

# Manufacturing From Home Using 3D Printers

by

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## **Abstract**

This project aims to give a person an overview of what is required for a person to start their own manufacturing business. More specifically, it goes over how to create a 3D printing business at home, going over the different types of printers, the materials used, and the factors involved with getting a good print. Additionally, the business topics are covered, like what to consider when starting a 3D printing business and some of the resources that may be useful.

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# Chapter 1

## History

According to PBS's, "the history of money," currency started before the coin even existed. ([PBS96]) It started just by bartering cows and other various animals in exchange for a service or a good. The purpose of money is to encourage people to work to get money in exchange for the hours they put into doing a task for someone else. One might pay another if they do not have the skills or the time. The concept of money has not changed, however, what has changed is the location of where a person can earn money. According to Rule, during the 1700s in Britain, the primary source of income was agriculture, but as times changed and by the time the first census was taken around 1801, little more than one-third of the total population remained in agriculture ([Rul92]). And as time went on, the people in agriculture dwindled. The reason being is people were moving away from agriculture as their primary source of income and towards working in a factory. The income change resulted in many people having harsher living conditions as they would sometimes get paid less than before. People were working for endless hours. As long as the machine was working, a person watched over it. Eventually, times changed, and some families could earn extra money. As society moved on and new technologies were created, the idea of luxury changed, such as having a TV or a set of speakers. This has allowed people to get creative in what was sold. For example, a person can buy a pen holder that was 3D printed so that it would look more unique than any other on the market.

What is important to note is the place of work, for bricklaying, a person would have to go to the building site to lay the bricks. However, people with jobs like being a blacksmith or a baker could do these jobs at home and modify their houses so that they would be able to produce these goods. With the change of how things are manufactured, a person can run an entire manufacturing business from their home. It has changed so much of the work mentality as a person can be their own boss.

In 2020, there was a Coronavirus disease (COVID-19) outbreak, according to the WHO, COVID-19 can be described as, "an infectious disease caused by the SARS-CoV-2 virus. Most people infected with the virus will experience mild to moderate respiratory illness and recover without requiring special treatment. However, some will become seriously ill and require medical attention. Older people and those with underlying medical conditions like cardiovascular disease, diabetes, chronic respiratory disease, or cancer are more likely to develop serious illness" ([Org]). To help prevent the spread of the virus, the WHO advised that people stay 6ft apart or avoid going out in public as much as possible. This changed so much of the way the world worked. For years, working for a company required a person to leave the house, as it was believed that having everyone work under the same roof would help with collaboration. For a little while, there were questions of where a person would work and how to maintain social distancing. For example, in the retail industry, people would either quit work as they felt unsafe or, the job would fire the person since there was no need for them as fewer people were shopping. In fact, in San Francisco, the unemployment rate hit 14.7% in April of 2020. Thankfully, 11.5% is just for temporary unemployment, according to the federal reserve Bank of San Francisco ([WOKK20]).

However, there was another option, a person could work from home and work

with coworkers through the internet. This option was what many companies went to because it still allowed them to collaborate with other people. This allowed companies to continue with their work without too much change; it was even found people were more productive working from home. However, though this was an option, it was not optimal for mental health. The interaction of only seeing someone through a screen has proven to impact mental health without face-to-face talking to friends. Another issue was that people had a hard time separating work from home ([XBGLR20]). If a person does not separate the two, it can lead to stress and anxiety.

An alternative for some people to avoid the stress of meeting the work hour quota would be to start their own business. One way was to make products at home, like Christmas ornaments or pencil holders. This is more achievable due to the internet, and it can help with running a business since a customer can order items through the internet. The internet can take orders 24/7 autonomously. Being able to take orders from anywhere in the world and at any time makes being a full-time at-home worker feasible. An excellent example of this is a 3D printing or a laser cutting business. Both require the business to purchase materials to manufacture a part or produce a toy and then send it to the customer. This paper will focus on 3D printing and how a person can order the material, manufacture the part, and send the piece to the customer.

