Introduction to 3D Printing at Toronto Public Library

What Will I Learn in This Course?

Over the next 60 minutes, you will learn sequentially:

1. The basics of 3D Printing.
2. How and where you can 3D Print at TPL.
3. The 3D Printing process.
4. How to use Cura software to prepare a 3D file for printing.

Navigation

When taking the online module, you can:

- Use the speaker button in the bottom left of the screen to adjust the volume.
- Use the closed captions button to display captions when a video is playing. This button will appear on the far left of your screen when the slide contains a video.

Who is this Course For?

- This course is for anyone who would like an introduction to 3D Printing at TPL.
- TPL staff developed this course to make it easier for you to print 3D objects at the library. Basic keyboarding and Internet skills are

required to complete the online course. You can take this course as many times as you want!

Course Information

- The online module includes videos and interactive activities.
- To access these, you will require access to a computer with sound, as well as an Internet connection.
- Each section concludes with interactive quiz questions (don't worry, they're just for fun!)
- This course is intended for information purposes only. There is no certificate of completion at the end.

3D Printing Basics

This section includes:

1. 3D Printing Definition.
2. Historical milestones.
3. Examples of what can be 3D Printed.

Definition of 3D Printing

3D Printing is the action or process of making three dimensional solid objects from a digital file.

Some Examples of 3D Printed Objects

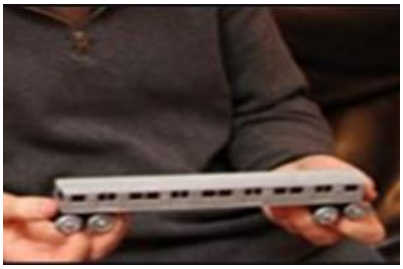
The Library's 3D printers allow you to print a variety of objects - toys, jewelry, phone cases, replacement parts for broken equipment and much more!

Here are some examples of items that have been 3D printed at TPL's Digital Innovation Hubs:

- A pair of U of T students designed their own robot arm using a 3D printer and Arduino (a microcontroller) at one of the Digital Innovation Hubs.

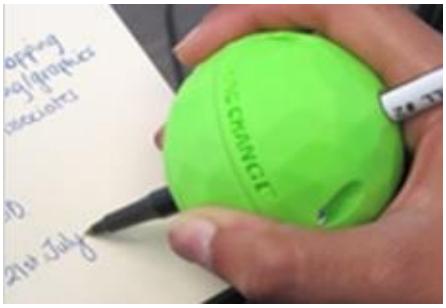
- A prototype of a 3D Printed watch.

- A 3D Printed train replica.

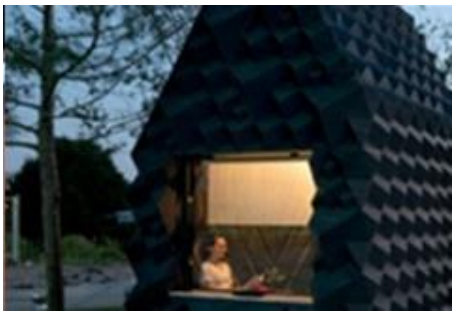


Here are some examples of the many world-changing applications using 3D printing technology:

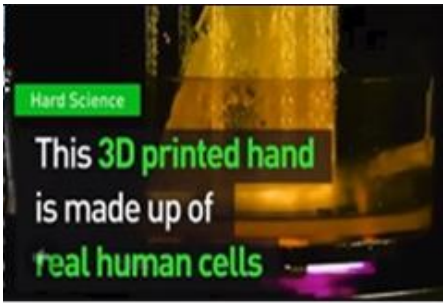
- 3D Printed assistive device used for writing.



- A 3D Printed House.



- 3D printing for the manufacturing of artificial organs has been a major topic of study in biological engineering.



3D Printing: A History

Timeline

Here are some 3D Printing Milestones:

- **1984:** Charles W. (Chuck) Hull invented the first form of 3D printing: Stereolithography. Stereolithography is the origin of the STL file format.
- **1992:** Fused Deposition Modeling (FDM), or Fused Filament Fabrication (FFF) process was granted a patent. FDM is the most common 3D Printing technology and is used by the printers at TPL.

- **2004-2007:** Open-source, self-replicating 3D printers emerged during this time, such as the RepRap project.
- **2008:** The first usable prosthetic limb printed.
- **2009:** Patents for FDM process expire trigging a drastic drop in the price and availability of consumer 3D printers.
- **2014:** TPL introduces 3D Printing at the Library in our first Digital Innovation Hub at TRL.

Quiz Questions: Let's Test Your Knowledge

1. **Question: What year did TPL get its first 3D Printer?**

Please choose one of the following answers:

a) 1984.

b) 2005.

c) 2019.

d) 2014.

