University of Alberta Library Makerspace
Certification: 3D Printing

University of Alberta Library Makerspace Certification: 3D Printing

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Introduction

The Mission of the Makerspace

The University of Alberta Library has a mission to provide service for the advancement of teaching, learning, and research within the University of Alberta community and beyond. In addition to providing access to the past and present through collections, we aim to offer support for the future with spaces and expertise that support the growing use of technology in scholarship.

The makerspace located at the Digital Scholarship Centre is intended to provide the University of Alberta community with an interdisciplinary space where researchers and students can learn and experiment with making technologies. By providing access to tools that are often expensive or not part of the standard university curriculum, the library hopes to awaken the curiosity and creativity of the community. The makerspace is a place for experimenting, testing, and exploring creativity. With the makerspace, the library hopes to foster a community that creates, seeks to answer questions, and develops solutions for real-world problems.

Purpose of this Ebook

The purpose of this ebook is to prepare you for use of the library makerspace. It includes important safety information and policies you will need to be aware of when you come on-site. It will also provide you guidance on how to use the 3D printers available in the makerspace. This book will only cover certification for the 3D printing tools and if you wish to use other tools in the Makerspace

you will need to complete separate certifications for those devices.

The certification process consists of three steps:

1. The completion of this Ebook.
2. Successful completion of the certification test
3. A short 30-minute onsite orientation with library staff

Accessing the Makerspace

Who can use the makerspace?

The Makerspace is free to be used by anyone in the University of Alberta community, including students, staff, or faculty. Members of the public not affiliated with the University may be granted access on a case-by-case basis by the Digital Scholarship Centre Leadership team or the Makerspace Coordinator. For safety and liability reasons, all users of the makerspace must complete certification for the machines they are using. This includes separate certifications for 3D Printers, Cutting Tools (Fabool Laser Cutter, Cricut), and 3D Scanners.

When can you use the makerspace?

You can make appointments to use the makerspace on the DSC website during DSC opening hours. You will need to ensure you can complete your print jobs during the time the DSC is open, or for longer print jobs, ensure you have booked time on a printer inside an enclosure, so the printing can continue overnight.

What can you create?

The Digital Scholarship Centre is equipped with a variety of devices that will allow you to scan, print, and cut certain materials. The makerspace includes four Ultimaker 3D printers, 1 Formlabs resin printer, a Fabool laser cutter, a Cricut maker machine, and two types of 3D scanners.

- The 3D scanners enable you to scan objects, even faces, and render a 3D model that can then be repaired and modified for 3D animation or printing.
- The 3D printers will enable you to render digital models into physical objects.
- The laser cutter is capable of cutting paper and wood up to 2 mm thick and engraving images and text on wood.
- The Cricut Maker machine is capable of cutting paper, fabric, cardboard and chipboard.

Using one or a combination of these tools presents a great variety of possibilities. Whether you are a student in Engineering or an Arts Major, the tools of the makerspace can support class projects, help with research or be used to tinker and learn.

PART I

GETTING STARTED

1. Policies and Community Guidelines

Learning Objectives

In this chapter you will learn:

- What uses the makerspace is intended for.
- The behavioural expectations of all users of the makerspace.

Respect the Intent of the Makerspace

To ensure the purpose of the Makerspace is upheld, every user is expected to adhere to a set of principles and policies.

- Come with a willingness to learn and share knowledge. For those who are experienced with maker tools, there will be times when there are others using the space without your experience. Be aware and willing to help others in the space, or find a member of staff to assist. For those new to using a makerspace, be open to suggestions from staff and other users. We also encourage you to be open, share with others what you are working on.

- As the purpose of the Makerspace is to support research and learning, we ask that you not create weapons or offensive materials.
- The makerspace is also not intended for the creation of items intended for commercial resale. The tools and space have been provided for exploration and experimentation, but once prototypes are finalized – a means of mass-producing your creations must be obtained elsewhere.

Respect Each Other and the Space Around You

In addition to using tools with care, conduct within the space and towards others also influences the safety and welcomeness of the space. As a user of the Makerspace, be sure to be respectful towards other users and the space itself.

- Keep the space as tidy as possible, dispose of scraps from your work, return all tools to their places. Keep floors clean: any spills should be cleaned and tripping hazards removed immediately. Any deliberate mess-making and chaos will not be tolerated and you will be asked to leave. If you don't know where items belong, ask a staff member
- No food or drink in the Makerspace.
- Be aware of the activity going on around you. Do not wear headphones or other equipment that may make you unaware of hazards around you.
- Share the space and equipment fairly with others.
- Abide by the University of Alberta Library and Museums Community Expectations

It is also important to stress that the Makerspace is dedicated to providing a harassment-free experience for everyone, regardless of gender, gender identity and expression, sexual orientation,

disability, physical appearance, body size, race, ethnicity, or religion. We do not tolerate the harassment of participants in any form.

If you are being harassed by another user, notice that someone else is being harassed, or have any other concerns, please submit a report here: http://bit.ly/DSC_Conduct

You may also submit a report or concern by emailing dsc.library@ualberta.ca. You may report harassment anonymously, or you can choose to include your contact information if you would like Staff to follow up with you for further investigation or to communicate actions that have been taken.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/ualmakercertif3dprinting/?p=39#h5p-1

An interactive H5P element has been excluded from this version of the text. You can view it online here:
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An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/ualmakercertif3dprinting/?p=39#h5p-3

2. Makerspace Safety

Learning Objectives

In this chapter, we will learn

- General makerspace safety rules and policies.
- Specific safety information related to 3D printing.

Safety is a Shared Responsibility

In the Makerspace, safety is of the utmost importance. Safety is a shared responsibility, which means all users must be aware and conscious of safety. Adhering to safety policies insures equipment is not damaged and most importantly, users are not injured. so that the space continues to open for use. Keep in mind these policies when it comes to safety:

Equipment

- Only use equipment that you have been certified to use.
- If you are uncomfortable or need a refresher on how to use equipment, ask staff for assistance.

- No outside equipment without asking Staff first.
- Review Safety Data Sheets before using unfamiliar chemicals or materials.
- Review and follow requirements outlined in the Safety Control Bands.
- Report broken or malfunctioning tools to staff immediately. Do not try to do repairs yourself.
- Do not leave machines running unattended. The exception is 3D printers, but if you are a certified Maker we also recommend that you check back periodically to monitor your print progress and catch errors and jams.
- Check that all pieces and tools are properly secured before operating equipment.
- Do not attempt to stop running equipment with any part of your body.
- Only one person should be operating a machine at a time.

Working in the Makerspace

- Ensure that you are working in a properly lit space free of clutter and obstacles such as bags, coats etc. There are lockers available in the hallway directly adjacent to the main makerspace that you can use to store your things while working.
- Ensure you meet Personal Protective Equipment (PPE) requirements for the activity. If you are using the Formlabs printer you should be using safety glasses and latex gloves.
- Wear appropriate apparel in the Makerspace. No loose clothing, long jewelry, open-toe shoes and long hair should be tied back. Nothing on your person should hang away from your body.
- Be aware and on alert when in the Makerspace. Only use the space when you are well-rested and never while intoxicated.

Be mindful of all equipment around you, especially tools with moving parts.

Incidents

- Report all incidents and near-misses to Staff immediately

3D Printer Safety

There are a few safety measures to consider specifically in regard to 3D Printers.

- Don't touch a 3d printer's print head- it is over 200 degrees celsius and will burn you. Always use tweezers to remove any filament from the print head.
- The print bed is warm, 60 degrees- it shouldn't burn you, but be mindful. Never remove a print while the print bed is still warm, and if the print bed has a removable surface, take it off before attempting to remove the print.
- When in doubt, power off the machine.
- Pay attention to what type of filament you are using. Some may melt at different temperatures and require a change in settings.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/ualmakercertif3dprinting/?p=41#h5p-4

3. Resources for your Virtual Certification

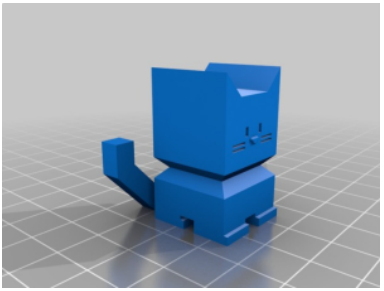
Before you dive into 3D printing basics, the slicing software used for the Makerspace 3D printers is available online. The Makerspace does have computers with these programs installed, but you can download these programs to practice on your own computer. The Cali Cat model is the test STL model you will use to practise printing.

Just click on the images to be directed to the downloads page.

