



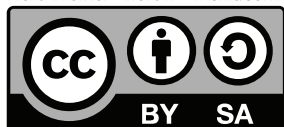
**Thinkers. Makers. Layer Geeks**

# Getting Started with 3D Printing in Portland

<http://www.herbweiner.com/3DprintingInPortland.pdf>

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## Introduction

This booklet is intended for anyone, of any age, even complete beginners, who would like to learn more about 3D printing. We have also tried to include resources that will be useful to more advanced readers.

**Do I need a 3D Printer?** You don't need to own a 3D printer to get started with 3D printing. Just as there are print shops that can handle all your standard printing needs, from flyers to engraved wedding invitations, there are 3D printing service bureaus available for people getting started with 3D printing. See page 9 for some 3D printing service bureaus.

**What is 3D printing?** 3D printing is the process of making a solid three dimensional object, typically by building up many thin layers of plastic or similar material from a three dimensional digital model. 3D printed objects can include toys, jewelry, and artistic models, as well as tools and functional parts. 3D printing is even being used to create functional prosthetic hands, arms, and other body parts for those who would not otherwise be able to afford them.

**Where do 3D digital models come from?** There is a variety of software tools that can be used to create 3D digital models. However, beginners often discover that they can find interesting 3D digital models for free or nominal cost online. 3D digital models can also be created by 3D scanning physical objects or even people. See page 9 for some sources of 3D models.



*3D Digital Model of Dodippogriff, by Arian Croft (dutchmogul), from Thingiverse (<https://www.thingiverse.com/thing:2505292>)*

**How can I learn more about 3D printing?** We have tried to list a variety of resources, including educational resources and businesses. We also invite you to attend our free meetings, where you will have an opportunity to network, ask questions, see demonstrations, and enjoy our educational presentations. We generally provide light snacks and beverages.

This booklet is available online in PDF format; scan the QR code on the cover or visit <http://www.herbweiner.com/3DprintingInPortland.pdf>. All of the links in the PDF are clickable, so you need not type in any web links.

See pages 5 – 7 for information on choosing a 3D printer.

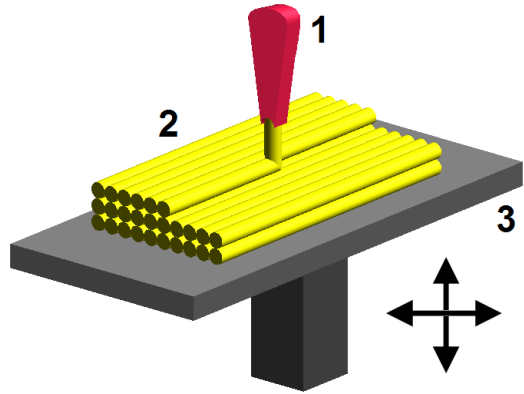
## How does 3D Printing Work?

3D printing begins with a 3D digital model. A common file format for 3D digital models intended for 3D printing is STL (STereoLithography, or Standard Triangle Language, or Standard Tessellation Language), although you may also encounter other formats, such as OBJ (Wavefront Technologies Object format) or 3MF (3D Manufacturing Format).

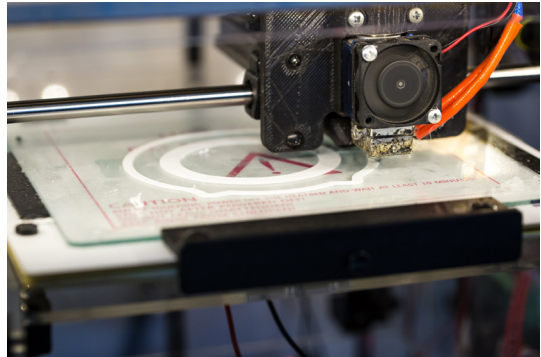
The most common 3D printers use a heated nozzle that ejects molten filament (plastic or other material), which is deposited in thin layers one on top of another to form the 3D printed part. Either the nozzle, or the table, moves as the part is being printed.

Since 3D printing requires building up many thin layers, the first step in 3D printing is to run slicing software. Slicing software determines how to break the 3D digital model into thin slices that the printer is able to print. Cura is an example of slicing software.

