



# CNC Machining and CAM

## Goals:

- Understand how CNC machines work
- Understand how to prepare 3D files for the CNC machine
- Understand how to use the CNC machine

### Key Terms

**CNC machine:** These machines use code to cut and carve different materials (plastic, wood, foam, etc.). CNC stands for computer numeric controlled.

**XYZ coordinate system:** The basis for how the machine understands the dimensions of a material. The machine uses the coordinate system to move across the material and cut/carve. X and Y are horizontal length and width, and, Z is vertical depth.

**2D Pocket:** machine operation that removes material to create a particular shape and has the option to finish the material.

**Contour:** machine movement that produces curves, circles, or cones.

**CAM** (aka computer-aided manufacturing): Software used by CNC machines to control movements for manufacturing. CAM software that's used at the Bronx Innovation Factory is Fusion 360.

**G-code:** programming language for CNC machine operations.

## Key Questions:

**What are the different parts of a CNC machine?**

Some of the important parts of the CNC machine to know include:



- **Bit/end mill:** The removable, moving piece of CNC machine that is responsible for cutting or carving materials. This comes in different forms for different effects and materials.
- **Chuck:** the piece of the CNC machine that holds the bit in place.
- **Vacuum system:** Important function that removes the waste material that's created in the cutting/carving processes.
- **Deck:** the bed where the material to be cut or carved is placed

### **What's the difference between CAD and CAM?**

The two types of programs serve different functions, but can be used to complete one project. For example, CAD is used to design the object, whereas CAM is used to tell the machine how to produce the object.

### **What can the CNC machine create?**

CNC machines can be used to create common objects and features such as cabinets, benches, and signs, as well as more artistic objects such as guitars and sculptures. Many common items can be carved in high-detail decoration using CAD and CAM softwares and the CNC machine. The machine can basically cut in 2.5D.

### **How does a CNC machine work?**

The machine uses G Code and XYZ coordinates to track its location. (Our machine has 3 axes so just XYZ. Other machines have 4 or 5 axes and will use additional variables). An end mill carves away material.

### **How do you create files for the CNC machine?**

Design files in CAD and then set parameters in CAM (including settings for the end mill, what direction you want the machine to cut in, etc.)

## **Additional Resources**

- [What is CNC Machining and How Does it Work?](https://www.youtube.com/watch?v=FNYEXjRmDtI)<sup>13</sup>

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- [Beginner tips for CNC machining](#)<sup>14</sup> (including what not to do)
- [Guitar body](#)<sup>15</sup> created with a CNC machine

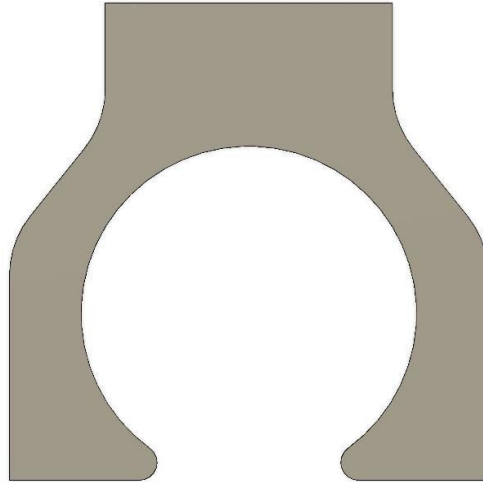
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<sup>14</sup> [https://www.youtube.com/watch?time\\_continue=44&v=uBVd8eAJclU](https://www.youtube.com/watch?time_continue=44&v=uBVd8eAJclU)

<sup>15</sup> <https://www.youtube.com/watch?v=-7iWHeVOECs>



## Exercise 1: Using CAM to Produce a Stool



**Goal:** The goals of this exercise are to design a stool in CAM (Fusion 360) and then produce the stool on the CNC machine.

### Phase 1: Draw stool design in Fusion 360.

1. Open Fusion 360 and start a drawing.
2. Draw center circle with a radius of 7 inches.
3. Draw a 20 inch horizontal line at the bottom of the circle tangential to the circle and aligned with the center of the circle.
4. Draw 12 inch horizontal line at the top of the circle, 13 inches from the center of the circle, aligned with the center line.
5. Draw the two bottom side vertical lines starting from the bottom end line, going up 12 inches.
6. Draw the top side vertical line starting from the ends of the top lines, down to 4 inches.
7. Connect the end of all the vertical lines, completing the drawing.
8. Add 4 inch fillets and extrude the drawing to the sheet thickness.
9. Create two small circles at the bottom, cut extrude.
10. Create center notches with sheet thickness + 0.08 inch.

### Phase 2: Prepare file in CAM



1. Open CAM.
2. Create setup, select setup coordinate system and stock.
3. Select CNC operation from the different operations options and select end mill (or create endmill).
4. Select geometry of operation tab.
5. Select geometry.
6. Select multiple passes and select depth per pass.
7. Simulate to check CNC machining process.
8. Generate gcode.

**Phase 3:** Prepare and use the CNC machine.

1. Open Shopbot 3 for the design file.
2. Calibrate machine in accordance to CNC coordinate system.
3. Upload gcode file and begin to cut.



## Exercise 2: Creating a Sign

**Goal:** The goal of this exercise is to create a square sign with text using CAM and CNC machining.



**Step 1:** Open Fusion 360 and create the shape of your sign.

**Step 2:** Create text for the sign.

**Step 3:** Once the design is ready, open the file in CAM to adjust the settings (setup, operations, end mill selection, etc.).

**Step 4:** Open Shopbot 3 and calibrate the machine.

**Step 5:** Upload gcode file and begin to cut.