OHIO 4-H | PROJECT IDEA STARTER

3D Printing

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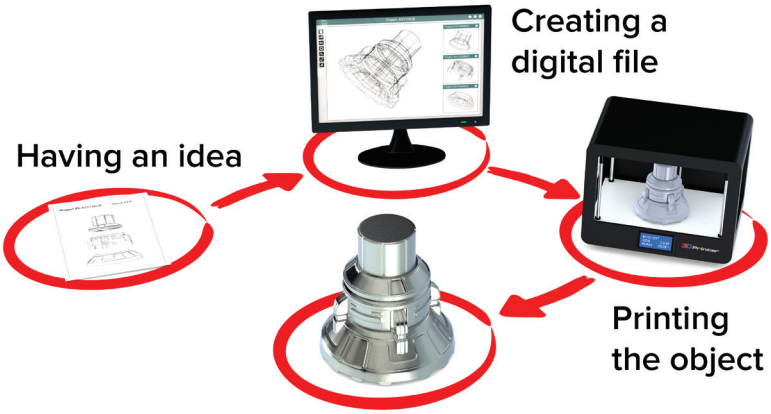
3D printing is a process that creates a three-dimensional, solid object from a computer model by building it one layer at a time. Because the object is built one layer at a time, 3D printing is sometimes also called **additive manufacturing**. This process can be used to make new and creative designs or replacement parts that are not available otherwise. By doing this, it is possible to make parts better, faster, and cheaper.

General Process for At-Home Printing

The process to a solid object involves these steps:

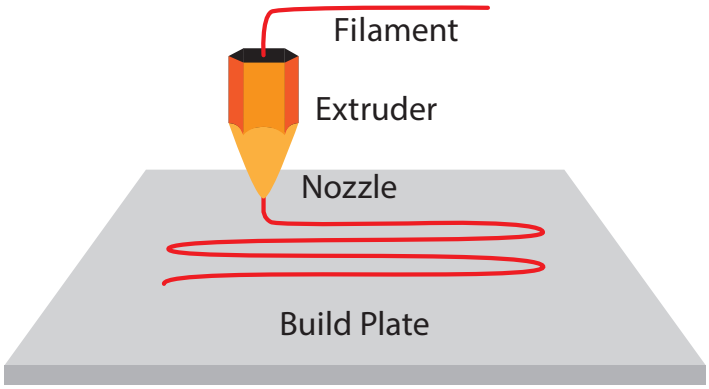


Material extrusion is one type of 3D printing, and it is the most common one for use at home. This process is also sometimes called **fused deposition modeling (FDM)** or **fused filament fabrication (FFF)**. This process builds parts using plastic material.

PLAN YOUR PROJECT

Use this idea starter AND publication 4-H 365 *Self-Determined Project Guide* as the starting place for your 4-H self-determined project. The *Self-Determined Project Guide* is available from your county OSU Extension office or on the Web at **ohio4h.org/selfdetermined**. You may choose to do a little or a lot depending on your level of interest. Be sure to register your project with your county OSU Extension office.

FFF uses a plastic filament that is heated up and pressed through a nozzle onto a build plate. The nozzle is attached to what is called an extruder. The extruder is used to pull the filament to the nozzle. A computer controls where the nozzle goes, and moves the extruder to make the 2D design on each layer. Once the material is deposited through the nozzle, it sticks to the previous layer then cools down to create the solid part. Then the nozzle moves up, or the build plate moves down, and the process is repeated on the next layer, and the next, and the next, until the entire object is built.



Common plastic materials used in 3D printing include ABS or PLA.

- **ABS** is acrylonitrile butadiene styrene, a thermoplastic polymer often used in the plastic injection modeling industry because it is rigid and withstands low temperatures.
- **PLA** is polylactic acid and is biodegradable, less expensive than ABS, and made from renewable resources. It is therefore often used in home and education settings and for making prototypes.

These filament materials can be used alone or combined with other materials to create a different look or function.

Material extrusion is just one type of 3D printing. Here are the other six:

- vat photopolymerization
- powder bed fusion
- directed energy deposition
- binder jetting
- material jetting
- sheet lamination

These different machines print with plastic, metal, ceramic, and more.

