



# CAD and 3D Printing

## Goals:

- Understand how the 3D printer works and what you can make with it
- Understand 3D modeling software, and how to convert from 2D or 3D
- Understand the process of reverse-engineering

### Key Terms

**Additive manufacturing:** The process of creating objects by building one layer at a time. This process uses less materials and time than more traditional manufacturing methods.

**3D printing:** A specific additive manufacturing process that creates a 3D object by layering materials according to a digital design.

**CAD** (aka computer-aided design): Software technology (such as AutoCAD) that's used to create designs.

**Reverse-engineering:** The reproduction of a 3D object following detailed examination of its construction or composition.

**Supports:** These can be breakaway supports, made of the same material as the 3D print, or can be printed in a different water-soluble material that can be washed away to leave the final 3D printed object.

**PLA:** Biodegradable plastic used for 3D printing. PLA has a low printing temperature, making it easier than other plastics to print with. Short for Polylactic Acid.

**TPU:** Plastic used for 3D printing. TPU has a rubber-like elasticity, making it more flexible than other plastics. Short for ThermoPlastic Polyurethane.

**.stl:** File format for CAD software used for 3D printing. Short for stereolithography.



## Key Questions:

### What can you make with a 3D printer?

The possibilities are literally endless. Here are just some examples:

- [Sneakers](#)<sup>5</sup>
- [Robots](#)<sup>6</sup>
- [Drones](#)<sup>7</sup>
- [Homes](#)<sup>8</sup>

### How does a 3D printer work?

There are several types of 3D printers, all of which function slightly differently. Two of the most common types are:

- Fused deposition modeling (FDM) 3D printers melts and extrudes plastic through a printhead. In this way, it is the most simple to a traditional inkjet printer, which deposits colored ink according to a 2D file. In the case of FDM 3D printers, the printhead deposits successive layers of plastic on top of one another to built a 3D objects. Before you can print a 3D design, specialized software must “slice” the object into cross-sections to know what to print for each layer. The Bronx Innovation Factory has an Ultimaker FDM 3D printer.
- Stereolithography (SLA) 3D printers convert liquid materials into solid parts, layer by layer, by selectively curing them using a light source in a process called photopolymerization.

We can print in several different materials:

- PLA
- TPU
- ABS
- PVA

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<sup>5</sup> [https://www.youtube.com/watch?v=2\\_Mz8saTcRI](https://www.youtube.com/watch?v=2_Mz8saTcRI)

<sup>6</sup> <https://www.youtube.com/watch?v=Zsw35FpJSz0>

<sup>7</sup> <https://www.youtube.com/watch?v=92wIASzGKbl>

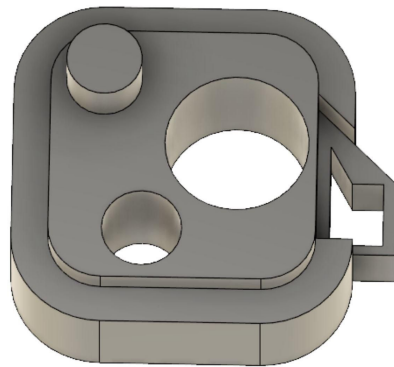
<sup>8</sup> <https://www.youtube.com/watch?v=GUdnrtnjT5Q>



- Nylon

### **How do you create a 3D file?**

We use Fusion 360, which can be downloaded for free if you're an educator or hobbyist.



Here are some especially useful functions in Fusion 360:

- Draw - Allows you to create and edit a shape that you design
- Extrude - Allows you to create a 3D shape from a 2D shape by pulling an edge or panel outwards
- Cut - Allows you to trim parts of the shape from the body
- Union- Allows you to combine two or more shape bodies
- Fillets- Allows you to round corners of a shape or object

### **How do you reverse engineer?**

Reverse engineering allows you to recreate any 3D object that you come across. First, ask yourself, what is the overall shape that I can draw first? Then, what can I add or subtract from that shape to get close to the shape of the object? In the exercises on the following pages, you will reverse engineer a tablet stand and a stool.

### **How do you print a 3D file?**

In order to print for the Ultimaker 3D printer at the Bronx Innovation Factory, we will use a software called Cura. Once you design the 3D file, convert this file to an .stl file and open in Cura.



Once in Cura, you need to adjust the settings that affect your final 3D printout. Some settings to adjust include infill, layer, height, thickness, material specifications, print out speed, etc. Before printing, another important consideration is the design's orientation for print out. Make sure that the orientation allows the printing process to be as easy as possible. Once the settings are ready, hit the print button.