In order to slice a 3D digital model, the slicing software needs information about your printer (for example, what is the size of your printer's print bed, and how thick is each layer) and information about the material that you are going to use for the 3D print (for example, what is the proper printing temperature for that material). If the same 3D digital model is printed on a different printer, or with different material, the output of the slicing software will be different.



*Close-up of nozzle ejecting molten plastic (1), deposited material forming 3D printed part (2), movable table (3). (Based on drawing in D. T. Pham, S. S. Dimov, Rapid manufacturing, Springer-Verlag, 2001, ISBN 1-85233-360-X, [https://commons.wikimedia.org/wiki/File:FDM\\_by\\_Zureks.png](https://commons.wikimedia.org/wiki/File:FDM_by_Zureks.png))*



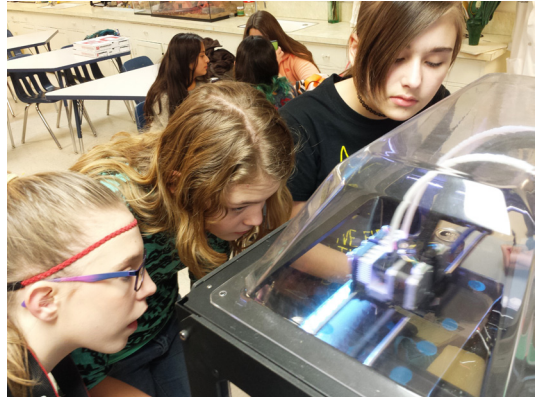
*Close-up of 3D printer showing the first few layers of a 3D print (Pexels, <https://www.pexels.com/photo/3d-3d-model-3d-model-3d-printing-459751>)*

## 3D Design and Printing for Kids

An ideal starting point for beginners of any age is <https://www.tinkercad.com>.

Tinkercad is free, web-based software suitable for beginners to create 3D digital models. You do not need your own 3D printer; you can print your 3D designs using Tinkercad, and have the finished products shipped directly to you.

MakerBot in the Classroom (<http://goo.gl/Byvdqm>) is a resource for educators interested in introducing 3D Printing into a classroom environment. (Note that kids can get started with 3D Printing even if they don't design their own models.)



*Students watch as the 3D printer works to create an object layer by layer (U.S. Air Force photo/Jere Matty, <http://www.arnold.af.mil/News/Photos/igphoto/2001500439>)*

### Did you Know?

In 2016 and early 2017, the members of the Portland 3D Printing Lab scanned ten sculptures by Auguste Rodin and 3D printed them. The 3D printed replicas were then displayed in the Portland Art Museum as part of the Rodin: The Human Experience exhibit, on display from January 21 through April 16, 2017. The 3D digital models are available on <https://www.thingiverse.com>.



*Visitors to the Portland Art Museum explore the Rodin Remix created by the Portland 3D Printing Lab. #rodinremix*

Members of the Portland 3D Printing Lab work with e-NABLE (<http://enablingthefuture.org>) to provide 3D printed assistive hand devices for those in need.

Members of the Portland 3D Printing lab designed and 3D printed half of a life-size cow (<https://www.forbes.com/sites/tjmccue/2015/09/29/the-logistics-of-3-d-printing-a-cow-in-portland>) that is now housed at the Urban Farmer restaurant in Portland. (See photo on page 5.)

## What Features should I look for in a 3D Printer?

The following is an overview of the features to consider when evaluating a 3D printer. The selection of features will obviously be more limited for an inexpensive entry-level printer than for more expensive machines, but even beginners should understand which features are available or not available on the printer they choose.

Note that if you only occasionally require some of the more advanced features, you can save money by purchasing a printer without these features, and using a service bureau when these advanced features are required.



*Lifesize 3D Printed (half) Cow designed by Portland 3D Printing Lab member Mazuir Ross. Cow consists of 99 separate pieces and required over 700 hours to print on 14 different 3D printers. 11 year old Paul poses with the cow to show its size. (<https://3dprint.com/63136/3d-printed-cow-portland>)*

