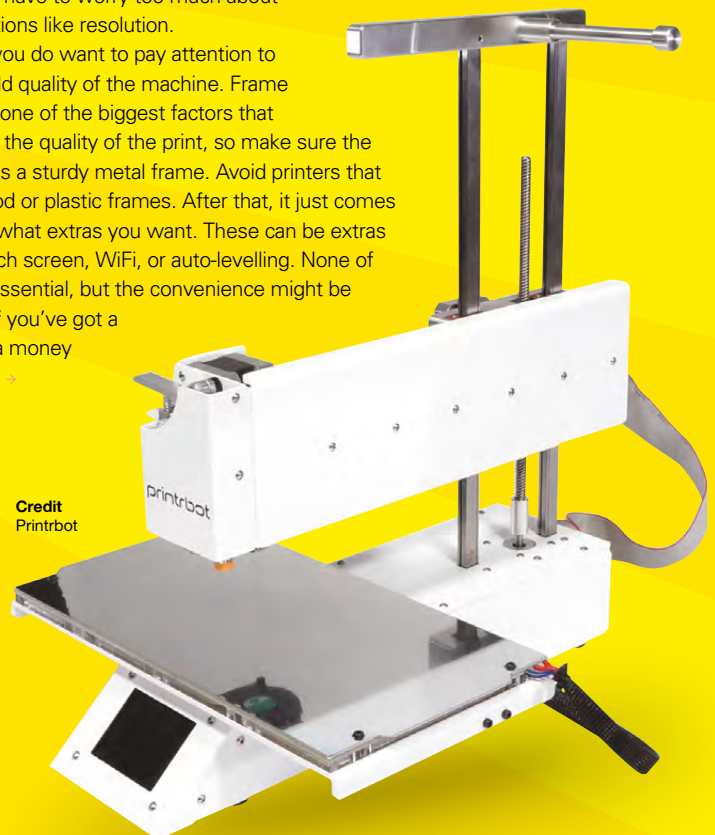
Filament Types Explained

The plastic material that your 3D printer uses is called filament, and all FFF 3D printers use some type of thermoplastic formulation. That means the filament is designed to melt when hot, but then return to a stable structure when it cools back down. Most filament comes in spools, commonly in amounts of 1 kg, which allows the material to be fed evenly into the printer's extruder.

The extruder contains a small stepper motor, and is capable of feeding the filament at very precise rates. The filament is then pushed into the hot end, where it's very quickly melted. Additional filament entering the hot end creates pressure, and forces the molten plastic out of the nozzle and onto the build plate. There, it cools and forms your part.

But, while all filament types follow this process, the specific type of thermoplastic being used can make a major difference in the resulting part. Some material is meant to be as strong as possible, some is intended to optimise print quality, and others are designed to be well-rounded for general use. Most hobbyists keep a selection of a few types on hand for different scenarios. In the rest of this section, we'll cover some of the most popular kinds of filament so you can decide what to order.

BASICS AND BEYOND

PLA and ABS are great filaments to get started with (see next page) as they're easy to use and work for a wide range of objects. There are some more advanced options that are good for specific purposes. One thing to be careful of is many these can leach unsafe chemicals into food or drink that they come into contact with. This isn't a problem for general makes, but if you're hacking any kitchen equipment or utensils, make sure that you get food- (and possibly dishwasher-) safe filament from a reliable supplier.

You may find that you waste quite a lot of filament in your 3D printing experiments. It's possible to get recycled filament, which may make you feel a bit better about the tangle of plastic in a failed print. →

Below ◈
A standard 1 kg spool of ABS filament

Credit MatterHackers

Speciality filaments

There are many more filament materials on the market, but most are meant for special-use scenarios. These exotic materials are designed for either aesthetics or for unusual tasks. For cosmetic cases, there is filament you can buy that replicates the look of other materials like wood or metal. There may be times when you require something physically unusual, like flexible filament or support material that can be dissolved. These are harder to use, though, and sometimes need specific types of extruders; make sure you follow the filament provider's instructions when printing with them.

Nylon

Pros
Very strong, low coefficient of friction, resistant to chemicals, flexible when printed thinly

Cons
Expensive, difficult to finish, usually only available in white or 'natural' colour

For a long time, nylon has been used in the engineering world to reduce friction in mechanisms with moving parts. When it comes to 3D printing, it's useful for parts that need to have a low coefficient of friction, or that could be exposed to chemicals which break down other materials. However, it's much more expensive than both PLA and ABS, and only comes in its natural colour. Because of its low-friction nature, it doesn't handle sanding or painting well.