Answer: d) TPL got its first 3D Printer in 2014.

2. **Question: Which of the following objects has been 3D printed at TPL?**

Please choose one of the following answers:

a) Pizza.

b) A robot arm.

c) Metal tools.

d) None of the above.

Answer: b) A robot arm.

3D Printing at TPL

In this section you will learn:

- Learn how you can design and print 3D objects at TPL.
- Learn the policies and procedures for 3D Printing at TPL.

Digital Innovation Hubs

Free access to technology, software & classes:

- There are eight Digital Innovation Hubs at the Toronto Public Library.
- These spaces are equipped with tools, creative software and dedicated staff to support digital creativity.
- You can access 3D printers and software to design and print your own objects.
- Please visit our website for more information.

Pop-up Learning Labs

Pop-Up Learning Labs are mobile equipment kits that bring new technologies and deliver programs on topics such as 3D design to branches across the city. Find a Pop-Up Learning Lab near you.

How to Book a 3D Printer

- Reserve a 3D Printer at one of our Digital Innovation Hubs by calling a branch directly.
- 3D Printers are also available on a first-come, first-served basis during library open hours at the eight Digital Innovation Hubs.
- A maximum of two hours is allowed for most print jobs.
- A dedicated printer is available for longer prints at all locations. You can make one booking every three days for these printers.
- A Toronto Public Library card is required.

Learning Centres

TPL also offers access to 3D Design software and the Adobe Creative Cloud Suite in 8 of our Learning Centres. You may Reserve a Computer online to work independently on your design. These spaces are not staffed but many of our eLearning resources, such as Lynda.com and Safari, include tutorials and courses on 3D Design and the Adobe products.

3D Printing Rules

Please remember:

- Printing items that contravene the library's Rules of Conduct is not allowed.

- Do not infringe on any person's intellectual property rights, including copyright, trademarks and patents, or any other rights, including privacy and publicity rights, when using the 3D Printer and other equipment and software at Digital Innovation Hubs.

Printing Costs:

A fee of $0.10 per one gram of filament (printing material) is charged for each print job. An average print job is about ten grams and costs $1. There is a minimum charge of $0.10 per print and 13% tax is applied.

Meet our 3D Printers – Video Transcript

The Toronto Public Library offers 3D printing in our Digital Innovation Hubs located at some of our branches across the city. We offer three different models of 3D printers: The LulzBot TAZ, the Maker Bot Replicator 2 and the Ultimaker 2 Plus.

The availability of printer models differs at each location. All of our printers use a process called fused filament fabrication. This process creates 3D objects using a continuous stream of thermoplastic filament. At TPL, we only use filament made of polylactic acid or PLA for short PLA is a biodegradable

type of plastic that is manufactured using plant-based resources such as corn starch or sugar cane.

It produces low emissions while printing and has been deemed safe to use indoors. The filament is fed from a spool, through a moving printer head that has been heated to over 200 degrees Celsius.

The printer head is also referred to as an extruder. As the filament moves through the heated extruder, it melts and is pushed up a nozzle onto the printer's build plate. Moving side to side, the extruder deposits one horizontal line of melted plastic at a time, these lines quickly harden and fuse together, forming a solid layer.

Once a layer of plastic is complete, the build plate moves down so that the extruder can begin a new layer on top of the last. This process continues until your 3D object has been completely printed bottom to top.

Quiz Questions: Let's Test Your Knowledge!

1. **Question: Where can you 3D Print at TPL?**

Please select one of the following options:

a) At all TPL branches.
b) Only at the Toronto Reference Library.
c) At any of TPL's 8 Digital Innovation Hubs.
d) You cannot 3D Print at any TPL locations.

Answer: c) You Can 3D Print at any of the 8 Digital Innovation Hubs throughout the city!

2. **Question: Excluding the all-day printer, how long can you use a 3D Printer?**

Please select one of the following options:

a) 2 hours.
b) 3 hours.
c) 4 hours.
d) 1 hour.

Answer: a) 2 hours.

Question: How much does a 10-gram print cost?

Please select one of the following options:

a) $1.50.
b) $10.00.
c) $1.00.
d) $5.00.

Answer: c) $1.00.

3D Printing Process

There are three stages to the 3D printing process:

1) **Design or Download a 3D Object**

   3D Objects can be downloaded for free online or designed using software on a computer.

2) **Slice**

   3D design files need to be processed with slicing software to convert the model into a file that is ready for the 3D printer.

3) **Print**

   3D printers use preloaded material (filament) to create printouts.

Step 1: Download or Design

Download:

One of the ways that you can get started with printing 3D objects is to download an existing 3D design from websites that collect user designed files.

- **Thingiverse:** Thingiverse.com is one of the largest depositories of user created 3D objects. Users are encouraged to download, remix and share digital design files for free!