- Price is an important consideration, and obviously depends upon the features offered. Look for the best combination of features available within your budget.
- Build Volume: One of the first questions people often ask about a 3D printer is “what is the biggest object that I can print using this printer?” The largest build volumes will only be found in expensive 3D printers intended for industrial use. Larger objects (like the cow in the photo above) can be printed in multiple pieces and fastened together.
- Ease of Use: Another question that is important for a beginner is “how easy is this printer to use?” Some printers are intended for beginners, have relatively few features, and are relatively easy to use. Other printers have more features, often requiring more tinkering. Some printers are sold as kits, and require more effort to get working than a printer that is already assembled.
- Automatic Bed Leveling: Many printers offer automatic bed leveling. Other printers require you to level the bed manually using adjustment screws. If the bed is not level, print quality may suffer, or the print may fail entirely. Automatic Bed Leveling is one of the features that contributes to ease of use.
- Print Quality (Resolution): Inexpensive printers may not be capable of producing a high level of detail. Some printers may offer faster printing speeds that produce less detail, as well as slower printing speeds that are capable of producing greater detail.

## What Features should I look for in a 3D Printer (continued) ?

- **Print Speed:** Inexpensive printers may not be very fast, although this is often not important if you are only printing small objects, and are not manufacturing high quantities of objects. Even a simple model may take 30 minutes to several hours to print on an inexpensive 3D printer.
- **Automatic End of Filament Detection:** Some printers automatically pause the print if the filament runs out, allowing you to replace the filament and continue the print. Other printers don't detect the end of filament, and continue the printing process even though filament is no longer being dispensed, causing the print to fail. On such printers, you must ensure that you have sufficient filament prior to beginning the printing process.
- **Filament Compatibility:** Many different types of filament are available, each with different characteristics (advantages and disadvantages). Some printers support a wide variety of materials, and others support only a few.
- **Multi-Material Capability:** Many printers support only a single material (filament type and color) for each print. Some printers can create objects with multiple colors or materials. Printing with multiple materials allows support material to be printed with soluble filament, so that the support material can be washed away after the print is completed. Printers that support only a single material require support material, when required, to be broken away and removed from the print.

There are two approaches to Multi-Material Capability: One approach is to have two or more extruders, and to switch extruders to print different materials. This is the most common approach.

Another approach is to use a device, such as the Mosaic Manufacturing Palette 3 Pro (<https://www.mosaicmfg.com/products/palette-3-pro>) or the Bambu Lab AMS – Automatic Material System (<https://us.store.bambulab.com/products/ams-multicolor-printing>). The second approach splices two colors of filament together before the filament passes through the extruder. This approach generally results in some waste of filament, because the printer needs to purge material when switching colors.

- **Local Printing and Connectivity:** Some printers can print locally (from a USB flash drive or SD Card), while some printers print from a computer, and the printing stops if the computer crashes or is disconnected. Printers offer different connectivity options, including USB, WiFi, and Ethernet.
- **Enclosed printers** provide better temperature stability for materials (e.g. ABS) that function best in a heated build environment, to minimize warping or models separating from the build plate, and may be safer if children or pets are likely to investigate the printer while it is printing.



## What Features should I look for in a 3D Printer (continued) ?

- **Type of Build Plate:** Different types of build plates and print surfaces offer better filament adhesion with a variety of filaments, as well as easier print removal.
- **Open or Proprietary Software:** Some printers require proprietary software, making you dependent upon the manufacturer for upgrades and bug fixes. Other printers are compatible with a wide range of software, like Cura and Simplify3D.
- **Ease of Maintenance:** Some printers use readily available components, making it easier to upgrade or replace failed or obsolete components, such as hotends or extruders.
- **Hybrid Machines:** Some 3D printers are designed to allow the 3D print head to be removed and replaced with a laser (for engraving and cutting) or a CNC head (for milling). One example of such a device is the Snapmaker Artisan 3-in-1 3D Printer (<https://snapmaker.com/products#Snapmaker-Artisan-3D-Printer>). Be aware that such hybrid machines require design compromises, and probably won't match the capabilities of dedicated devices.

If you are looking to purchase an inexpensive printer suitable for beginners, you might consider the Official Creality Ender 3 (\$169, <https://www.amazon.com/dp/B07BR3F9N6>) or the Official Creality Ender 3 Pro (\$219, <https://www.amazon.com/dp/B07GYRQVYV>).