3D printing is becoming a new process that allows parts to be made cheaper and faster than a factory producing the same components. Additionally, it lets a person make prototypes within their own house. However, 3d printers require a person to look over the printing process and confirm that everything is operating correctly. This is one reason to have it printed by a different business. 3D printing has the advantage of allowing a person to make new items without the need to have a mold

created or needing a mold injection machine. This speeds up the process that it would take for someone to test a part.

# Chapter 2

## The Business

### 2.1 Type of Printing

According to the US Chamber of Commerce, when thinking of starting a 3d Printing business, there are a couple of factors to consider ([For21]). The first one is what the company will do, a person does not have to stick to just one type of printing. This is something to consider as it will depend on what kind of printer would best suit the need. A decision would be if the business will make something or take in orders and make that part or do a little of both. If the business's sole purpose is to make parts designed solely by the company, it comes down to what kind of parts are being printed, like if it will be something small like jewelry or something big like a toy dump truck.

Suppose a person chooses to make their own items like children's toys or an iron man masks. However, if adults are more of the target audience, then making jewelry or a pencil holder would be a better choice. Additionally, a person could make spare parts for a particular type of equipment. Something that could be handy if that equipment is discontinued and very few companies make the part required. A person could also make promotional products, and when a company orders the items, the logo for the company could then be printed on it. If a person is designing their own products, they should know/ (want to learn how) to create a part in a 3D software like AutoCAD or tinker cad. The reason being is that this is what the printer uses



so that the desired shape can be printed. However, this should not be the deciding factor as there are many options for 3D software that are free to use.

If designing parts is something a person is not particularly fond of or does not want to deal with, the hassle of figuring out how to create something. A person could take orders in and manufacture the part. This would be a simple take an order and then print out the piece. However, this market can be competitive, and it will always be a competition for which can produce the best quality parts for the lowest cost, resulting in that a person has to pay particular attention to the quality of the print. Something that can take time and lots of practice to get the correct settings down pat. Another factor in doing it this way is that a person should be willing to reach out to companies to get customers. This entails that though there will be a little less 3D printing work in designing parts, more work will be involved in getting customers. An alternative to printing the order for someone else is renting out the printers. This would allow the business owner to simply have to own the space for the printer and do the printer maintenance. The income would be of people renting the printer for the week or a timeline close to that.

## **2.2 Printers**

After deciding what kind of business, the type of 3d printer must be chosen, this factor can change the way the final product may come out; and how much it would cost to run the printer, while also considering how much work has to be done after the print. A paper titled Emerging Technology and Applications of 3D Printing in the Medical Field goes over a couple of options for the type of printer including the ones listed below ([Mar18]). The report is intended for the medical field however, it goes over all the different types of printers out in the world that may be applicable

to printing at home.

A widespread type of printer is a Fused deposition modeling(FDM). This is a type of printer in which a filament is fed into a hot nozzle that will melt the material and then extrude it onto the layer below it building up the model. These printers can be relatively inexpensive, making them an excellent choice for the beginner; however, getting precise fine prints can be a little challenging and can result in the print taking longer. Additionally, the material and the colors of the print also limit the capabilities as the material has to be made into a filament spool and also change form when heated in order for the material to be printed ([Mar18]).

Another type of printer is stereolithography(SLA) style printing. This is a type of printer that uses a UV laser and a photopolymer resin bath; a layer can be added by shining the UV laser along the path meant to harden. Digital light processing (DLP) printers operate about the same way, in that light is used to fuse the material to the next layer. This is an excellent method for producing high-quality prints with a smooth surface. However, as with everything, there is also a downside, the prints can be a little more brittle than if they were printed from an FDM printer. The cost for the material also costs more than if an FDM printer was used ([Mar18]).

A Polyjet is much like an FDM printer in that material is used to extrude the material. Ultraviolet light is used instead of air to dry the material and get it ready for the next layer. Allowing for fast and even drying time, allowing the user to get amazing 3D prints as a result. Additionally, a Polyjet can print in more material than the other two printers with various colors, textures, and densities. However, this type of printer costs more than the other two previously listed printers ([Mar18]).