Cura is used with the Ultimaker Printers

formlabs

Preform is for the Formlabs printer



Cali Cat – The Calibration Cat

4. Video Tour of the Library Makerspace

The makerspace is located within the Digital Scholarship Centre (DSC) on the 2nd floor of Cameron Library. The following video tour will show you how to find the DSC and makerspace, and more about the space itself.

A YouTube element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/ualmakercertif3dprinting/?p=45

PART II

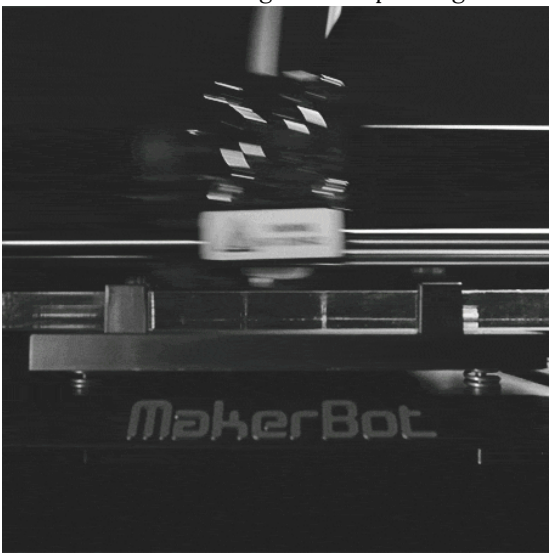
3D PRINTING EQUIPMENT AND MATERIALS

5. What is 3d printing?

3D Printing: Basic Overview

Three-dimensional (3D) printing is an additive manufacturing process that creates a physical object from a digital design. The technology generally works by fusing layers of materials to build up to a physical object. There are different types of 3D printing, including Fused deposition modeling (FDM) or Filament Fabrication (FFF), which is the most common type, and Stereolithography (SLA) or resin based-printing, which involves photochemical processes. We have access to both types of 3d printing within the Digital Scholarship Centre.

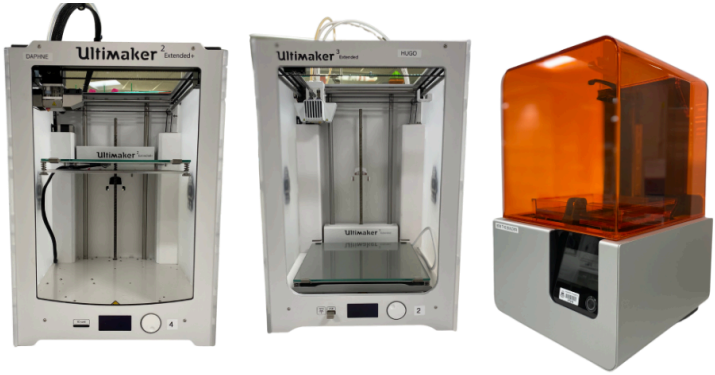
Here is a GIF illustrating FDM 3D printing:



[General Electric. (n.d.). Halloween tech GIF. Retrieved August 23, 2021, from https://giphy.com/gifs/ge-tech-halloween-ge-5dp4lTsHxtqGA]

6. Available 3D Printers

Choosing a Printer



Not all 3D printers are the same. There are three types of printers in the DSC: two Ultimaker 2+ extended, two Ultimaker 3, and one Formlabs Form 2. We typically recommend using Ultimakers as they create strong prints suitable for multiple needs and projects. The Formlabs Form 2 has some important constraints to be aware of; for example, it will result in smaller, heavier prints, with a significantly longer process. You will find the relevant details for each type of printers outlined in the table below:

	ULTIMAKER 2+ EXTENDED	ULTIMAKER 3	FORMLABS FORM 2
Website	Ultimaker	Ultimaker	Formlabs
Software	Cura	Cura	PreForm
Location	Makerspace	Makerspace	Makerspace
Enclosure	One Ultimaker 2+ extended	One Ultimaker 3	No
Size	22.3 x 22.3 x 30.5 cm	48.9 x 34.2 x 38 cm	52 x 34.5 x 33 cm
Filament	PLA & PVA	PLA & PVA	Resin
Filament Type	2.85 mm	2.85 mm	N/A
File Type	.stl	.stl	.stl
When to Use	Any print (creative, engineering designs, prototypes, etc.)	Any print (creative, engineering designs, prototypes, etc.)	Smaller, more detailed and intricate prints.

Note: Cameron Science, Technology, and Business Library has Prusa 3D printers that are used for our mediated 3D printing service. To learn more about this service, check out the webpage:

https://library.ualberta.ca/services/3dprinting

7. Available Materials

Filament

The Ultimaker printers in the DSC makerspace use two different types of filament.

Type of Filament	PLA Filament (2.85mm)	PVA Filament (2.85mm)
Image		
Description	**PLA (polylactic acid)** is highly versatile, easy to print and is a fully biodegradable thermoplastic polymer consisting of renewable raw materials. PLA filament is used to print 3D objects using Print Core AA 0.4MM.	**PVA (polyvinyl alcohol)** is a leading water-soluble support material for multi-extrusion 3D printing. It offers freedom and convenience to design complex model geometries that require supports. PVA filament is used for 3D printing using Print Core BB 0.4mm

Resin

The Formlabs Form 2 uses liquid resin to produce 3D prints. The resin comes in cartridges that can be found at the back of the printer. There are different types and colours of resins, but we ask that you print using the tank already in place. The following resins are available:

Resin Type	Colour	Features
High Temp	Clear	High thermal stability
Flexible (legacy formulation)	Black	Hard, flexible

For a full list of existing resins, visit the materials library from Formlabs.
More details on how to load filament will be explained in a later section of this module.

[Formlabs. (n.d.). Resin Cartridge. Retrieved September 10, 2021, from https://formlabs.com/materials/]

PART III

PREPARING FILES FOR PRINTING

8. 3D Printing File Types & Where to Find Them

File Format

All submissions need to be stereolithography files, with an STL extension (.stl).

Standard Triangle Language or STL is a file format native to the stereolithography CAD software created by 3D systems. The file format is supported by other software packages and is used for rapid prototyping, 3d printing and computer aided manufacturing. Invented by the Albert Consulting Group for 3D Systems in 1987, it has remained relatively unchanged for 22 years.

The STL format is considered the standard for 3D printing and rapid prototyping. It allows for the simple and fast fabrication of a physical part, model or assembly. The STL file actually doesn't save the physical dimensions of a unit and requires other software to determine its sizing in either millimetres or inches.

3D printers create objects one layer at a time, using a series of horizontal layers that are filled with solidified material (PLA filament) which are fused together.

Where to find models

There are a variety of open source, freely accessible models online that you can download and use. Keep in mind that if submitting a model from these sites to our printing service, you may be asked

to articulate the educational purpose of the submission. Here are a few sites to consider:

Free 3D Models:

Thingiverse.com: MakerBot's searchable design library community.
3D Warehouse: SketchUp's searchable design library.
Instructables: From the AutoDesk community.

Free 3D Modelling Software

To create your own 3D model, you'll need some software. Here are a few free ones you can try:

Tindercad: a browser-based 3D design platform, no part of Autodesk (free version available)

SketchUp: comes in free and pro-versions

Blender: open source 3D animation suite

OpenSCAD: free software for creating solid 3D CAD (Computer-aided design) models. Useful for creating models of machine parts.

9. 3D Model Design: Tips and Tricks

Whether printing a model that you designed yourself or printing a freely available model from the internet, there are some important design considerations to keep in mind before printing.

In this chapter you will learn

- appropriate sizes for your design and what to do if you design is too large for our printers
- what units of measurement to use when designing
- how to support overhanging parts of your design
- about print-bed contact points

Size

The build volume (the amount of space available to print) of the Ultimakers in the DSC makerspace is **223 x 223 x 305mm**. Specifically, the print bed measures **223 x 223mm.** Your design will need to fit within these dimensions.

3D printing can be a slow process. While the Ultimakers are technically capable of printing an object as large as their full build volume, it would take a prohibitive amount of time. The following are a list of estimated print-times (using the makerspace's default settings) that should help guide your design:

Object	Estimated print time (Ultimaker)
 Golf ball	1 hour and 30 minutes
 Baseball  Cricket ball	6 hours and 30 minutes

 Human skull	32 hours

Modularity

If your design will be too large for the printer's build volume, you may want to consider modularity which involves printing the model in separate parts, combining them to make up the complete model (Krishnan). This can be done after the model is designed, but you may want to design with this in mind.