SAFETY

Safety is a critical aspect of 3D printing at home, but all of the possible hazards are preventable:

- Some materials release harmful chemicals and gasses into the air. Enclosures are often used to contain these chemicals. If your printer is not enclosed, it should be operated in a well-ventilated space, or you should use only materials that have lower emissions.
- The plastic filament must be heated up to be pressed through the nozzle. You should never touch the hot surfaces on the printer.
- Many moving pieces are used during the creation of your part. These moving parts can cause pinch hazards. Never interact with your printer while it is printing.
- Your specific printer may have additional hazards. Before operating a 3D printer, always carefully review the safety information.

MAINTENANCE

To make sure the printer stays clean and functions well, several steps are required every time it prints or after it has printed for a certain amount of time. Instructions are included with every printer

purchased, so if you do not see any for the printer you are using, be sure to find them. Following the manufacturer's instructions is strongly recommended. Typical maintenance activities are described here.

For Each Print

- ☐ Clean the build platform. Make sure to replace anything used to help your print stick (tape, glue, hairspray, etc.)
- ☐ Clean the nozzle. Preheat the nozzle and then press a small amount of filament through it. Do NOT touch the nozzle; it is hot! Use a steel brush to clean the nozzle.
- ☐ Level the build platform.

At a Specified Interval

Check the manual, but these tasks are typically completed every 1,000 hours of printing or every month of use.

- ☐ Clean the extruder. Take the extruder apart and remove any filament that is inside.
- ☐ Check all the rubber belts on the printer for wear or tear. Also check that the belts are still tight. Replace or adjust as needed.
- ☐ Check that all connectors (screws, etc.) on the printer are tight.
- ☐ Lubricate the printer. Use the oil specified in your user's manual on the rods and rails of your printer.
- ☐ Make sure that your printer's software is up to date.
- ☐ Replace any old or broken parts.

Use the following steps to explore what you can 3D print using material extrusion and to discover the many other possibilities that are out there!

HOW TO GET STARTED

To make sure the printer stays clean and functions well, several steps are required every time it prints or after it has printed for a certain amount of time. Instructions are included with every printer purchased, so if you do not see any for the printer you are using, be sure to find them. Following the manufacturer's instructions is strongly recommended. Typical maintenance activities are described here.

Step 1. Find a printer.

The price of 3D printers is now reasonably low, and many people buy one to have at home. They are also available for use in many public locations, such as schools, libraries, and community centers. There may even be something called a **makerspace** in your area, where equipment is shared with a community. Some spaces are free to use, and others require a fee.

When buying a printer, things to consider include cost, resolution, safety features, and troubleshooting support resources.

Step 2. Select or create a design.

The code for many ready-made model designs is available online. You can choose one of those to start, or you can create your own design using computer-aided design (CAD) software. Deciding what to print is a fun step! Browse designs available online or find something in your life that could be improved with a printed part. The CAD 3D design is used to send instructions to the printer about the amount, location, and type of material to use.

3D printing can be used to create many shapes, but the layer-by-layer process must always be considered in your design. Because each layer is placed on the previous layer, **orientation**, or how the object is placed and built, is critical. If there is no material below the layer you are trying to print, a **support structure** must be used. A support structure is often added to a print directly in the printer's software, and that software helps you decide where the supports are needed. You can also consider the need for support structures while you are designing your part.

Scaling, or sizing, your part is also essential. Make sure your design fits on the build plate and is within the maximum distance between the plate and the nozzle. If you do not scale your part to fit the printer, it may print off the plate or be partially finished.

Step 3. Print a part.

After you have selected your design, you are ready to print! Make sure the software and hardware for your printer are both prepared.

Software: The design must be in the correct file format for your printer, usually an STL or STP file. Import the STL file to your printer's software and **slice** the part. If your printer does not come with slicing software, you can download software for free at **ultimaker.com/software/ultimaker-cura**. Slicing the part converts it into the layers for printing.

Hardware: Depending on the printer, the hardware setup varies, and you should follow the manufacturer's instructions. You must prepare your printer and load material to get it ready to print. Choose what material you would like to use and load it into your printer. Make sure to tell your printer what material you are using so that it will heat to the right temperatures.

Most printers have a preview mode. Decide how long it might take to print it, as most printing takes several hours. Leaving a printer run overnight is not recommended. You want to be able to occasionally check your print to ensure there are no errors.