PLA

Pros
Good for general printing, affordable, widely available, comes in many colours, a heated bed isn't required

Cons
Not very strong, can be difficult to sand, won't stand up to high temperatures

The most popular filament type on the market, and for good reason. PLA is very easy to work with, and can be printed without a heated bed. It's capable of capturing detail nicely, but doesn't accept post-print sanding very well.

PETG

Pros
Extremely strong, flexes rather than breaks, decent detail

Cons
Expensive, opaque colours are usually unavailable

PETG is more expensive than PLA and ABS, but less so than nylon. Its primary benefit is its strength and durability, and unlike ABS, warping isn't a problem. The material is naturally translucent, and doesn't take dyes well, so opaque colours aren't often available.

ABS

Pros
Strong, more resistant to high temperatures than PLA, readily available in a range of colours

Cons
Requires a heated bed, prone to warping, fine detail is often lost

ABS is only slightly less popular than PLA, but has a few drawbacks that should be considered. Most importantly, it can't be printed successfully without a heated bed, which means it's not an option if your printer isn't equipped with one. It's also very prone to warping, and special design considerations need to be made – particularly with large parts. But it's much stronger than PLA, and is more suitable for parts that will see physical use.

QUICK TIP
Make sure to purchase filament with the right diameter for your printer (either 1.75 mm or 3 mm)

Credit
Aleph Objects, Inc.

Right ↗
The LulzBot Flexystruder is meant specifically for flexible filaments

The Software You'll Need

Software for 3D printing can be broken up into four categories: **3D modelling, slicing, printer control, and printer firmware.** Unless you're building your own 3D printer, which is a topic for another article, you shouldn't have to worry about the firmware; it should be already installed and tested by the manufacturer. And, if you're just planning on printing designs modelled by other people, you don't need 3D modelling (CAD) software.

Right ◆
Slicing software has a variety of options for refining your prints

DEFAULT SLICER SETTINGS WORK WELL

The slicer and the printer control are usually combined into a single software package. The job of the slicing software is to convert an STL file (either one you model yourself or which you find online), into G-code instructions that the printer's firmware can understand. This takes into account the printer's specifications, as well as the parameters that you set for individual prints.

Tweaking those parameters is a key part of getting good printing results. Factors like print speed, layer height, and hot end temperature can all dramatically impact how the part turns out. But, as important as these are, they can be difficult to understand. Extruder retraction, for example, temporarily reverses the direction of the filament flow. But, how do you know how far it should retract, for how long, or how quickly?
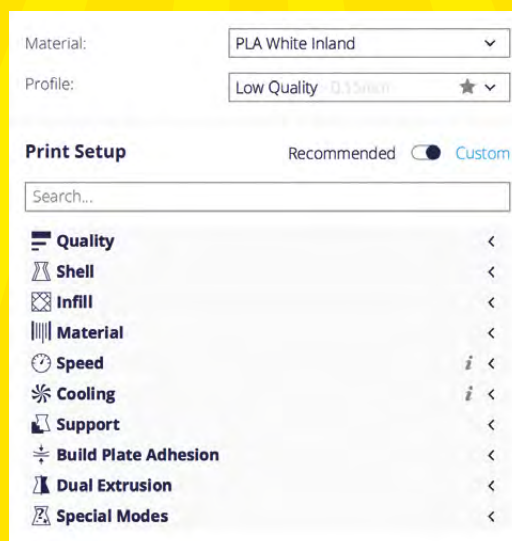
SO MANY SETTINGS...