The last kind of printers being brought up is a selective laser sintering (SLS), selective laser melting (SLM), and electron beam melting (EBM) printers. All the printers act on the same principle, in that a laser is used to fuse the materials much

like a resing printer. However, the difference is that the material used is a powder. The advantage of this is that materials such as metals or ceramics can be used, allowing a person to have a solid print. However, the cost of this printer is very high, and though some places may use it for the beginner printer, it would not be the best choice ([Mar18]).

Looking over what kind of printing a person maybe doing will help determine the best fit. For example, if a person is doing jewelry, it may be a good idea to maybe use a resin printer as most of the time, the jewelry does not require a lot of strength, however, a lot of detail. The resin printer performs best in the details, as the details will be evident, and the prints will not take very long. But looking more at a general-purpose printer for a beginner is the FDM printer. This type of printer usually costs a little less than the others listed, and a person can still get high-quality prints; however, it just requires more time and attention. Something to note is that for some FDM printers, the higher cost of the printer may be worth the price as it may have more features. Like an encloser to monitor the print area's temperature or maybe an auto bed leveling feature, something that will save a person-hours from setting up the print. These traits can sometimes lead to a better quality print without spending hours or days debugging a printer to get the perfect prints. However, the price does not guarantee a perfect print, in some cases, it merely helps with getting better prints and reducing downtime. The other types of printers mentioned are more for higher-up companies or businesses that require that kind of printing. These are still suitable printers for a business; however, they need more skill to run, and the material can cost a little more, making them more for an established company.

## 2.3 Printing Material

After picking the printer, it would be time to get the printing materials like filament for FDM printers. A paper titled "A review on the fused deposition modeling (FDM) 3D printing: Filament processing, materials, and printing parameters" is an excellent overview of the different types of material in printing with filament some of the one listed can be seen below ([KIA<sup>+</sup>21]). The filament is the material the 3D printer uses to build up the part physically. This term is common with FDM printers; however, it may be used for other types. It is most common with FDM printers because other printers like SLA printers use a resin to build up the materials. There are countless materials in the field of filament, and it would be impossible to go over them all. Therefore, below are three possible materials that may be used to print using only FDM printers.

One of the most basic filament types used quite often by 3D printer enthusiasts is PLA. This filament is a thermoplastic with the bonus of being biodegradable. What is neat about this material is that it can be used for "medical applications because it is biocompatibility, is not metabolically harmful" ([KIA<sup>+</sup>21]). It is also one of the more straightforward materials to print with as the environmental factors can be a little more lenient, making that an excellent choice for a beginner material. However, this material is not very durable, making it not a great choice for moving parts.

There is also a material such as ABS. This material is more robust and can withstand impacts better compared to PLA. Making it a better choice if a person knows the printed part will be thrown around and will get beaten up. However, this material does produce toxic fumes when being printed, requiring an exhaust fan for the fumes. Additionally, when printed, the material is more dependent on

the air temperature, which is why most people build an enclosure around the build area when printing with the material ([KIA<sup>+</sup>21]).

The last material that will be discussed is PP; this is the kind of plastic used throughout most household appliances, cars, military, etc... Showing that clearly, this material has some fantastic properties. The ideal formula to have a good print with the material is still fixed, but it is still a vital material in its current formula ([KIA<sup>+</sup>21]).

Each company has its own formula for filament, meaning that the material will act differently under the same conditions. This is important to consider as the printer's setting may have to be changed for the print to correctly. Outside of the formula of the material, when printing, the humidity of the filament can be a huge factor; the more dry the filament is when it gets printed, the better the result. The material listed above is only a small list of all the possible materials. The list given applies to FDM printers, and of the material, the best one to get started with would be PLA. As a bonus, the cost for the material is cheaper than the other materials listed.

## 2.4 Purchase the Materials

When it comes to buying the materials and putting the initial cost toward a business, it may be a good idea to consult a 3d printing consultant. ([Sch21]) They will be able to help with which printer may be best for the business setup and which filaments will best serve the desired purpose. And some of them also work with the companies that a person can buy the printer from, meaning that they can help ensure a person can get the best print.