## Safety Considerations

Please be aware of the following safety considerations:

- 3D printers have hot extruders, and often hot print surfaces. Keep children, pets, your own hands, and flammable materials away from hot components.
- 3D printers have moving parts. Keep children, pets, and your own hands away from moving parts while printing is in progress.
- Many 3D printing filaments (e.g. PLA, PETG, TPU) are relatively safe, but some (e.g. ABS, Nylon, and Polycarbonate) emit potentially harmful fumes. Even relatively safe filaments can release fine particles into the air. 3D printers are best used in a well ventilated area.
- If you build a 3D printer from a kit, be sure to follow the instructions carefully, to avoid electrical hazards.
- When working with hybrid machines that contain lasers, or resin 3D printers (refer to page 9) that emit ultraviolet light, be sure to wear eye protection and follow safety procedures carefully.
- Resin 3D printers (refer to page 9) use resins that may irritate skin or eyes and may emit harmful fumes during printing and curing, so wear protective gloves and eyewear, and use only in a well ventilated area.

## What do I need to know about 3D Scanning?

3D Scanning is the process of capturing a 3D model of a physical object, so that the model can be 3D printed (or used in other software). There are several considerations involved in 3D Scanning:



*Jessy uses a 3D Scanner to create a 3D Digital Model of Phil. Photograph courtesy of Adam McGee, Portland 3D LLC.*

- The price of 3D Scanners varies widely, depending upon features.
- Supported Materials: Not all scanners can capture transparent or reflective objects, and may have difficulty with shadows or dark colors.
- Unlike taking a photograph, 3D Scanning takes time, although some 3D scanners are faster than others. People would need to remain motionless if they are to be successfully 3D scanned.
- Scan Accuracy, Resolution, and Volume: Accurately scanning small objects and capturing all desired detail (e.g. jewelry) would be difficult for many 3D scanners. 3D scanning large objects (e.g. a car or a house) would typically require a specialized 3D scanner.
- Color Capture: Some 3D scanners capture only object geometry, not color. Other 3D scanners are able to capture color.
- Editing and Touch-Up: 3D scans often require editing or touch-up in order to be useful. This may involve removing extraneous objects, such as the floor or table upon which the scanned object is positioned.
- Output Format: Different output formats are available, depending upon the application for the 3D scan. If you want to 3D print the scanned object, ensure that the output of the scanner is suitable.
- Portability: Some 3D Scanners are portable, but others are not. Even some portable 3D Scanners need to be connected to a computer while they are scanning.
- Calibration and Setup: Some 3D Scanners require calibration or other setup, sometimes prior to each scan, while other 3D Scanners offer automatic calibration.
- Training and Expertise: Some 3D Scanners require considerable training and expertise in order to achieve acceptable results.

3D scanning is complex, and even a \$1000 scanner may not reliably produce good results. For difficult to scan objects, it may be best to utilize a professional 3D scanning service bureau.



## 3D Scanning Applications and Service Bureaus

- Qlone (<https://www.qlone.pro>) is a 3D scanning app for iPhone, iPad and Android.
- Autodesk ReCap (<https://www.autodesk.com/products/recap/overview>) is a service that allows you to “create accurate 3D models with reality capture.” A limited free mode is available.
- Portland 3D LLC (<http://www.pdxddd.com>) is owned by Portland 3D Printing Lab member Adam McGee, (503) 536-5471. (See photo above.)
- Digital Scan 3D (<https://digitalscan3d.com>) is a Portland-based service bureau offering professional quality scanning and printing. (503) 954-2945. They can even scan people and make miniature full color selfies.

## Resin Printing

Resin 3D Printing (Stereolithography or SLA) uses liquid resin rather than plastic filament to form 3D printed objects. Lasers and / or ultraviolet light is used to harden and cure the resin. Here are some things to know about Resin Printers:

- Resin 3D printing can produce highly detailed and precise models with complex geometries and intricate patterns.
- Resin 3D printing is suitable for miniatures and models, jewelry and art, and even dental and medical applications.
- The materials used for resin 3D printing are generally more expensive than the material used for traditional 3D printing.
- Please be aware of the safety considerations required for resin 3D printing. Please refer to the Safety Considerations on page 7.