Design:

Another way to get started with 3D printing is to design the object yourself. There are a number of 3D design software programs available at the Toronto Public Library.

Design Software:

- **Sculptris:** Free virtual sculpting software with a primary focus on the concept of modeling clay. It is geared toward character sculpting and organic models. Sculptris is available for Windows and Mac OS. TPL also offers free, in-person classes on using Sculptris.
- **Tinkercad:** An easy to use, web-based computer aided design (CAD) application where users can create 3D objects. It features many built in tutorials and is a great for those who have no experience with 3D design. Tinkercad is available using any modern web browser. TPL offers free, in-person classes on how to use Tinkercad.
- **OpenSCAD:** A free software application for designing 3D objects. It is a script-only based modeler that renders objects from code. OpenSCAD is available for Linux, Windows, and Mac OS.
- **Blender:** A free and open source 3D creation suite. It supports modeling, animation, rendering, compositing and motion tracking, video editing, and game creation. Blender is available for Linux, Windows, and Mac OS. TPL also offers free, in-person classes to help you learn how to use Blender.
- **Rhinoceros (Rhino):** A 3D computer graphics and computer aided design (CAD) application which focuses on producing mathematically

precise representations of curves and freeform surfaces in computer graphics. Rhino is available for Windows and Mac OS.

- **Autodesk Fusion 360:** A powerful computer aided design (CAD) and computer aided manufacturing (CAM) software. It combines fast and easy organic modeling with precise solid modeling to create manufacturable designs. It supports collaboration and advanced features like part assembly modeling, animation, rendering, and simulation. Fusion 360 is available for Windows and Mac OS.

File Formats:

Whether you download a file online or design a 3D model yourself, the file must be formatted to print in the library in either. stl or .obj formats. These are computer file formats that store information about your 3D model.

Step 2: Slicing

3D design files need to be processed with slicing software to convert the model into a file that is ready for the 3D printer.

Later in the course, you'll learn how you can use the slicing software "Ultimaker Cura 4.0" to prepare a file to 3D print.

The process is called" slicing," because the software "cuts the 3D model into thin horizontal layers.

Slicing Key Settings:

- **Layer Height:** Layer height determines the thickness of each layer of extruded filament. Using a smaller layer height increases the printer resolution and will provide a smoother texture on the finished print. However, small layers make the printing process more time consuming; a printer would need to print ten 0.1mm layers to build 1mm of height compared to about three layers using the 0.3mm setting. Typical consumer 3D printers can print a layer thickness between 0.1mm to 0.3mm.
- **Infill and Shell:** Each layer of an object is one of two parts: shell or infill. The shell is the outline defining the outer shape of the object. A thicker shell will strengthen the object. Infill is the material printed inside the shell, usually in a hexagonal pattern. Infill density (percentage) determines the durability of the printout. More infill makes the object stronger and less makes it lighter and quicker to build. Most printouts do not require infill above 25%.
- **Supports:** Supports are like scaffolding for parts of an object that extend outward from its main body, called overhangs. A general rule of thumb is if an overhang tilts at an angle greater than 45-degrees it will require supports. However, small layers make the printing process more time consuming; a printer would need to print ten 0.1mm layers to build 1mm of height compared to about three layers

using the 0.3mm setting. Typical consumer 3D printers can print a layer thickness between 0.1mm to 0.3mm.

- **Build Plate Adhesion:** This is a thin framework printed underneath the object to provide stability while printing. Raft and Brim are two options for build plate adhesion. Rafts are used to help stabilize models with small footprints or to create a strong foundation on which to build the upper layers of your object. Brims are an extra layer of filament printed around the first few layers of an object. They provide less stability compared to Rafts since they do not go under the object.

Step 3: Print

The third stage in the 3D Printing Process is "Print."

You will learn how to prepare a file for 3D Printing using the free software application "Ultimaker Cura" in the next section.

3D Printing Materials:

3D printers use preloaded filament to create printouts.

There are many materials used for 3D printing; two of the most common materials are PLA and ABS.

- PLA (Polyactic Acid)
    - PLA is biodegradable, produced from crops such as maize.
    - It melts at a fairly low temperature (around 180°C to 220°C).

- Very minor fumes.
- PLA plastic is used at TPL because it is deemed safe to use indoors.

- ABS (Acrylonitrile Butadiene Styrene)
  - Prints on a heated bed.
  - Shrinks as it cools.
  - ABS is stronger than PLA, but unfortunately due to the strong fumes as the filament is heated, this material can not be used in a public library setting.

Quiz Questions: Let's Test Your Knowledge

1. **Question: The 3D Printing process consists of the following steps:**

Please select one of the following options:

a) Export, save, reset.
b) Download or design, slice, print.
c) Preview, layer, print.
d) Copy, slice, print.