Hint: Some printers ask if you want to print a **raft**. A raft is a mesh starter printed on the build plate before the project itself is printed. It helps protect the first layer of your design and easily detaches when the part is complete. If the build plate is not heated, another way to give your print a good start is to spray the build plate with hairspray. Finally, adding painter's tape to the build plate, again only if the build plate is not heated, makes it easy to remove the project when finished.

Step 4. After you print.

After a 3D printed part is created, several things can be done to make it look its best. This is called **post-processing**. Because the part is printed layer-by-layer, lines show in the surface of the part. These lines can be reduced using finishing methods. The finishing method used depends on the material used to print the part.

As mentioned earlier, a common material for material extrusion 3D printing is ABS. If you used ABS, try sanding your part to improve the surface finish. (Sand only by hand. An electric sander will quickly damage your project.) If you used a different material or if you want a different surface finish, other finishing techniques are available.

Sanding is the most straightforward finishing process when smoothing the surface of a printed part. Here is how to do it:

Supplies

- Printed ABS part
- Coarse and fine sandpaper (200-600 grit)

Instructions

- Start with a coarse grit sandpaper (200-300 grit) and use a small circular motion to lightly rub the surface of your part. ABS material sands very quickly, so be careful not to remove too much material.
- Gradually increase to 600 grit to create a smooth surface. A higher grit number creates a smoother surface. You may need to try different amounts of time and pressure to get your ideal surface. It is better to remove less material than too much! If you need to remove more material, you can return to a lower grit number.

AREAS OF INTEREST AND THINGS TO DO

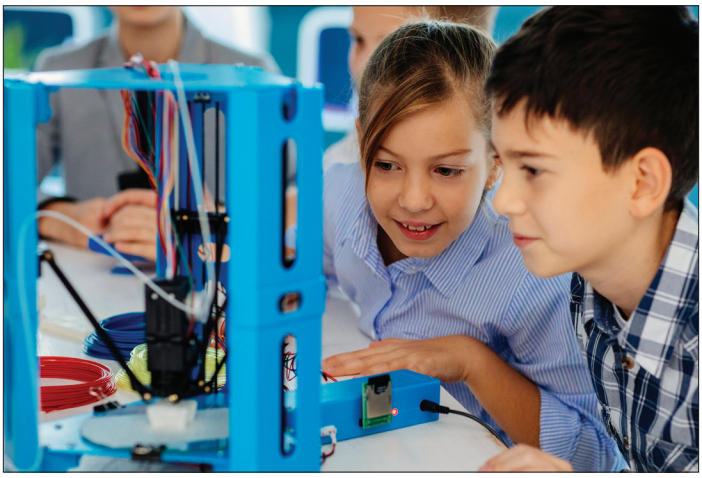
Every self-determined 4-H project can be broken down into areas of interest. These are the specific things members want to address during their project adventures. Using 4-H 365 *Self-Determined Project Guide*, identify at least three areas of interest with at least three activities per area to explore. Take your ideas from the list below or make up your own.

Look for a Printer

- ☐ What 3D printers and materials are available in your community for you to use? Provide a summary of local locations, the equipment they have, and how much it costs to use them. You might find some that are free!
- ☐ Learn more about buying a 3D printer by looking online and in retail locations near you. Consider all the features, like size of the build plate, ability to do multicolor printing, etc. When you have identified the one you want to buy, explain your selection to your project helper.
- ☐ Before you decide whether to use a community resource or buy, identify and talk to someone who already uses or has a 3D printer. Ask them to show you the process the follow, start to finish. Can they show you what they have printed? What do they like and dislike about the 3D printer they use?
- ☐ Consider purchasing a printer by going in with some friends or by suggesting the purchase of a 3D printer for your club or other group. Learning together is often more fun.
- ☐ Determine if you can use your printer to make money. Are there things you can print and sell? This might allow you to buy a more expensive printer.

Look for a Model

- ☐ Go to **thingiverse.com** and explore the available part designs. What are they? Do you have to pay for them? Find at least five designs you can have for free.
- ☐ Download free computer-aided design (CAD) software such as **blender.org** or **tinkercad.com** and create your own simple design.
- ☐ Explore more sophisticated for-sale software such as Fusion 360 from Autodesk **autodesk.com/products/fusion-360/overview**. Would it be worth buying it?
- ☐ Make a list of design resources you find during your research. Share it with others interested in 3D printing.
- ☐ Does your printer have an app? Download it and go mobile with your design work.