## Online Sources for 3D Digital Models

- <https://www.thingiverse.com>
- <https://www.printables.com>
- <https://www.youmagine.com>
- <https://pinshape.com>
- <https://3dexport.com>
- <https://www.stlfinder.com>
- <http://www.yeggi.com>

## 3D Printing Service Bureaus

- <https://www.shapeways.com>
- <https://hydra.direct>
- <https://www.3dhubs.com>
- <https://www.makexyz.com>
- <https://corvallis3d.com> (in Beaverton)

## Software for Creating 3D Digital Models

- <https://www.tinkercad.com>: A web-based, visual 3D rendering tool that comes with great starter tutorials. Level: Great for **beginners**.
- <https://www.sketchup.com>: Level: Great for **beginners**.
- <http://www.openscad.org>: Free software download containing a coding/visual 3D rendering tool. Level: **beginning** to advanced, great for beginners who know how to code.
- <http://pixologic.com/sculptris>: Great for art and organic objects. Like working with modeling clay. Great for **beginners**.
- <http://www.autodesk.com/products/fusion-360/overview>: Free software download for students and educators containing a visual 3D rendering tool. Note that Autodesk has a wide range of 3D rendering products. Level: **beginning** to advanced.
- <http://www.freecadweb.org>: “FreeCAD is a parametric 3D modeler. Parametric modeling allows you to easily modify your design by going back into your model history and changing its parameters.” Level: intermediate to advanced.
- <https://www.blender.org>: Level: Intermediate to advanced.
- <http://www.solidworks.com>: Level: Intermediate to advanced.
- <https://www.rhino3d.com>: Level: advanced.

## Educational Resources

- <https://3dprint.com>. 3D Printing news and online discussion forum.
- <http://3dprintingforbeginners.com>. 3D Printing 101 and blog.
- <https://www.shapeways.com/tutorials/getting-started>. Includes a section on 3D Design & Printing for Kids.
- <http://www.instructables.com/id/How-to-Get-Started-With-3D-Printing>. Online tutorial uses Fusion 360.
- <https://opensource.com/life/16/6/how-get-started-3d-printing-blender>.
- <http://www.makeuseof.com/tag/beginners-guide-3d-printing>.
- <https://www.tes.com/teaching-resource/getting-started-with-3d-printing-for-teachers-11598345>. Downloadable 59 page PDF resource guide.
- <http://pdx3dprintteach.blogspot.com>. 3D Printing Teacher Resources.
- [http://www.advis.org/Customized/Uploads/ByDate/2016/April\\_2016/April\\_21st\\_2016/Falcone%20-%20GettingStartedwith3DPrinting74942.pdf](http://www.advis.org/Customized/Uploads/ByDate/2016/April_2016/April_21st_2016/Falcone%20-%20GettingStartedwith3DPrinting74942.pdf). Information on Tinkercad and Sketchup.
- <https://www.lynda.com/3D-Animation-Prototyping-tutorials/Up-Running-3D-Printing/151814-2.html>. Online 3D Printing course.
- <https://all3dp.com>. 3D Printing news and stories.

# The Portland 3D Printing Lab

The Portland 3D Printing Lab is a group for anyone interested in 3D printing, from artists to 3D modelers to Makers, advanced to beginner. Generally, we meet about once a month, sometimes for a presentation, sometimes to collaborate on projects, and sometimes just to socialize. Everyone is welcome, and there is no charge to attend. This is a great place to learn more about 3D printing and to meet interesting people. The group has around 2200 members; many of them own or work in businesses involved in 3D printing, so the group offers a rich source of knowledge and experience that can be helpful to anyone getting started with 3D printing.

- <http://pdx3dplab.com>.
- <https://www.meetup.com/portland-3d-printing-lab>.
-  @pdx3dplab.
-  #pdx3dplab.
-  <https://www.facebook.com/groups/pdx3dplab>.

The next two meetings are at Autodesk, 221 SE Ankeny Street, Portland, Oregon 97214:

- Wednesday, October 18, 2023, 5:30 – 8:30 PM.
- Wednesday, December 6, 2023, 5:30 – 8:30 PM.



*Shashi Jain introduces the June 2017 Meetup of the Portland 3D Printing Lab.*



*Attendees at the Portland 3D Printing Lab 2016 Holiday Party assemble 3D Printed Holiday ornaments, which they were able to take home that same evening.*



*Portland 3D Printing Lab members gather at Hedron MakerSpace in September 2015 to assemble 3D printed prosthetic hands for e-NABLE, to be donated to those in need.*



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