Unit conversion

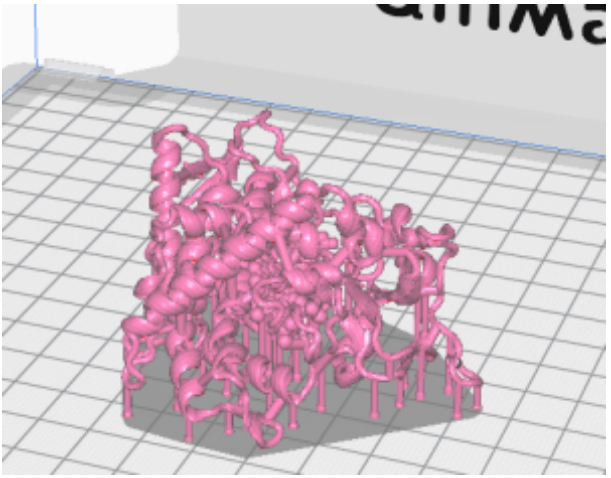
The Ultimaker printers and their accompanying software (Cura) use the metric system of measurement. If at all possible, we suggest that you design your model using millimetres rather than inches. In some cases, designing in inches can result in a much larger than expected

finished product. If designing in mm is not possible, you may need to adjust the model's size to accommodate.

Fine Details

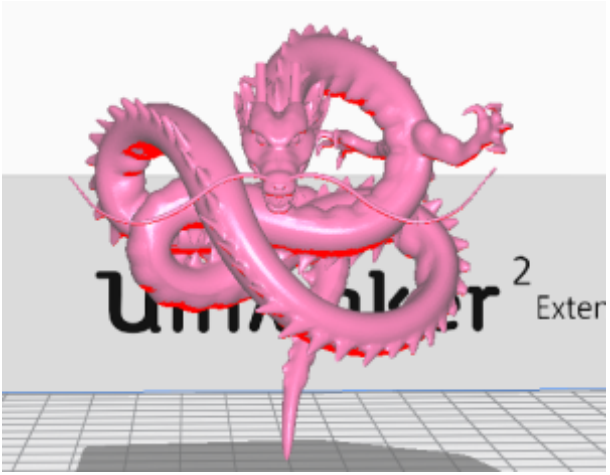
Fine detailing on a 3D model can be tricky to print with the Ultimaker printers. Because the printer creates its models by heating up plastic and spitting it out of a small hole in the extruder's nozzle, the level of detail is limited by the diameter of the nozzle's hole (Carolo).

Here are some examples of models that will probably not print very well using the Ultimaker printers:



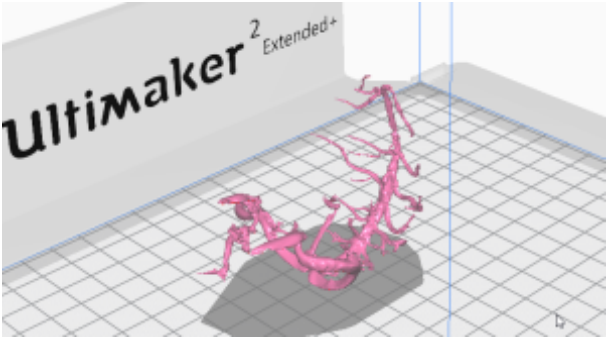
A design of a cytochrome (sokamarintchak). This is an example of a design that might be difficult to print using the Ultimaker printers.

(https://www.thingiverse.com/thing:1540639)



A design of a dragon (rubaxx). This design might prove difficult to print using the Ultimaker printers

(https://www.thingiverse.com/thing:3077771)



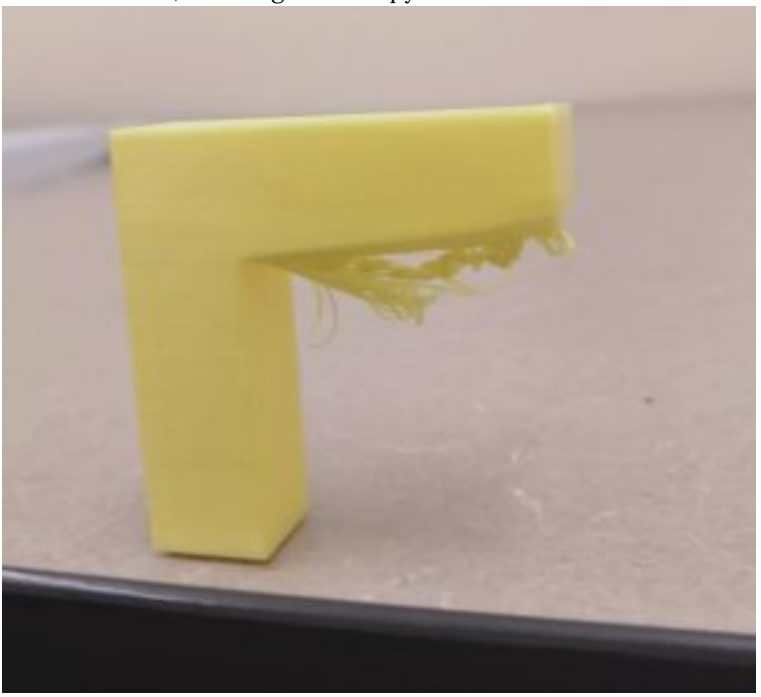
A sinus vein (hyla). The fine detail might be difficult for the Ultimaker to print.

https://www.thingiverse.com/thing:150173

Overhangs and supports

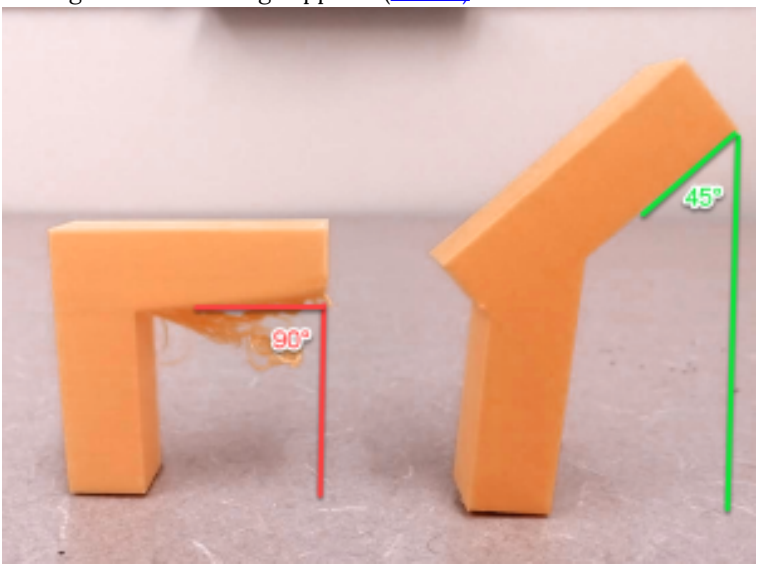
As mentioned in an earlier chapter, most of the 3D printers in our makerspace create physical models by laying down thin strips of melted plastic (filament), one layer at a time, to create a finished model.

If the machine attempts to print a line of filament in a place where there isn't a printed a line of filament to support it, the printer will print into mid-air, resulting in a droopy mess.



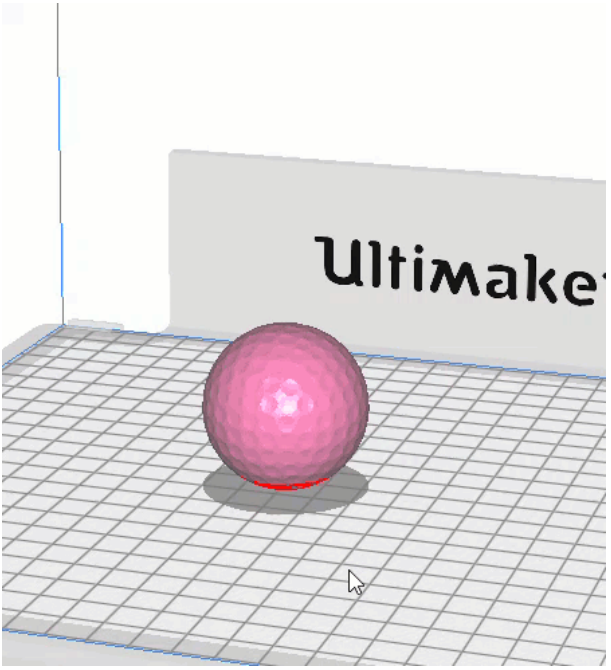
To protect against droopy messes, 3D printing software can generate supportive material (called supports) that can be easily removed after printing. These supports are generated by the 3D printing software; you should not have to design supporting material into your model. More on how to generate supports for your model in the following chapter.

As a general rule, 3D printers should be able to print a 45 degree overhang without needing supports (Kondo).