## Additional Resources

- [7 shocking 3D-printed things](#)<sup>9</sup>
- [2D-printed chocolate](#)<sup>10</sup>
- [3D printed project ideas](#)<sup>11</sup> with free files from New York City-company, Adafruit
- [Fusion 360 How To](#)<sup>12</sup> video

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<sup>9</sup> [https://www.youtube.com/watch?v=TAp93r\\_q1Fc](https://www.youtube.com/watch?v=TAp93r_q1Fc)

<sup>10</sup> <https://www.youtube.com/watch?v=slksoDJPJ94>

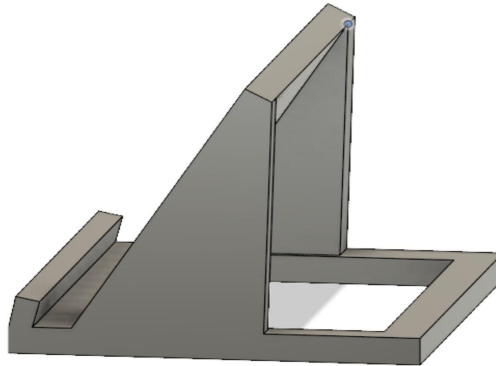
<sup>11</sup> <https://www.youtube.com/watch?v=l0AmRR9w0nw>

<sup>12</sup> <https://www.youtube.com/watch?v=7B9wem3vCVQ>



## Exercise 1: Tablet Stand

**Goal:** The goal of this exercise is to create a stand that can hold a tablet device. For this exercise, we're not giving you the dimensions of the stand—we want you to create a stand that is whatever size you want—but the stand must be proportional.



### Step 1: Create the base

- Create a rectangle
- Extrude the rectangle
- Cut a rectangular hole
- Extrude the hole

### Step 2: Build front and back supports

- Zoom to the side plane
- Draw the front support
- Draw the back support
- Extrude both shapes

### Step 3: Build side supports

- Draw the side supports
- Extrude those shapes

### Step 4: Convert to .stl

- Save the shape with the extension .stl

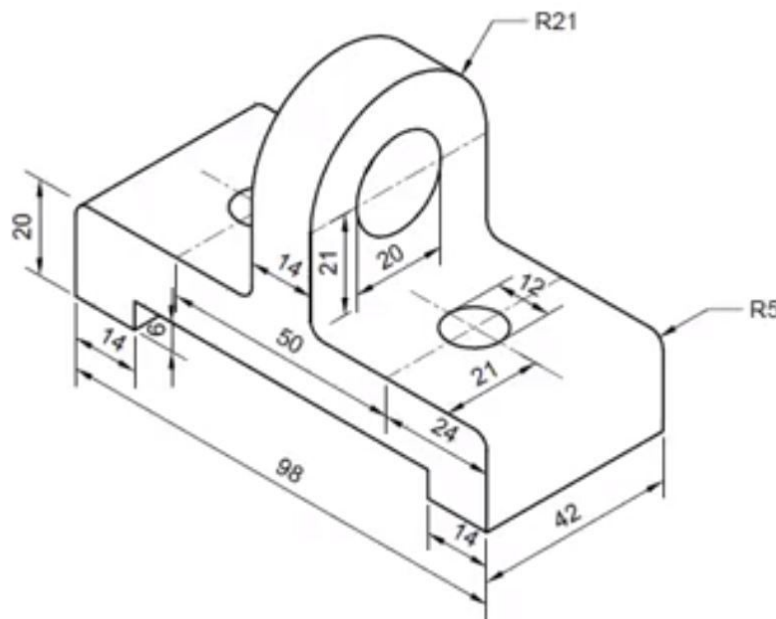


**Step 5:** Adjust settings in Cura. The recommended settings are:

- Print speed - automatic, does not need to be tampered with.
- Infill - normally we use 20%.
- Generate support - depends on the design, if angles are over 45 degrees.
- Build plate adhesion - depends on design, if plate is needed.

## Exercise 2: Support Part

**Goal:** The goal of this exercise is to create a support part—first by creating your own sketch and then by printing. In this exercise, we’re giving you the dimensions to replicate, but you can begin the drawing however you want. There is no correct way to start the drawing—just try whatever makes the most sense to you.



**Step 1:** Look at the sketch above and brainstorm on the different ways to begin the drawing. Think about where you want to start the drawing. Why start there?

**Step 2:** After thinking about where to start, begin drawing your own support part design in CAD. Remember to follow the dimensions in the sketch above.



**Step 3:** After your sketch is ready to print, open the .stl file in Cura. Review the different settings in Cura. Are these the settings you want to keep? If you adjusted the settings, how would this change the printing process?