When it comes to buying the printer, the preference for buying the printer can

be from Amazon or from the 3d printing manufacturer directly. That does not have much of a preference, but something to look for would be reliability, customer service, and a bundle item, such as getting a discount on the filament. These are all factors, into if a person should buy from that company. As for the filament, a tip from the website all All3dp was written by Carolyn Schwaar, who for 30 years has been writing articles on additive manufacturing. ([Sch21]). A person can buy the material wherever that material is the cheapest and readily available. It does not have to be only from one seller. However, as in the section above, something to look at is what filament best works for the printer to get the best results. Another item to look for is finding the wholesale seller of the filament to save money in the future and create strong business connections.

A way to save some of the money for the filament is to recycle the filament; the upfront cost for the system can cost more than simply buying the spool of filament. However, this is an excellent option if many prints require support material. Most of the time, the material will just get thrown away as it is no longer needed. The downside to recycling is the initial upfront cost. It can cost almost two thousand for a sound system, including the shredder, the extruder, and the spooler. However, it can save a person from having to buy new filament, as every couple of prints, the material can be recycled and reused. This process requires a person to add their own material to the mix to help strengthen the material, meaning money still has to be spent to make new filament, but it is less than the cost of a new full spool.

## 2.5 Knowledge of Printers and the Printing Environment

Looking more at FDM printers, two categories will affect a printer: the printer's parameters and the working parameters. Looking more at the same paper that had info about the different filaments of a good print. It states that the machining parameters are all the factors like the heated bed, nozzle temp, the nozzle diameter, to name a few. Then there are the print factors like the build orientation, the raster angle/width, etc. The raster could also be seen as the infill support materials. These are just some factors that will affect a print; the settings will be slightly different for each printer. So, the only way to know which settings are the best for each job is to play around with the printer. ([KIA<sup>+</sup>21])

Besides factors like the raster, the external factors play a crucial factor in the print quality; factors such as the print bed temp and the nozzle temp also play a role. Looking more at the problem, it may be a good idea to set up all the printers and run the business out of a shipping container. But looking farther out, another factor is the temp of the room for the material, the humidity in the room, and for the owner's health, are the printer fumes being pushed outside. These are all important factors [KIA<sup>+</sup>21].

There is a couple of reasons this may be a good idea. First is the lower cost of maintaining the suitable room parameters. In many homes, there is already AC and heating and all the necessities to keep the temp and humidity of an area at a constant setting. However, the cost to keep it at those settings can be a little higher since it takes more energy to cool and warm up a bigger space like a house compared to a shipping container with a much smaller area. It allows a person to

have better control over the outside factors related to printing while also keeping the cost of maintaining the printers lower. The next benefit is customizability; this can be very helpful when having a small shop or any shop. The reason is that a person can organize the space as to what best suits the need, not changing the task to fit the space. Having a small space for printing things is excellent for the factors listed above; however, it can also benefit a person's health. With most filaments except for PLA, whenever the printer melts, the material releases fumes into the air, and some of the fumes can be bad for a person's health, so it may be better to fumigate it outside. Having a container as the shop may be more accessible as a person can cut a hole for the ventilation on any side of the container a person can cut a hole in the wall for venting. The last benefit is the separation between home and work. This is something that can be hard for some people. An article titled Researchers working from home: Benefits and challenges goes over how people can be more productive working from home; however, it also shows how people have a hard time switching off from work. ([AKvdLS21]) Having a separate building from the printers can help the printer work differentiation between work and home.

However, there are some downsides to this idea, the biggest ones being cost; a shipping container can be close to three thousand dollars. ([EVE]) this price is just for the container without the modifications needed to have the place heated and to have the vents needed to let the fumes out. Initially, a person may have two printers, making it hard to see why an entire area is necessary. However, making the big initial investment can help expand the business in the future easier.

Having more than just one printer can be a challenge to manage, as there always has to be someone that has to be looking over the prints; making sure that the print is being constructed level on the build surface or that the layers are being built right on top of one another. This challenge gets more complicated once a second printer



is added to the mix. It is almost necessary to have 3D printer management software when having a printing business. There are many to choose from that exist on the market, such as Astroprint, or BuildBee, and a couple of other ones([O'N21]). Each one has its own advantages and disadvantages. It is up to the user to find which one will best suit the need. The reason to have software such as this is that it can help control multiple 3d printers from one location and minimize downtime by telling the user exactly when the print is done.