Bed Contact

The success of your printed design could depend on the reliability of the model's bed contact. The smaller the point of contact between the design and the print-bed, the more likely the model could topple over during printing.



The tiny pink square at the bottom of this golf ball is the only amount of this model that actually touches the bed plate.

Most 3D printing software can help accommodate small points of contact by adding material in the first few layers. The most common of these tools are called skirts and brims. We will discuss skirts and brims in the following chapter, but in the meantime, it is worth considering whether your model's point of contact on the print bed

???HP5 test: which one will need supports, which one might not print well. Etc...

10. 3D Model Design: Supports, Infill and Build Plate Adhesion

Before we demonstrate the specific steps needed to print your 3D model using Ultimaker Cura software, there are some fundamental concepts that are necessary to understand about 3D printing.

In this chapter, you will learn about

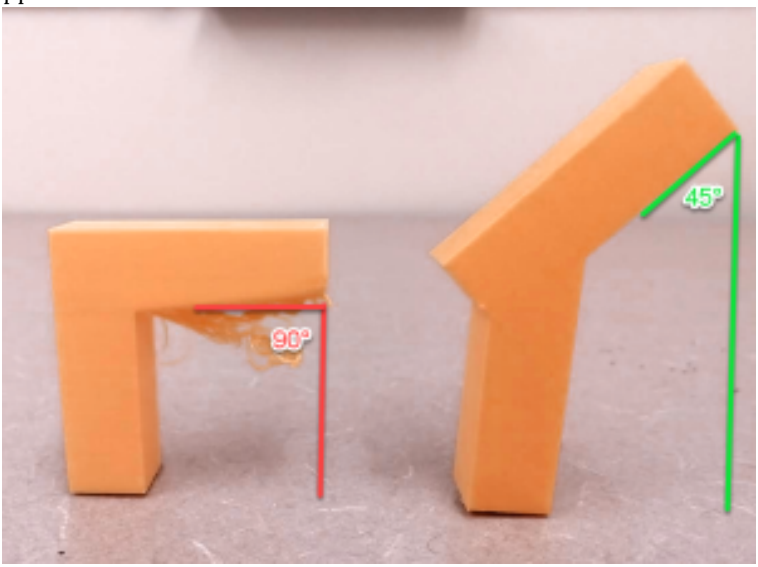
- Supports
- Infill
- Buildplate adhesion

Overhangs and supports

As mentioned in the previous chapter, if the machine attempts to print a line of filament in a place where there isn't a printed a line of filament to support it, the printer will print into mid-air, resulting in a droopy mess.

The printers in the DSC should be able to print a 45 degree overhang without needing supports. If your model has an overhang

that exceeds 45 degrees, you will want to consider enabling supports in the Ultimaker's Cura software.



To protect against droopy messes, Ultimakers's Cura software can generate supportive material (called supports) that can be easily removed after printing. These supports are generated by the 3D printing software. Supports are generated by the 3D printing software; you should not have to add supporting material into your model when designing.

> Tip: Although generating supports can be very helpful, there may be more efficient ways to print the model. Can the design be oriented in such a way that supports are not needed? Can the design be cut into multiple parts (recall modularity from the previous chapter) to eliminate the need for supports?

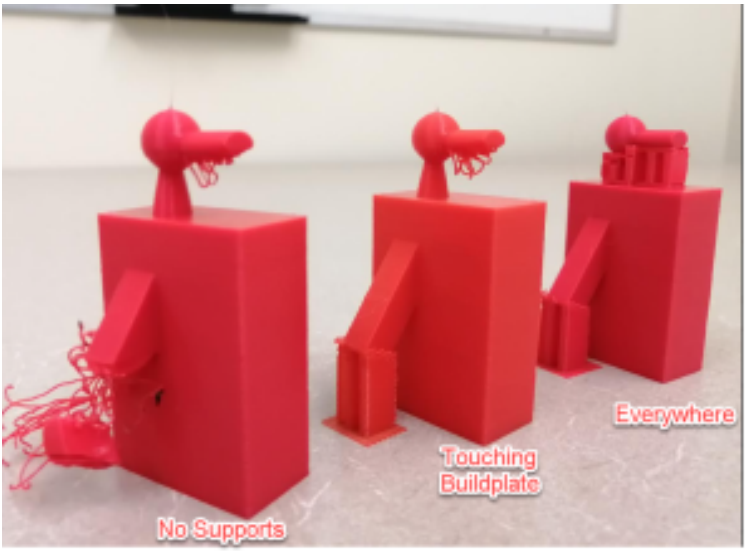
Generally speaking, the Ultimaker printers are capable of generating 2 different styles of supports, depending on the needs of the models:

1. Touching Buildplate

When “Touching Buildplate” option is selected, the printer will only create supporting material for overhangs if the supporting material can start on the print bed.

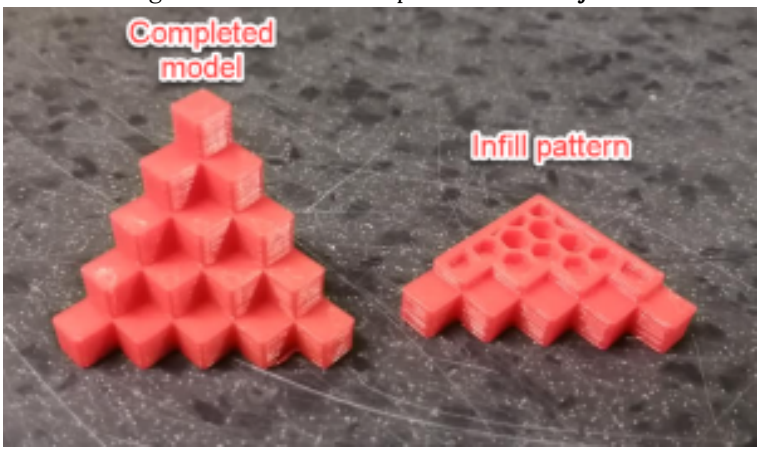
2. Everywhere

When the “everywhere” support placement option is selected, the printer will create supporting material for all overhangs, regardless if the supporting material needs to begin on the model itself.

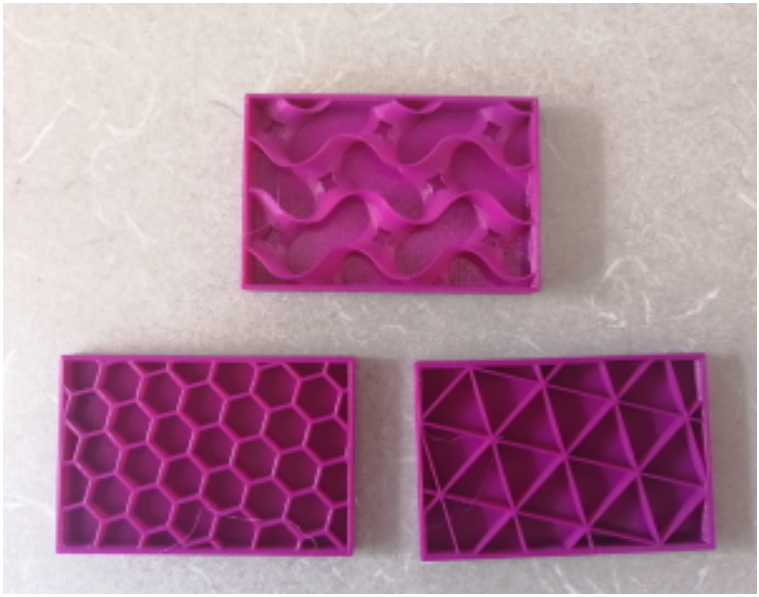


Infill

In order to save time and material, 3D printers will print the inside of a model using a resource-efficient pattern called ***infill***.

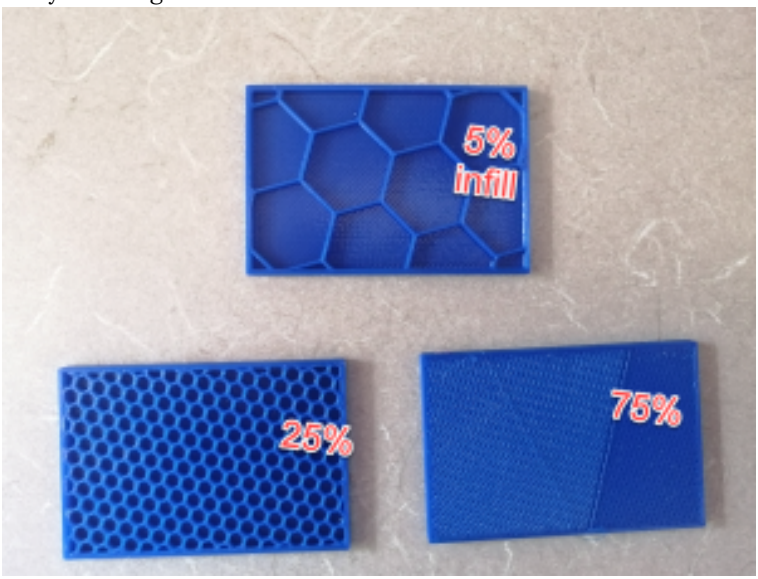


Infill can come in a variety of patterns, as seen below:



Importantly, the density of the infill can be determined during

printer set up (which will be demonstrated in the next chapter). Infill density can range from `1% to 100%.



