

Intro to 3D Printing

3D printing is a process of additive manufacture, this is where layers upon layers of material are built up to create a three dimensional object from a digital design.

The 3D printer at MPL (and most commercially available 3D printers) use fused deposition modeling technology to create objects. FDM is where plastic filament or thread is unspooled from a coil and fed into motor that which then pushes it through a heated extrusion nozzle. Think of it like a glue gun, the hot plastic comes out and fuses to the layer below it. The layers are slowly built up until an object is formed. The way the form comes together is controlled by the design file. When your file is processed it is sliced up into flat, thin readable layers. With each new layer the build plate lowers a tiny bit creating space for the new layer to be added on.

FDM stands for: **F** **D** **M**

Anatomy of the Printer





Draw a line from the corresponding part to where it is located on the 3D printer.

- Touch screen
- Printer Jets
- Filament Cartridge
- Print Pad
- USB



Safety While Printing

Match the safety symbols with what they mean and the areas of the printer which they apply to.

	PRINT JETS	MAY CAUSE PERSONAL INJURY	
SHOCK HAZARD			INTERNAL ELECTRONIC COMPONENTS
	PINCH POINT HAZARD		
PRINT PAD	HOT SURFACE HAZARD	CAUTION	
	PRINTER CHAMBER HEATER	MOVING PARTS	

Material Safety Data Sheets (MSDS) detail any hazards that could be associated with the materials used while printing.

Select all that are true. The Markham Public Library provides MSDS for the following items associated with the 3D Printers.

- | | | | |
|--------------------------------------|---|--------------------------------------|--------------------------------------|
| <input type="checkbox"/> Hot Water | <input type="checkbox"/> CubeStick Glue | <input type="checkbox"/> Sandpaper | <input type="checkbox"/> Print Jets |
| <input type="checkbox"/> ABS Plastic | <input type="checkbox"/> Build Plate | <input type="checkbox"/> PLA Plastic | <input type="checkbox"/> Electronics |

Design Options

Here is a list of the free 3D design software:



Autodesk 123D Design
Easy-to-use yet powerful modeling tool with library of existing components or the ability to create from scratch. Also available for the iPad.
Windows, Mac, Online Service



Blender
A powerful application with full-fledged professional tools, Blender has a wide community and resources to help you learn.
Windows, Mac, Linux



Tinkercad
A fantastic beginner program, that leads you to learn complex things through simple quests. Runs right in your browser, and the skills you learn are easily transferable to more advanced programs.
Online Service



FreeCAD
An open source parametric 3D modeler, great for both the home user, hobbyist and experienced designer. Parametric modeling allows for easy editing of your design.
Windows, Mac, Linux



Sculptris
A free, introductory digital sculpting tool, a great stepping stone for digital sculptors, created by the makers of Zbrush.
Windows, Mac



3D Model To Print
A cloud-based software service, focused on 3D architectural models. 3DMTP automatically and efficiently transforms 3D designs into scalable and 3D printable model files.
Online Service



3D Tin
Another browser based program using WebGL, this is free as long as you share your designs under Creative Commons.
Online Service



Open SCAD
OpenSCAD is not an interactive 3D design tool. It is something like a programmatic 3D-compiler that reads a script file containing 3D geometry definitions, and in turn generates a solid 3D model as output.
Windows, Mac, Linux, BSD



Sketchup
Drawing-based tool for architects, designers, builders, makers and engineers who design for the physical world. SketchUp Make is a free version and SketchUp Pro is a paid version with additional functionality.
Windows, Mac



And here is a list of sites to download files from:



Cults
A French community and marketplace where modelers can share or sell their designs, Cults has a collection of high quality models you can download.



Instructables.com
Instructables is the DIY projects repository that doesn't really need to be presented. Many 3D printing projects are available. Instructions come with .stl files.

PREMADE 3D DIGITAL DESIGNS



Autodesk 123D
Autodesk 123D is a suite of computer aided design (CAD) and 3D modeling tools aimed specifically at hobbyists. Along with the suite of tools, Autodesk also has a website where users can upload their creations and share it with other users.



GrabCAD
Grab CAD is the biggest free 3D models repository. But without a "3D printing" filter, it's really hard to know which designs are ready for 3D print.



Thingiverse
MakerBot's Thingiverse is a thriving design community for discovering, making, and sharing 3D printable things. It's the worlds largest 3D printing community.



YouMagine
Similar to Thingiverse, YouMagine is a community website run by a 3D printer company. This one is run by the open source 3D printer company Ultimaker.