Luckily, the 3D printing hobby has come a long way, and most slicing software provides default options that work well in most cases. There will still be settings that can benefit from experimentation and tweaking, but those default options are a good place to start. Your filament should also come with instructions on specifics related to the particular material.
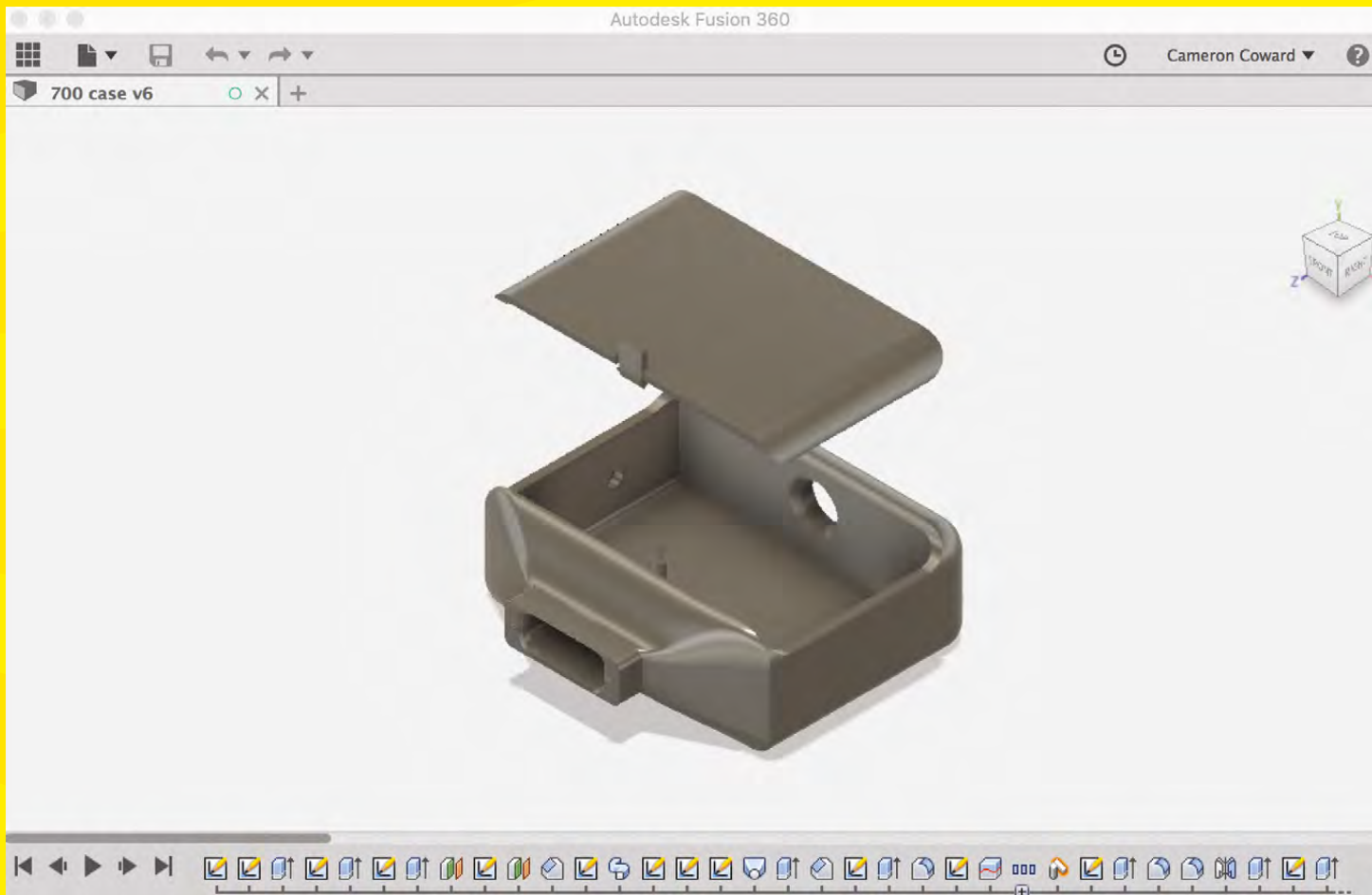
The control software is much more straightforward. It simply sends the instructions that were created by the slicer to the printer itself.

Autodesk Fusion 360

700 case v6

Some printers will have this built into a control on the printer itself, but the function is the same: to interpret the G-code. The two most popular examples of software packages are Cura and Repetier (which uses Slic3r by default). Both are great options, and will work well for most people.

Finally, there are many choices when it comes to CAD software for making your own 3D models. There are plenty of professional options out there that are commonly used by engineering teams, such as Solidworks, Inventor, and Creo, but these cost thousands of dollars and are unnecessary for most hobbyists. As a direct result of 3D printing growing as a hobby, a number of free or low-cost CAD programs have become available.

One noticeable example is Autodesk Fusion 360, for which we had an in-depth tutorial in the first issue of HackSpace magazine, and there are other programs you might also want to consider, such

as TinkerCAD and FreeCAD. For those of you who are more comfortable thinking in terms of code, OpenSCAD is a popular choice that lets you program a 3D part in the same way that you might with something like CSS or even BASIC graphics. →

Credit
Ultimaker

Print Quality and Common Problems

QUICK TIP

Actually measure the diameter of your filament, as it's rarely exactly as labelled.

While it's generally pretty easy to get your printer oozing plastic, many beginners find themselves frustrated when their prints come out looking sloppy. You've probably seen photos online that showcase intricate and beautiful 3D printed parts, and it can certainly be disheartening when your first parts don't meet those expectations. Fortunately, most problems that cause poor print quality are well understood, and can be fixed with a few tweaks to your settings. We'll cover a few of the most glaring

examples here, and you'll find that the online printing community is friendly enough to provide you with solutions to any issues you might encounter.