The lower the percentage, the more blank space within the model's internal structure and the more fragile the model. The higher the percentage, the more material used to print the model's internal structure and the less fragile the model.

It may be tempting to want 100% percent infill, but you probably don't need as much infill as you think. Even printing with 5-10% infill creates a really solid, formidable model. A higher infill percentage will also take more time to print, and waste more filament than necessary.

As far as strength is concerned, increasing infill density results in diminished returns. A model with 50% infill will be 25% stronger than a model with 25% infill, but a model with 75% infill will only be 10% stronger than a model with 50% infill.

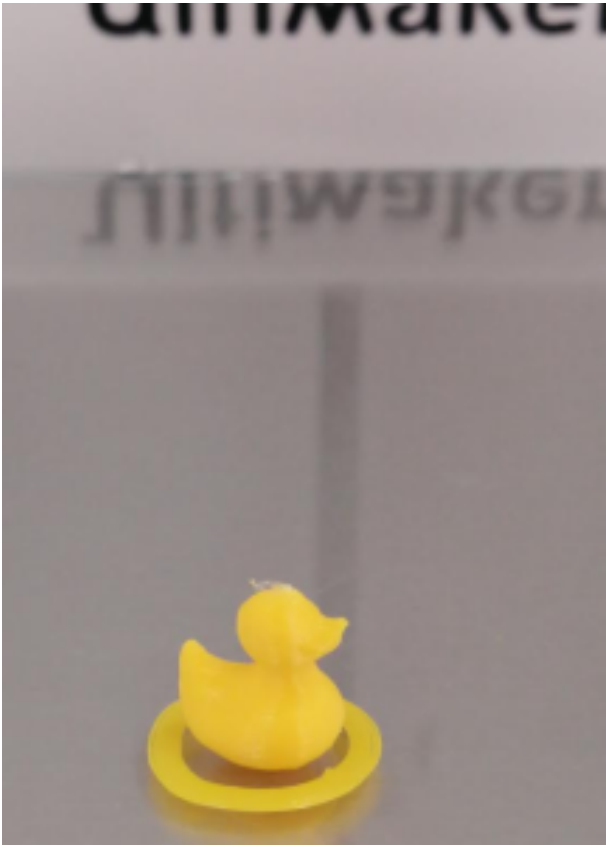
In short, we recommend using 5% infill for most projects.

Build Plate Adhesion

Depending on your design, your 3D model may need some help sticking to the print-bed. If there is no way to orient your model that provides a stable and wide contact point to the print-bed, you may have to consider one of these 3 techniques to help with the foundation of the printed model:

1. Skirt

A skirt if simply a thin row of filament that get printed around the perimeter of the model's contact point on the bed. It actually doesn't do anything towards providing foundation, but it is useful for visualizing the model's print-bed contact point and getting out any imperfections in the print head. It is also useful in priming the extruder; setting up a smooth filament extrusion and getting rid of any residual filament. This will work for most prints and is therefore the most recommended option.



Skirt

2. Brim

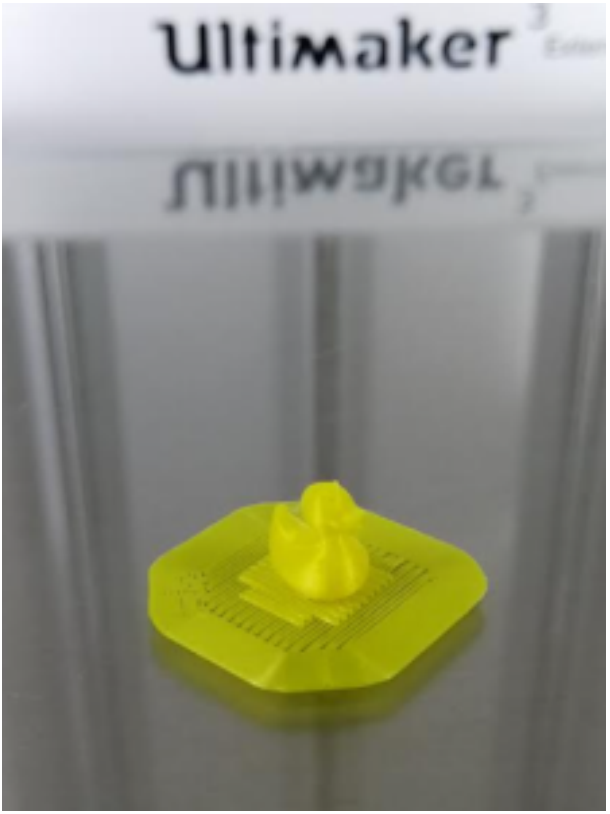
A brim is similar to a skirt, except that the perimeter continues printing concentrically until it touches the first layer of the printed object. This will give a significant foundation to a small print-bed contact point (recall the small print-bed contact point in the previous chapter).

Brim

3. Raft

A raft is a full bed of layered filament that will rest underneath your

model. The amount of layers used for a raft can vary, but the default in the DSC is 2 layers, but can be modified if needed.



raft

Have your .STL file ready

Although the makerspace computers are equipped with a variety of 3D design software, you will want to come to the makerspace with a complete .STL file of the model you wish to print. You can come with the model on a USB stick, SD card, or saved in the cloud. The

DSC will provide SD cards and USB keys to transfer files from the computer to the printers.

11. Print Setup: Using Netfabb, Cura (Ultimaker), and Preform (Formlabs)

In this chapter, you will learn

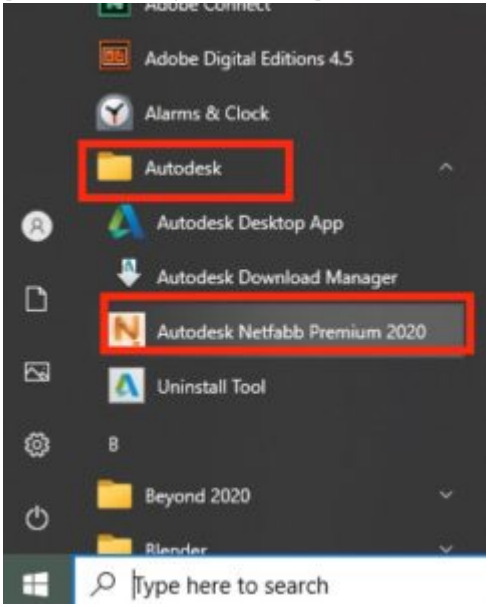
- How to repair your STL file
- How to use the Cura software to make your STL file print-ready for Ultimaker printers
    - Basic print setting
    - Custom print settings
    - Resizing and duplicating your model
- How to use the PreForm Software to print using the Formlabs printer

Repairing your .STL file (Ultimaker only)

Before loading the .STL model Ultimaker's Cura software, you will need to make sure that the model is fully manifold; this will increase the likelihood of a successful print, saving time and resources in

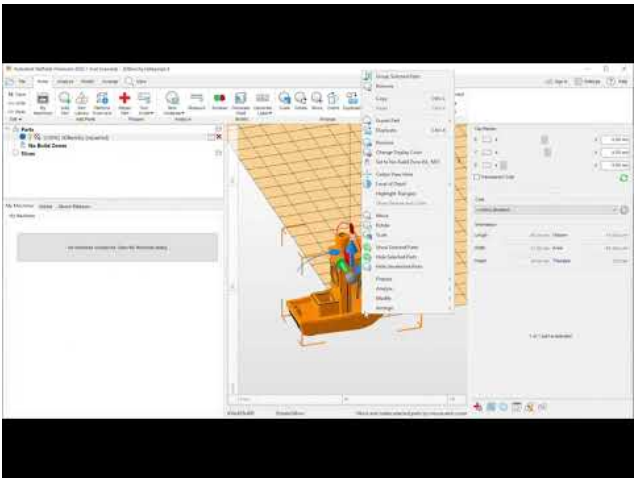
the long run. To do this, you will want to “repair” the model using Autodesk Netfabb:

1. Open the Autodesk Netfabb app (under the Autodesk application folder) on the computer workstation:



2. If prompted for a license, select “Start non-licensed version”

3. follow the steps on this video to repair the model:



A YouTube element has been excluded from this version of the text. You can view it online here: *https://openeducationalberta.ca/ualmakercertif3dprinting/?p=32*

Slicing the print job in Cura (Ultimaker only)

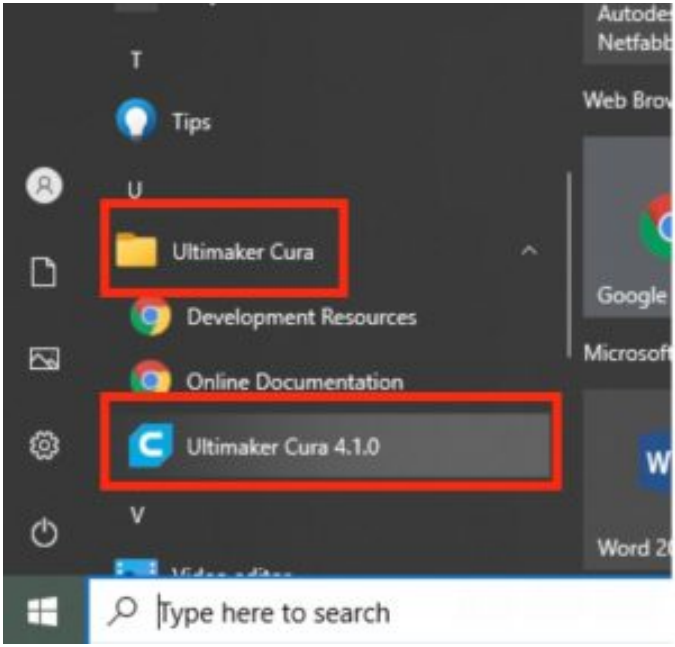
Once you have your fully repaired file, you will need to turn that .STL file into a file format that the 3D printer can read; a file of code that includes specific movements that the machine will make. The file of code is called a .**gcode** and the process of turning an .STL into a .GCODE is called ***slicing***.

To 'slice' your .STL into a .gcode, you will use **Ultimaker's Cura** software.

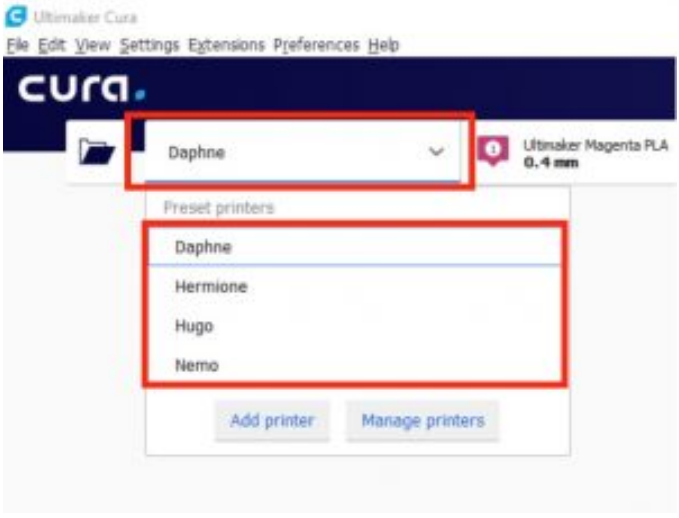
There is lots of great information on Ultimaker's webpage about how to use Cura. The version in the DSC makerspace has already been set-up to be used with the DSC printers, so you won't need

to add or manage any of the printers within the software. Furthermore, you will not need to sign in to an *Ultimaker account* or connect to *Ultimaker Cloud*.

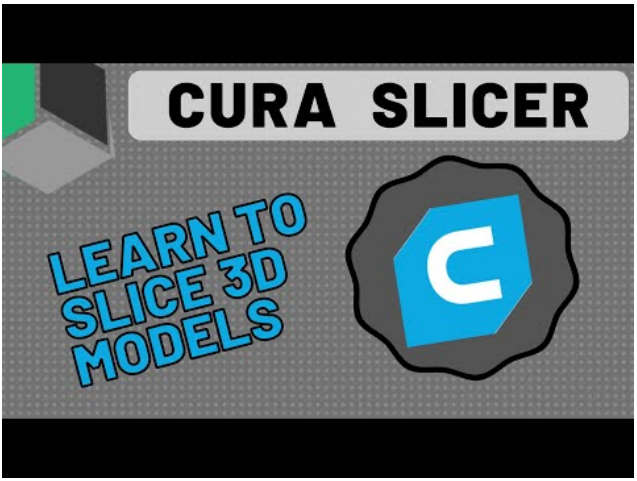
1. Open the Ultimaker Cura Software:



2. In the top left hand corner, select the printer with which you will be printing. The printer's name can be found on the top of the machine near the Ultimaker logo. This will ensure the correct .GCODE is created for your printer.



3. The video below should cover the remaining steps needed to create your model's .gcode (the video should start at 9m:42s):

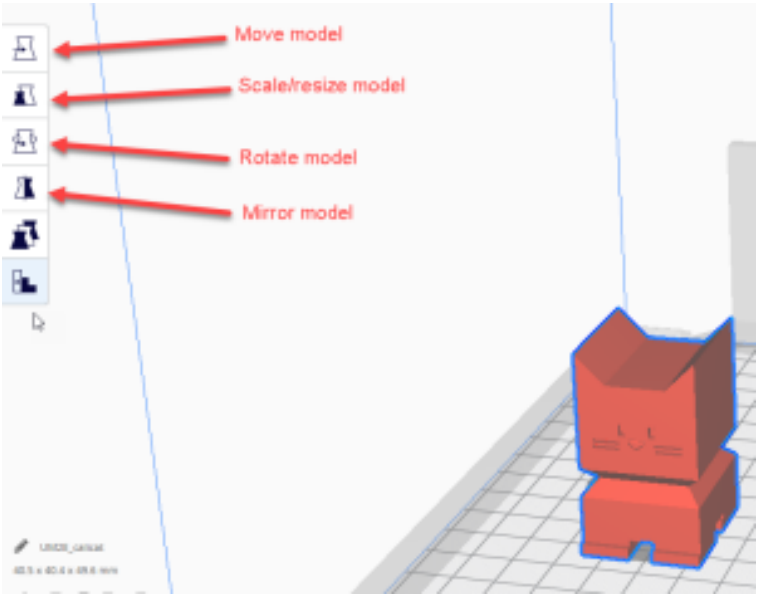


A YouTube element has been excluded from this version of the text. You can view it online here: https://openeducationalberta.ca/ualmakercertif3dprinting/?p=32

(3D Now. (2020, December 9). *[Updated] The Ultimate Beginner's Guide to Cura Slicer!* [Video]. Youtube. https://www.youtube.com/watch?v=l_wDwySm2YQ&t=582s)

Orienting, resizing and duplicating

When a design is selected, a few important and basic features become available on the left hand side of the Cura window (demonstrated at 18m 41s in the video above). Some of the more useful and basic tools are:



When these tools are toggled on (by clicking them), the model can be moved, rotated, resized, re-oriented and mirrored. When doing this, you have the option of manipulating the model manually with your mouse cursor, or by entering values. Below is an example of resizing a model by changing the percentage value:

Displaying F3CD5B8D-57AC-4F63-BD78-CA23C3C9EA8E.GIF

Furthermore, right-clicking on a model will give you access to a number of features as well, such as *multiply selected model* and *delete selected model*:

Displaying 6E6EC87B-0771-4767-97CE-594FCA665D76.GIF

LAYER BUILD!