Pinshape.com
Pinshapes goal is to make 3D printing simple and fun. It will engage both makers and designers of any experience level.



Fabster
Born out of a Facebook group, Fabster is mainly a platform to show what can be done with 3D printing. The site has a great selection of 3D-printed jewelry and accessories.



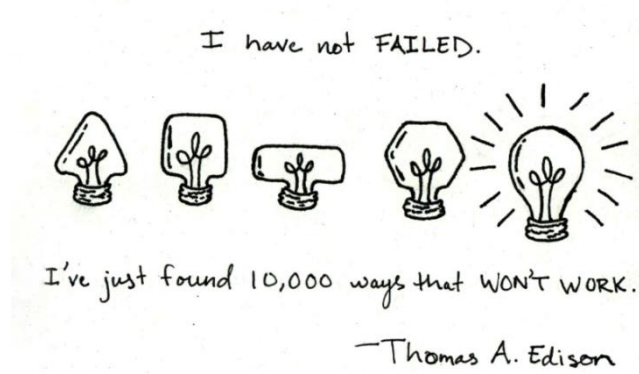
Mini Factory
My Mini Factory is the 3D model repository managed by iMakr. The site contains 3D models designed by professionals and all uploaded designs are tested for quality.



Bld3r.com
Billing itself as a 3D Printing Social Network, Bld3r is a thriving community of makers who like to feature their creations. Users vote on the best creations, so popular creations rise to the top and get better exposure.



FAIL
[F] FIRST
[A] ATTEMPT
[I] IN
[L] LEARNING



Things to Think About when Selecting/Creating a Design

Copyright & Intellectual Property

See the Government of Canada Canadian Intellectual Property Office website for more information including the Canadian Copyright Act. Additionally, see the Creative Commons website for information on how their licensing and reuse permissions work.

Design Settings Matter

Not all the designs you download will print properly. Even when it is an object that you have found online and have seen other printed examples of. Details such as number of microns, fill percentage, supports used, raft, sidewalk or even the type of printer can contribute to the success or failure of a print.

Consumer Product Safety

The Consumer Product Safety Act of Canada can provide you with the regulations required to ensure that your product is safe. You can visit the Health Canada about Consumer Product Safety website for more information.

Printing Food Safe Items

Currently the Markham Public Library only offers printing in ABS plastic. ABS plastic should not be used with food as it is not BPA-free. It is recommended that 3D printed items be used for display or prototype only.

Printing Weapons

See the Government of Canada Department of Justice website for the Canadian Criminal Code and the Canadian Firearms Act in respect to what is prohibited under Canadian Law. Additionally, we ask that you respect the Markham Public Library Customer Service promise found on our website and act with civic responsibility.

.STL

.stl is the only file format that can be converted using the CubePro software. You cannot design objects using the CubePro software only convert .stl files into .cubepro files.

Supports

Supports are required for any part that has an overhang. The rule of thumb is anything with a 45 degree angle or greater will require a support. If you do not add a support and one is needed your project will a best droop and at worst fail completely.

Raft or Sidewalk

A raft is a mesh that your object is built on top of. A sidewalk runs around the outside of your object and helps keep the corners sharp. Both options help anchor small parts to the build plate and help to stop edge curling/shrinkage.

CubePro Software

The CubePro software can be found in the CAVE (Creative Audio Visual Experience) digital media lab at the Cornell Library or you can download it yourself at <http://www.3dsystems.com/shop/cubepro/activate> just scroll to the bottom of the page and look under Software.

You can also go through an online CubePro Software walkthrough here: <http://infocenter.3dsystems.com/cubepro/user-guide/cubepro-software>

1. Launch the CubePro Software

Select the **CubePro** icon on the desktop.

2. Open Model

Select the **Open Model** button on the **Home** tab, this will launch a pop-up window. Select your .stl from you downloads folder or from your USB, then select **OK**. Your object should appear on the stage which is a digital representation of the build plate.

File Error

If you get the message '**3D Verify has determined that your STL file is bad, do you want to open and continue with the 3D Verify fixed STL file?**'

Simply select **OK**.

This will save a new 'fixed' copy of your STL file in the same folder as the original. The fixed file will have a **_v** and the end of it. For example if the file is called: LabradorLowPoly.stl the fixed file will be LabradorLowPoly_v.stl

Size Issue

You may also get the message 'Open file in mm?' Select **OK**. You can always change the size of your file later by selecting the 'to inch' option under **Scale Geometry**.