Additionally the user is also able to start a print from a computer and does not have to also be directly in front of the printer. A big reason a person may want it besides helping to manage the prints is the transfer of files, instead of a user going back and forth with a USB drive between a computer and the printer. The user can simply put the print job onto any of the printers while staying in one spot by transferring the print data through the cloud.

## **2.6 Taking orders**

Once the shop has been set up, a person has all the materials ready to start printing. The designs for the prints have to be made and begin printing the orders. Or, if the business is to fulfill orders, then it would be time to find customers who would give the small businesses a good reputation while allowing the business to find the best price to produce the parts. When it comes to advertising/selling the product, there are a couple of ways this can be achieved. There is the traditional way of going door to door of companies until a couple of companies are willing to let the business print the parts for them. Or a person can make a website and take in orders from the website. If the business is to sell items simply, it tends to be a little easier, as, over the past years, there have been so many advances in people

being able to start their own business from home. The reason being is that there are companies that have created websites or stores that will sell homemade products.

Amazon is an excellent example of this; as a person can make a business and then sell the item through the online retailer, this is awesome as thousands of people will see the product every day when they are looking for something. The same idea also applies to the online store of Etsy; however, this website is a little different in that a person would go to this website because they know everything sold on the website was made at home and is owned by a small company just trying to make a living. This is a great route to go; however, as with all things, there are downsides. A big one is that the companies get a portion of your profits. Looking at Amazon, the cost that goes toward Amazon is based on the item category and whether Amazon is the one fulfilling the order or if the seller is. ([Liv]) On Etsy, the fee is a little different as the price is based on the fact you listed something, it is twenty cents per item that is listed, and then Etsy gets 5% of the total cost of the item. Additionally, a person can pay to have specific items advertised, of course, for an extra fee. ([Ets21]) Which by looking at websites, it shows that each store has its benefits and downsides, which is why a person may choose one over the other.

An alternative to selling the items online is to sell the products at craft fairs; granted, there is a cost still for having a table at the craft fair, but it is a one-time payment and is not based on your sales. Potentially allowing a person to keep more of the profits.

## **2.7 Shipping**

Getting the item to the customer is the last part of the product. This last part depends on where a person is selling the item. If the product is making custom

prints for other companies, the owner could use any main shipping methods like UPS, FedEx, or USPS. If the shipment is international, it would not be a bad idea to consider DHL; they are not heard of often in the US but are still a viable option. If a person were to choose Amazon as the seller, there are two ways of getting the package to the customer; one way is to select any of the options listed above or have Amazon fulfill the order and take care of the shipping. This benefits the business not having to worry about making sure to complete the orders. It also helps as since Amazon has its own shipping, a person's ruling could be fulfilled in one-two days without paying for the faster shipping. There is a shipping cost if a person chooses Amazon, as expected, but depending on the item and the weight and other factors, it may be cheaper to select Amazon for the shipping. For Etsy, the shipping is all done by the business owner, and they would choose any of the ways stated earlier, like UPS or FedEx. Then comes the craft fair; this method can be straightforward as a person goes shopping, and when they buy the item, they would be able to get the item immediately.

# Chapter 3

## Conclusion

### 3.1 Conclusion

Working from home is not an entirely new concept; it has been done in the past. However, as time went by, working from home was still not something that was often done. However, in 2020 a new virus called COVID-19 came to light and forced people to work from home. Some people have decided to leave their old company and start a new business completely. To avoid the stress of working for a boss, some people went to a home manufacturing business. Manufacturing at home is a kind of business that can involve laser cutting or 3D printing. With a company in 3D printing, a person has to decide the type of items to be printed, the type of printer, and the type of filament. After determining the significant parts of the business, the materials need to be purchased. Once all the materials are purchased, the shop needs to be set up and printed. After the business is set, the product can be printed and sold on Amazon or a site like it. A big question for a business with something like this is how fast a person can get a return, which can vary on many parts of the business, the kind of product, the industry the product is meant and factors like the cost, time per part and so forth. What can be produced at home will continue ever to change and will change the supply chain in the future.

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