Answer: b) The 3D Printing process consists of the following steps: download or design, slice, print.

2. **Question: Two of the most common materials used for 3D Printing are:**

Please select one of the following options:

a) 3D and ABS.

b) PLA and ABC.

c) PLA and ABS.

d) Paper and ABS.

Answer: c) The two most common materials used for 3D Printing are: PLA (Polyactic Acid) and ABS (Acrylonitrile Butadiene Styrene).

Using Ultimaker Cura

Learn how to prepare a file to 3D Print using Ultimaker Cura.

Ultimaker Cura – Video Transcript:

Ultimaker Cura is a free, open source slicing application that prepares you file for 3D Printing. You can use it on your own computer or visit one of our Digital Innovation Hubs to access it.

Cura 4.0 Ultimaker is a free slicing software that allows you to prepare your 3D models for 3D printing. A digital representation of the build plate displays the height, width, and depth of the 3D printers build area. First, make sure to have the Ultimaker 2+ print model selected.

If it's not there, click Add Printer, select the Ultimaker 2+, click on Add Printer in the bottom right corner. Next, bring in a 3D model. There are

three ways we can do this.The first way is to click on the Folder icon in the top left.

Locate and select your file and the folder, and click on Open.

A second option is to click on File, Open File, and then locate and select your file in the finder. Once you've found your file, you can click on Open. The third way is to simply drag and drop the file into Cura. When the file loads, Cura will automatically slice the model, giving you the total print time and how many grams of plastic will be used, based on the current settings. In the Settings menu, you can set a couple of options. Firstly, the layer height, then the infill percentage. And lastly, you can choose options of whether to include support or adhesion to your print. Every time you make a change to the settings, Cura will automatically reslice the model, providing a new print time and a weight in grams.

We can change our view of the model with these five icons in the bottom left. We have a front view, a top view, and two side views. We can also click and drag the right mouse button to orbit around our model. You can roll the scroll button to zoom in and out. And you can click and drag the scroll button to pan around your scene. The red areas will automatically highlight any parts of your print that may need support during the printing process. Clicking on either Preview tab, either in the top or the bottom of your screen, will show you a preview of the model with the brim and supports already added.

The vertical slide bar on the right tells you how many layers your model has been sliced into and allows you to view your model layer by layer. It also allows you to see the infill and any possible design defects your model may have. Click on the model to activate the tool bar on the left. Move Tool allows you to move your model to anywhere on the build plate simply by clicking and dragging any of the three axis arrows; the red arrow for the X axis, the green arrow for the Y axis, and the blue arrow for the Z axis.

A scale tool shows you the dimensions of your model and allows you to adjust the size, making it bigger or smaller. You can do this by either clicking and dragging any of the axes points on the gizmo, or of course, by typing the percentage or exact dimensions into the dialogue boxes. The Rotate tool allows you rotate the position of your model.

Simply click and drag the gizmo circles to rotate to the desired angle on any one of the three axes. You can also click on the Lay Flat button which will ensure that the model is flat on the build plate.

The Reset button will reset the model to the original rotation. This works for all of the tools. When finished, click Save to a Removable Drive to save the file to an SD card, which is provided by the Digital Innovation Hubs.

Make note of the name of the file and click Eject. Staff will then take the SD card insert it into the 3D printer and begin your print job.

Quiz Questions: Let's Test Your Knowledge!

1. **Question: What is the final step when using Ultimaker Cura before printing?**

Please select one of the following options:

a) Click on Add Printer and select Ultimaker Cura.

b) Click File, Save As, and select 3D Printer.

c) Click Save to a Removable Drive, make note of the name of the file, and click Eject.

Answer: c) The final step before printing is to click Save to a Removable Drive, make note of the name of the file, and click Eject.

2. **Question: What type of software is Ultimaker Cura?**

Please select one of the following options:

a) 3D design software.

b) Slicing software.

c) Web design software.

Answer: b) Cura 4.0 Ultimaker is a type of slicing software.

Additional 3D Printing Resources

Here are some additional 3D Printing Resources that are available for free with your Toronto Public Library Card:

Free Online Resources (Library Card Required)

- **Learning 3D Printing** from Lynda.com.
- **Learning Tinkercad** from Lynda.com.
- **Learning to use MakerBot 3D Printers** from Lynda.com.
- **3D printing with Autodesk 123D, Tinkercad, and MakerBot** from O'Reilly for Public Libraries.
- **3D modeling and printing with Tinkercad: create and print your own 3D models** from O'Reilly for Public Libraries.

Closing

Thank you! We hope that you enjoyed this Intro to 3D Printing at TPL course.

Please visit our website for more information about how you can get started 3D Printing at the Library.