Your first step when you encounter a problem is to verify that your slicer and printer control settings match the 3D printer model you purchased. This will include parameters like build plate size, steps per millimetre for each axis and the extruder, and nozzle size. The manufacturer of your printer should have these specifications readily available, along with instructions on how to set them. After checking that those are correct, you can move on to finding
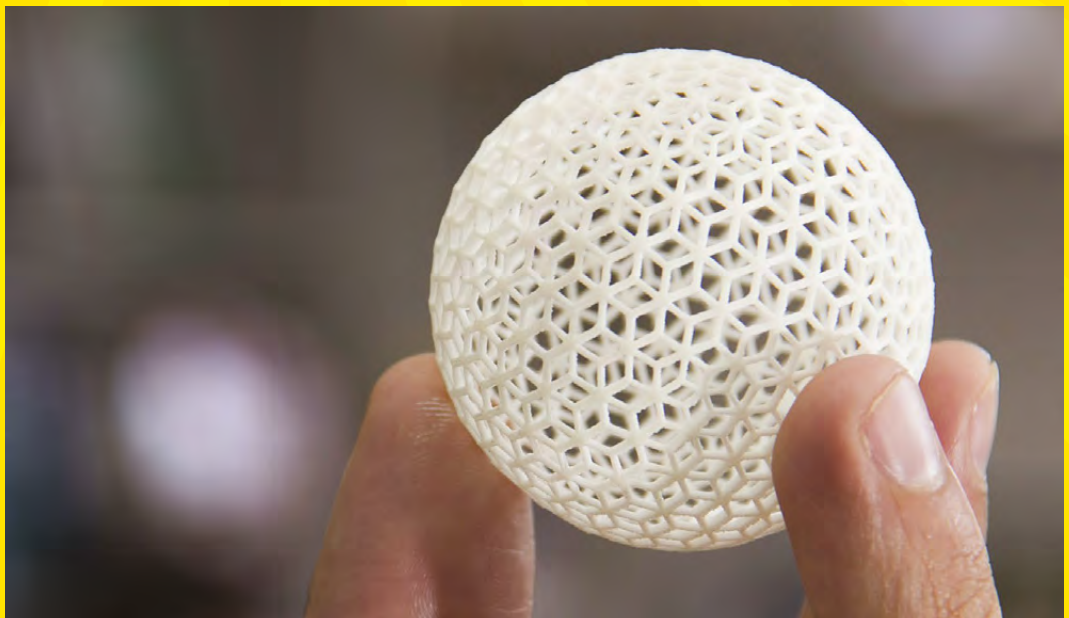
Right ◈
Your first prints probably won't look this good, but you can get there

what's causing your particular issue. The most common of these problems is first-layer adhesion on the build plate. If the nozzle is too high above the build plate, the part won't stick well and will come loose while printing. If it's too low, the first layer will be inconsistent. If your bed isn't level relative to the X and Y axes, you'll get a combination of these two problems. Follow your manufacturer's instructions for setting the height and levelling the bed.

GOOGLE SEARCHES ARE YOUR FRIEND

Another common issue that will dramatically reduce the quality of your print is stringing. This will result in thin strands of plastic that create a kind of web on your part. Most of the time, this can be fixed by turning on retraction and wiping to ensure the nozzle is clean before it moves to a different section of the print. If you still encounter this problem after that, your hot end temperature may be too high for the material you're using. Try turning it down by 5–10°.

Most other print quality problems can be attributed to overly aggressive printing. This will often manifest as shadowing of features on the part, very visible layering, or poor dimensional tolerances. This can be solved by simply printing

at a slower speed, or by reducing the acceleration rate. A printer with a very rigid frame can handle faster speeds and higher acceleration, but most lower-end printers aren't quite as solid. It will take longer to print your parts, but the quality of the result will make it worth it. ☐

Get printing

Designing objects for 3D printing can be daunting, but don't worry: the 3D printing community has built up a fantastic library of designs that you can print out on websites such as Thingiverse (**thingiverse.com**). A few of our favourite 3D printable objects from Thingiverse and beyond are:

◆ **Digital sundial:** The shadow changes into the numerals of the current time; **hsmag.cc/PnNPrz**

◆ **Mechanical vice:** Perfect for holding projects together while working on them; **hsmag.cc/mCTtqH**

◆ **InMoov Humanoid:** A life-size humanoid that can be created on a printer with a 12 cm × 12 cm × 12 cm print volume; **inmoov.fr**

◆ **3D scanner:** Pop your smartphone in this holder and use its camera to create 3D models; **hsmag.cc/SNGEjq**

◆ **Telescope:** The frame for a parabolic mirror telescope; **hsmag.cc/IYnaTj**

QUICK TIP

Always start with the filament manufacturer's recommended settings, but feel free to experiment from there.