3. View Your Model

Select the **View** tab. View your object from different perspective by selecting the **Top View, Left View, Right View** and **Front View** buttons. You can also zoom in and out by selecting the **Zoom In** or **Zoom Out** buttons. You can also manually manipulate the digital stage by clicking the left mouse button and holding as you move the cursor around the screen.

Tip

Make sure your object is sitting flat on the build plate if not you will require supports which can be added after you select Build button. You can also change your object's placement using the Move Geometry or Rotate Geometry tools.

4. Move Geometry

This will change the placement of your object on the stage. Select the **Home** tab, then in the Move Geometry section of the tools ribbon select **Move Model**. This will allow you to drop and drag your object to another spot on the stage. You can also use the **Move X** and **Move Y** buttons, change the number to negative to move your object in the opposite direction. A red square will appear when your object is outside of the build area.

Tip

Make sure you deselect the button after you have made your changes.

5. Rotate Geometry

This will change the rotation of your object on the stage. Sometimes an object will import incorrectly and not be sitting flat on the build plate and a simple rotation will correct this issue. Select your model and then select the rotate **X°**, **Y°** or **Z°** button. Select **Revert** to rotate your object back into the original position. Make sure to deselect your object once your rotation changes are complete.

Tip

You cannot lower an object to the build plate if it is not sitting flat. You would need to add supports under it.



6. Set Colours – Printer Configuration

In order to set the colours to print go to the **Settings** tab and select the **Printer Configuration** button. A pop-up window will appear with a number of options. If you are printing in one colour only, please set up both jets but make sure that the colour you want to print in is in Print Jet 1.

Printer Type	Cubepro
Nylon Options	Leave this box unchecked as MPL currently does not offer nylon printing.
Print Jets	2
Print Jet 1 Material	Use the drop down menu to select the print jet material and colour. Currently, MPL only offers ABS printing so it should always say ABS before the colour. Check with library staff to see what colours are currently available for printing.
Print Jet 2 Material	

Tip

Make a note of your settings. Library staff will set up the printer cartridges in advance, you will need to let them know what colour you selected for Print Jet 1 and Print Jet 2.

7. Pick Colour

Go to the **Home** tab, the **Pick Colour** circles will now reflect the printer configuration you have made. Select your colour, then select your item, then deselect your colour.

Tip

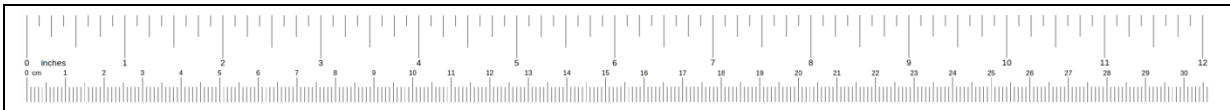
If you wish to print an object with multiple colours you must set this up during the design stage of your object. Colour is associated with the shell layers of your design and therefore multiple colour prints should have multiple shell layers. One layer means one colour only.

8. Build

Once your changes are complete select the **Build** button, this will launch a pop-up window.

9. Build – Print Mode

Set your **Print Mode**, from the drop down menu select **Premium**, **Standard**, **Draft** or **Custom**. The settings for these modes will be displayed in the sections for **Print Quality**, **Print Strength** and **Print Pattern**.



Layer resolution is measured in microns (μm). A micron or a micrometre is the term for one millionth of a metre, which is one thousandth of a millimetre and is equivalent to roughly 0.000039 inches. $1\text{mm} = 1000$ microns

10. Build – Raft and Support

Decide whether you would like to add a raft, supports or a sidewalk to your item. Use the drop down menus to select **None** or the colour in which these structures will be printed in.

11. Build

Once you have all of your options set select the **Build** button at the bottom of the pop-up window.

12. Save your File

Save your file to a USB. The file should not be in a folder as it will not be able to be located by the Cubepro printer. We recommend saving your file with a recognizable file name as you may try to convert it several in order to change the estimated print time, etc. Save File As: Name Jet 1 Colour Jet 2 Colour Print Mode Supports.

Example: Dog Black White Standard Raft

Select the **Save** button when done.

13. Time

Once your file is converted you will see the estimated print time appear on the screen. Please make a note of this as you will need to provide the estimated time when you book the printer.

Note

At this point you may want to go back in and try converting your file with various settings as to impact the time it takes to print, etc. Just remember that if you are saving multiple prints you need to remember which one will be your final.