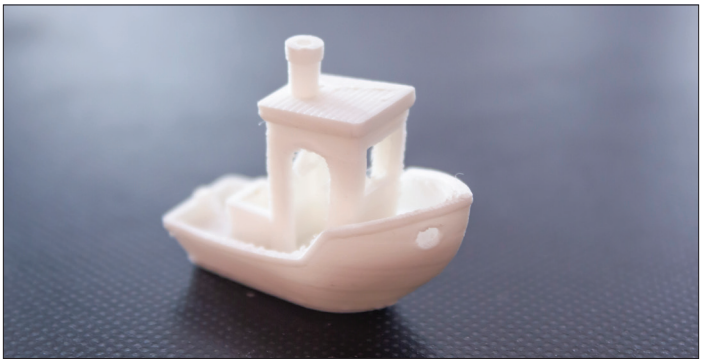
When You Print

- ☐ Depending on the printer you use, the process for preparing to print can vary. It may involve cleaning the nozzle, applying something to the build plate to help the first layer of your part stick, or something else. Make a handy checklist for the preparation needed to print your part.
- ☐ Estimate the time it is going to take to print your part. Were you correct?
- ☐ Did you use more or less material than you thought you would? If so, why? What can you do to be more accurate?
- ☐ Did everything go right the first time? If so, you are lucky! Many times, changes need to be made based on experience to get the part to print well. Describe any changes you needed to make, or anything else that you would change next time.

Post Processing

- ☐ Remove any supporting pieces that were needed for the printing process. Would you change anything if you were to print the same part again to help with the post processing?

- ☐ Print two versions of the same part and sand only one of them. Use the before and after versions to teach someone else about post processing.
- ☐ Print a simple part and sand the surface until gaps are exposed. Show your part to someone and explain what caused the gaps from the printing process.
- ☐ Research post-processing techniques other than sanding and use one of those techniques. Compare this surface to your sanded surface. Describe how they compare to each other.



Learn More

- ☐ Why is 3D printing called additive manufacturing? Is there such a thing as subtractive manufacturing? Compare the two and use your comparison to explain 3D printing to a friend.
- ☐ Identify and visit a company in your area that uses 3D printing. Be prepared with some questions to ask and share what you learn with your project helper.
- ☐ With guidance from a parent or guardian, look at videos about 3D printing on **YouTube.com**.
- ☐ Create a short video of your own that explains 3D printing to younger children. If you use the time lapse feature on a smartphone, you can include a quick look at how your object was printed.
- ☐ Describe how at least one other 3D printing process works, the material it uses, and what it is used for. Choose from vat photopolymerization, powder bed fusion, directed energy deposition, binder jetting, material jetting, and sheet lamination. Here is a good video from America Makes about all of the different processes: **youtube.com/watch?v=_K1C_dkZK98**
- ☐ Research how 3D printing is changing the world of medicine, housing, auto manufacturing, space exploration, food, and other areas. Create an ad that promotes 3D printing and the possibilities for its use.
- ☐ What is a prototype? Find out and explain what 3D printing has to do with creating prototypes.

Build Community

- ☐ Join a school club, take a class at a community center or makerspace, or start your own dedicated club to learn more and share ideas about 3-D printing.
- ☐ Subscribe to a newsletter, magazine, or social media group dedicated to 3D printing.
- ☐ With your parent or guardian, see if you can visit a maker space on a regular basis and learn more from others there.
- ☐ Use your new talent to create small objects and toys to give away or sell. Always tell the recipients the objects were made using 3D printing.

RELATED RESOURCES

Youtube.com is full of helpful tutorials about 3D printing. Here are some of our favorites:

- The Ultimate Beginner's Guide to 3D Printing – Part 1 (2017, 11:23 minutes), **youtu.be/3LBTkLsjHGQ**
- The Ultimate Beginner's Guide to 3D Printing – Part 1 Revised (2020, 31:22 minutes), **youtu.be/GJ98Lydc54k**
- The Ultimate Beginner's Guide to 3D Printing – Part 2 (2018, 17:54 minutes), **youtu.be/VN1RO1Oey-w**

With your parent or guardian's help, go to YouTube or elsewhere online and see if you can find other helpful tutorials.

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