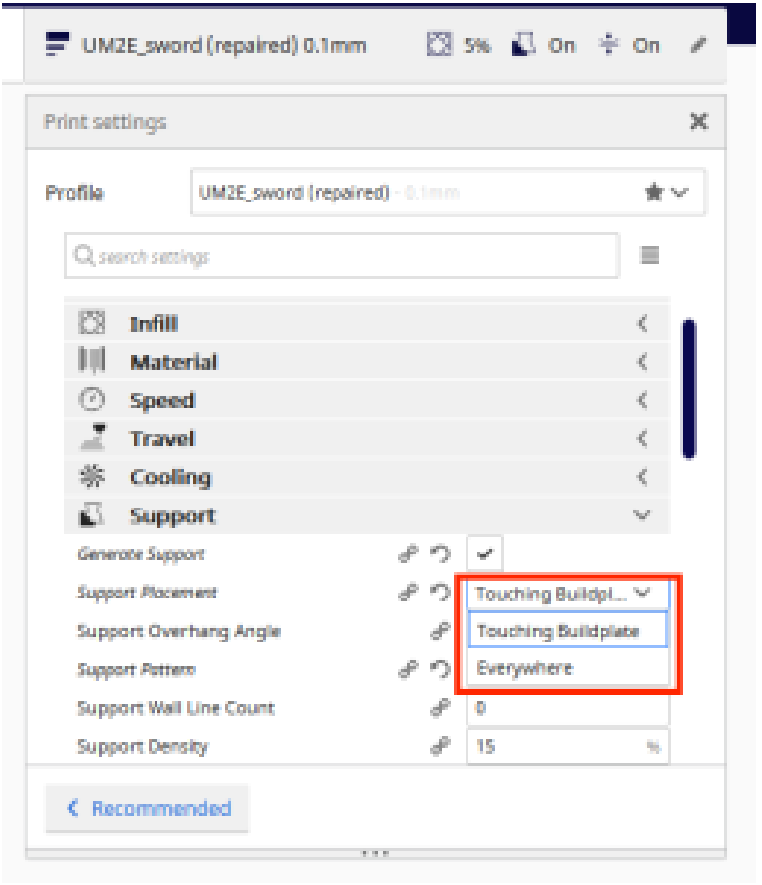
Custom Print Settings

Even for a first-time user of Cura, it may be necessary to use a few of the Custom Print Settings (14m:02s in the video above). If you hover your mouse's cursor over a setting, an information box will appear that explains the setting.

Displaying 2021-11-03_14-15-37.gif

Support

Of the many many settings that can be customized, the support setting is one that often requires attention. In Custom Settings, when the "Generate Support" box is checked on, you will be given the option to choose what type of Support Placement you would like:



For a refresher about these different types of supports (*touching buildplate* and *everywhere*), please review the previous chapter's section on overhangs and supports.

Speed

Another custom Setting that can be useful is the Speed setting.....

Build Plate Adhesion

There are a also few different options for creating solid print-bed adhesion.

Displaying Snag_61b9370b.png

Please review the differences between Skirt, Brim and Raft in the previous chapter.

H5P QUESTION:

"Using this model, what is the estimated print time after resizing it to 150% (using 5% infill and at 60mm/s speed)?

Multiple Choice:

34 mins

1hr 17 mins (CORRECT ANSWER)

4hr 23 mins

2hr 21 mins

Saving File

After clicking "Save to File" (24m:01s in the video above), use the USB/SD card hub to save the .gcode file to either a USB stick or an SD card (depending on which printer you will be using.)

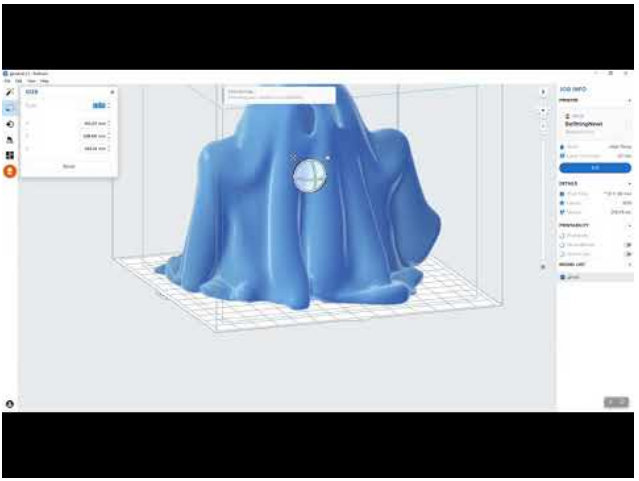
USB/SD Hub

Once the file is saved on the USB, but sure to eject the device before removing it or the file may corrupt and cause errors when printing:

Displaying 2021-11-03_14-23-51.gif

Setting up the print job in PreForm (Formlabs only)

When printing with the Formlabs Form 2, you will prepare your file using the PreForm software. Unlike the Ultimakers, the Formlabs does not require you to “repair” or slice your file before printing. The video below shows you how to use PreForm effectively:



A YouTube element has been excluded from this version of the text. You can view it online here: *https://openeducationalberta.ca/ualmakercertif3dprinting/?p=32*

PART IV

PRINTING IN THE DSC MAKERSPACE

12. Navigating the Makerspace

Learning Objectives

In this chapter, we will learn about navigating the makerspace area. We will cover:

- How and when you can come to print.
- The location and use of supplies and tools.

Info about access dates/ times/ processes [need more info on DSC plans/processes to complete this]

You will find the makerspace door is adjacent to the row of lockers when you enter the DSC. You can use the lockers to store your belongings (coat, bag etc.). Try to use lockers rather than cluttering up the makerspace work area, creating other potential hazards. You will find the devices are spread around the room and there are ample chairs to sit and computers to do your model slicing.

Be sure to check the makerspace hours on the DSC Website.

Materials and Tools

You will find that the supply cupboards are all labelled so that supplies and tools are easy to find. Photo: Hanne Pearce

The makerspace is equipped with additional filament and some paper, acrylic vinyl and wood products for the various devices as well as tools for use when operating the machines. You will find a set of white cabinets labelled with the appropriate types of supplies and tools. Only use materials you are familiar with and intended for the device you are using.

In 3D printing, some tools that come in useful include:

- tweezers for removing hot filament from the extruder or print bed.
- a scraper tool, for extracting prints from the build plate.
- glue sticks, for adding to the print bed if you are experiencing issues with filament not adhering to the build plate.
- scissors and plyer for removing printing supports.
- paper towels and cleaner for tidying up after you are done.

While there is resin available for the form labs printer, **you must use the resin tank currently installed in the machine**. If you require the use of a different coloured or type of resin, please speak to staff.

Please be courteous and share materials and tools with others. Be sure to return unused supplies and tools to where you found them.

If at any time you are experiencing difficulties with a printer and are unsure how to proceed, feel free to ask staff to assist you. If a printer is not working properly alert staff instead of trying to repair it yourself.

Enclosures

There are two enclosures in the DSC makerspace. Photo: Hanne Pearce

You will find two Ultimakers inside enclosures in the makerspace (an Ultimaker 2+ Extended and an Ultimaker 3).

Some notable enclosure features are:

- Aluminum frame
- Polycarbonate windows (shatterproof)
- Lockable handles
- Filtration system (for UFPs and VOCs)
- Flexible feet

Enclosures are currently set to cut power to the printers if the internal temperature of the enclosure reaches 50 degrees Celcius, or if the filter life has been exceeded. If you are having difficulties with enclosures, please ask staff for assistance.

Please note: You must finish your print by closing time for safety purposes.

13. Using the Ultimakers

Learning Objectives

In this chapter we will learn the basic steps of operating the Ultimaker 3D printers, including:

- Starting prints.
- Cleaning the build plate.
- How to load filament.
- How to abort and troubleshoot printing problems.

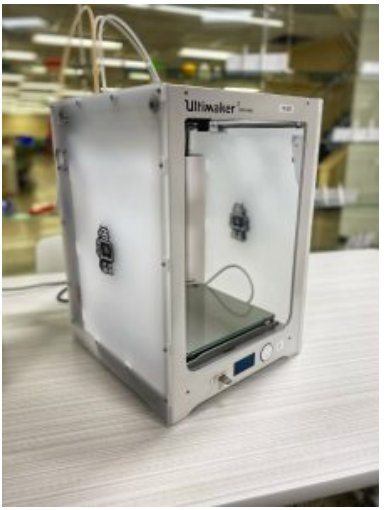


Photo: Hanne Pearce

Once you have finished slicing your model into a G-Code file using Cura, you can save it onto either the SD card or the USB designated to the printer. If you've forgotten how to create your G-Code, please refer back to **Chapter 11**

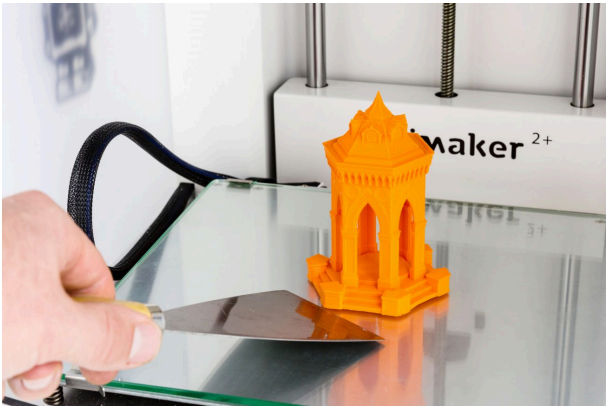
There are two different Ultimaker printers in the makerspace that can be used:

Ultimaker 2 Extended+: single PLA filament and extruder

Ultimaker 3: dual PLA filament and extruder OR single PLA filament and single PVA support filament

Printing with Ultimaker 2 Extended+

- Insert SD card into the Ultimaker slot
- Rotate the dial and click on "PRINT"
- Rotate the dial again and click on your desired file. It will begin once the print head heats up to over 200 degrees Celsius and the build plate heats up to 60 degrees Celsius; do not touch the print head or build while it is hot.
    - Use tweezers to remove any excess filament that may come out while the print head is warming up (**never use your hands**)
- Once the print is complete, wait for the build plate to cool down and then remove the object



Ultimaker. (2020). Removing the print [image]. Website: https://support.ultimaker.com/hc/en-us/articles/360011789500-Printing-with-the-Ultimaker-2-

Printing with Ultimaker 3 Extended

- Insert the USB into the Ultimaker slot
- Rotate the dial and click on “PRINT”
- Rotate the dial again and click on your desired file and the print job will begin
- Once the print is complete, wait for the build plate to cool down and then remove the object

Cleaning the Build Plate

The photo shows the clamps that keep the build plate glass in place. Photo: Hanne Pearce

It is good practice to clean the Ultimaker build plate. You can remove the glass of both the Ultimakers 2+ and the Ultimaker 3 build plates by opening the clamps that hold it in place. Only clean this build plate glass when the print bed has cooled. Once the clamps are open, slide the glass slowly out of the machine and lay it on a table. Glass cleaner and paper towels are available by the supply cupboards, this can be sprayed on the glass and dried using the paper towels. Avoid holding the glass in your hands while doing this, as the glass could easily slip out of your hands and break. Use the support of a table to do the cleaning to avoid breaking the glass and putting a machine out of use.

Once the glass is clean and dry, slide it back into the machine and move the clamps back in place so that the glass is secure.

Changing Filament

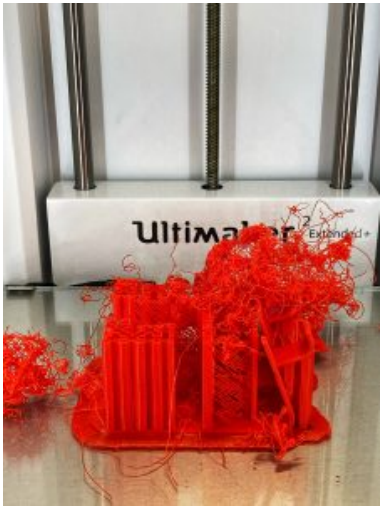
Before printing, locate the colour of filament identified when setting up the print in Cura, as this will avoid printing errors. Load it onto the specific printer you need and begin your printing. The video below illustrates how to do so/change filament on the Ultimaker 3. The same process can be used on the Ultimaker 2 Extended+.

A YouTube element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/ualmakercertif3dprinting/?p=233

[Print Your Mind 3D. (2019, May 9). How to change your filament – Ultimaker 3. https://www.youtube.com/watch?v=c2XznbVFOBs&t=1s]

Trouble Shooting

While we always hope that our prints will run smoothly, there are times when the printers experience a problem and a print fails. Here are some common issues and how you can resolve them.



Signs that your print has failed include stringy filament. Photo: Hanne Pearce

Print Job Fails and Aborting

You will likely know if your print job has failed, but clear signs that a print has failed include:

- when the filament is printing all over the place and no longer building the model.
- if part of the model has been printed incorrectly or without proper supports
- if supports fail and the print is lopsided and ruined.

When prints fail, make sure to **abort the print job**.

To abort on both the Ultimaker 2+ and Ultimaker 3: rotate the dial and select PAUSE. The printing will pause, then rotate the selection wheel and choose TUNE>>Abort. It will ask you to confirm, rotate the dial and select YES and the print will quit and begin the cool-down process.

Make sure to let the build plate cool before removing your failed print.

The filament is not adhering to the build plate

Sometimes when filament expires or goes bad it will not properly adhere to the build plate when printing the model. It is particularly important to watch your print the beginning to ensure the filament is printing properly. If you are having difficulty with filament not adhering properly:

1. Abort the job, and apply glue using a glue stick to the build plate and try printing again. Glue sticks can be found in the supplies drawers labelled 'supplies'.
2. Change the filament (see above) before reprinting.

Difficulty removing prints from the build plate

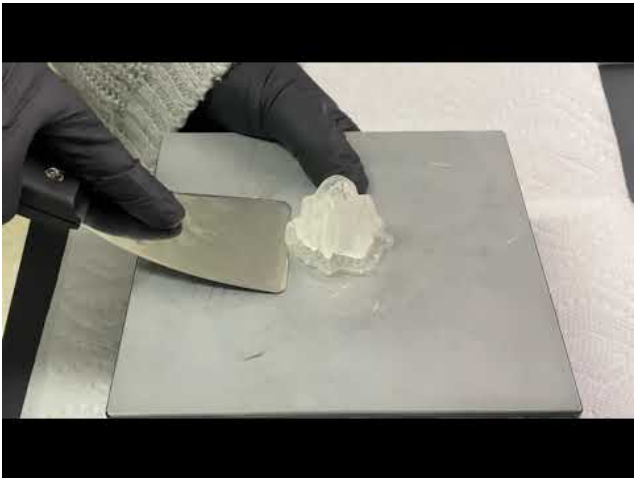
Sometimes the filament adheres really well to the build plate and it can be challenging to remove your object from the build plate without also damaging your newly printed model. Here are some suggestions on how to make this easier.

1. Always ensure the build plate has cooled. The heat change will cause the filament adhering to the plate to contract and the model will come off far easier when the glass is cold.
2. Remove the glass from the machine with the model still on the glass (see cleaning the machine above). Place the glass on a table and retrieve some glass cleaner and paper towels from the supply cupboards. Spray a bit of glass cleaner on the glass around the base of the model so that the glass cleaner can run under the model. Usually, this process releases the model.
3. If these earlier methods do not work, ask staff if they can put the build plate into the freezer for you for a little while. After a few minutes in the freezer, the warming and cooling process should cause the filament adhering to the plate to contract

enough for the model to be released.

14. Using the Formlabs

If you are using the Formlabs Form 2 to print your model, be aware that it involves more after-print steps than the Ultimakers. For more detailed instructions, please watch the following video.



A YouTube element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/ualmakercertif3dprinting/?p=229

Printing

Before you use the Formlabs, make sure all its components are in place: the resin tank, the printing platform, and the resin tray. After turning on the printer using the front button, open Preform on one of the makerspace stations. Make the necessary adjustments (size,

supports) and send the file to the Formlabs. Push the front button once again to launch the printing process. The Formlabs will heat up before starting the print. It will also give you a time estimate of the process.

Washing

Wearing gloves, turn on the washing station and press OPEN. Open the Formlabs, unlock the printing platform and carefully slide it out. Flip it up to avoid resin drips and hook it in position in the washing station. Select SLEEP, then set a timer for the washing process. Once the washing step is over, the lid will automatically open. Unlock the platform, flip it once again, and set it aside. Allow your print to dry for at least 30 minutes before the next step.

Curing

Once the 30 minute period is over, remove the print from the platform using the scrapper. Carefully remove the supports. NOTE: your print will be fragile. Take your time and make sure to be gentle. Turn on the curing station. Place your print on the plateau, close the lid, and set the appropriate curing time and temperature. Once the process is over, you can take your print out of the station.

15. Final Steps

Final steps towards 3D printing certification

Two steps remain before your certification is complete.

1. Please complete the following quiz related to information provided throughout this book. You must get 100% to pass, but you can take it multiple times. [INSERT QUIZ]
2. Once you've completed the above quiz, please register for a 30 minute in-person training session for a hands-on review of the 3D printers in the Digital Scholarship Centre (DSC). Information on these sessions and registration can be found here: [INSERT REGISTRATION LINK]

Once you complete the steps above, you are welcome to use the makerspace in the DSC, following guidelines for accessing the space as indicated here [INSERT ACCESS GUIDELINES HERE].

If you are interested in other makerspaces or sites of innovation on campus at the University of Alberta, consider checking out:

- The Elko Engineering Garage
- eHub
- Student Innovation Centre
- The Pod

Alternatively, on the main floor of Cameron Library, we do offer a mediated service to assist students with 3D printing. This service is free to University of Alberta students, faculty and staff wanting to print a 3D object for educational purposes. This may include models for an assignment, research instruments, prototypes, creative designs or other objects.

Please visit our 3D Printing page for further information. If you have any questions concerning this service, please email us at: **make.library@ualberta.ca**

This is where you can add appendices or other back matter.