14. The Build Progress pop-up window will ask you if you want to ‘Replace the model file with the generated build file’, we recommend that you always look at the generated build file to determine if your file will print correctly. Select ‘Yes’ and you will see your converted file on the screen. This is how your file will print. If it looks solid then your file will print correctly but if this file looks thin and you can see areas where the build plate shows through then your file will print this way. To repair this type of issue you need to improve the shell layer of your .stl file.



Unfortunately, MPL does not provide 3D design support. Changes required to the digital design file in order to improve the quality of the 3D print are the responsibility of the customer. We recommend taking the tutorials provided by both the free and commercial 3D design software to assist you in developing your 3D design skills.

- 15. When printing one colour with only one print jet we recommend saving your file twice, once with it set up to print from Jet 1 and once with it set up to print from Jet 2. This will give you a back-up option if Jet 1 of the 3D printer is not functioning correctly.

Book the Printer

Visit the library branch or call to book the 3D printer. Walk-in appointments are welcome provided there are no prior reservations. Maximum 4 hours per print job but you can special request longer time slots when required. No overnight printing, all print jobs should be estimated to end a half hour before close of the library. Please provide your library card number when booking the printer so staff can confirm that you are certified to use the 3D printer.

When booking the printer you will need to let staff know the following information:

Colour in Print Jet 1: _____

Colour in Print Jet 2: _____

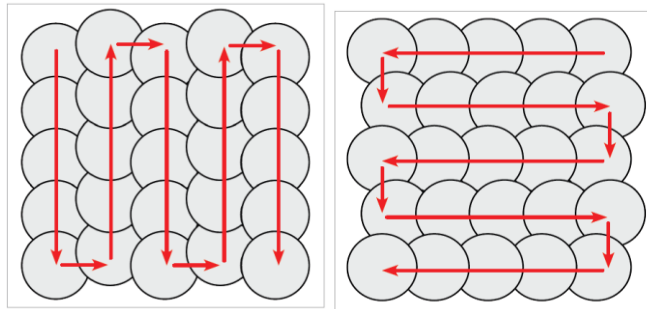
Estimated Print Time: _____

Get Printing

At the time of your printing appointment bring your USB with both your .stl and your .cubepro file on it. Go to the information desk and let the library staff know that you are here for your 3D printer appointment. They will direct you to the printer set-up for you and walk you through the printing process.

Printing Process

1. Plug your USB into the printer.
2. Touch the touch screen to start.
3. Select the Print icon on the touch screen.
4. Find your file by scrolling through your USB using the touch screen arrows, select the PRINT button on the bottom of the touch screen.
5. Wait for the printer to lift and then lower the print plate. Open the door once the print plate stops moving and apply the glue in the following pattern:



Apply the glue in 2 layers, firstly in small circular motions moving from front to back and then in small circular motions moving from left to right. You only need to apply glue in an area slightly larger than the area of your object. Close the printer door and select the checkmark at the bottom of the touch screen when you are finished.

6. The printer will now process the file and begin printing.

If at any time during the printing process if your print goes awry staff will cancel the print job and make note of the time. You will be charged only for the print time used.

7. Please return approximately 15 minutes before your print job is estimated to be complete. Prints can run under or over time.
8. Once your print is complete, the completed print time will be displayed on the touch screen. Take note of the completed print time as it will indicate your final print payment required.
9. Get a library staff member to unlock the printer door and record the completed print time.
10. Pay for your print job.
11. Select the checkmark button on the touch screen so that the printer begins the cool down process.
12. Remove the print plate after allowing for it to cool. Take it, along with the scraper to the sink on the 2nd floor in the fireside lounge area.
13. Run the print plate and your object under hot water. Run the water until the glue is fully dissolved and the object releases from the plate. Use the scraper to gently prod your object or lift the edge so the water can get to the glue beneath it.

Be careful when using the scraper. Always keep your hands behind the scraper, do not use excess force. Only use the scraper to pry underneath your object so the water can get to the glue.

14. Once your object is released dry the print plate and return it to the printer or library staff.

3D Certification Quiz

The last step of the 3D Printing Certification process is to complete the 3D Printing Certification Quiz which can be found on both the MPL website and our CAVE blog.

The Cave Blog can be found here: <http://thecavemarkham.blogspot.ca>

Once you have completed the 3D Printing Certification Quiz you can print out your certificate and present it to a library staff member at the Cornell Library branch to have the updated certification information added to your account.