This tutorial is designed to create a wireframe model of a part. This tutorial will not simulate a full G-code program for a 3D print because the program for a whole object is, at minimum, 15,000+ lines long. This is because of the complexity of the layering and infill pattern.

Cube
10 mm x 10 mm x 10 mm
NC Viewer Program

1. Open Browser > go to ncviewer.com
   This site is a simulator for compiling machining code, whether it is machining, turning, or 3D printing.
Work screen movement
Mouse
- Left Click - Select
- Left Hold - Pan
- Right Hold - rotate screen
- Center Roll Bar - Pull = Zoom out
  Push = Zoom in

Machine Setup Code
Setting Units
- G20 = inches
- G21 = mm
It is important to set the units so the machine knows how far to incrementally change when programming in the distance from one point to the next

Coordinate Position
- G90 = absolute position
- G91 = incremental position
- G92 = offset coordinate system
User needs to make allotment for the size of the tool they are using. Use absolute position make the change in the \( x \), \( y \), \( z \) coordinates when laying out the coordinate points. Use incremental or offset positioning within the program setup phase.

Note: Because we do not know the size of the tool we are using, absolute position will work best.

Homing
A series of \( x \), \( y \), \( z \) coordinate movements that moves the tool away from the build plate allows for easy setup and removal of the object. The home position is typically a location up and away from the build plate or off the stock material that is to be machined so nothing gets damaged when the extruder head heats up or the cutting tool begins its motion. For this tutorial we will set a home position that is to the upper-right of the wireframe model. The user will not set this position as the origin of the virtual machine, but keep the origin point as one of the corners of the object.
Code: Cube 10 mm x 10 mm x 10 mm

1. Select New Program Icon

2. Type in the following Code
   (NOTE: Two forward slashes // allow the user to place a comment. The code after the “/” will not be recognized by the machine and therefore will not interfere with the code.

   ![Code Snippet]

   Coded line ID generated by software. Note that not all compilers contain line code ID

   Coded line ID generated by user. This is designed to help identify a line of code when each line has a unique marker. Incremental changes (for example: N10, N20) does not have to be by tens, but can be setup as any incremental change. Creating a larger space between ID changes allows the user to add a new line between two existing lines; this way the rest of the program does not need to be renumbered.

3. The next line of codes are used to set up the machine.
   a. 3D Printer: setting up extruder head temperature, build plate temperature, etc.
   b. CNC machine: tool number from the carousel, tool speed, etc.

   We will setup this program as if we were using a 3D printer to create the object.

   Practice writing the following code below:

   ![Code Snippet]

4. The homing position should always be set away from where the object is being printed; continue writing the following code.
Press play in the work screen or plot from the coding window and you should notice an orange line moving from the center of the build plate up vertically and then on an angle towards the third quadrant on the graph.

5. Code the cube 10 mm x 10 mm x 10 mm
   a. 1st wall (front surface): write down the following lines of code.

   ```
   15 //10mm x 10mm x 10mm Cube Print
   16 //1st Wall
   17 N110 G01 x10 y0 z1
   18 N120 G01 x10 y0 z10.1
   19 N130 G01 x0 y0 z10.1
   20 N140 G01 x0 y0 z1
   ```

   b. Press play to plot the code.
c. 2nd wall (left surface): write down the following lines of code. Press play to plot the code. Current tool location = (x0 y0 z.1)

```
21  //2nd Wall Left Face
22  N160 G01 x0 y10 z.1
23  N170 G01 x0 y10 z10.1
24  N180 G01 x0 y0 z10.1
25  N190 G01 x0 y0 z.1
```

d. Reposition the tool:
   Option 1: trace a line to move the tool back to starting location.

```
26  //Trace over bottom left line to reach start of bottom surface
27  N200 G01 x0 y10 z.1
```

Option 2: Move the tool away from the part and reposition it using a combination of G00 and G01. For Example:
Note: For this tutorial user will follow Option 1

e. 3rd wall (back surface): write down the following lines of code. Press play to plot the code. Current tool location = (x0 y10 z.1)

```
//3rd Wall Back Surface
N210 G01 x10 y10 z.1
N220 G01 x10 y10 z10.1
N230 G01 x0 y10 z10.1
```

f. Trace a line to move tool back top right corner of back surface

```
32 //Trace over top edge of back surface to begin right surface
33 N240 G01 x10 y10 z10.1
```
g. 4th wall (right surface): write down the following lines of code. Press play to plot the code. Current tool location = (x10 y10 z10.1)

```plaintext
34 //4th Wall Right Face
35 N250 G01 x10 y0 z10.1
36 N260 G01 x10 y0 z1.1 //Retraces right edge of Front Face
37 N270 G01 x10 y10 z1.1
38 //Return to Home
```

h. The top and bottom surfaces are complete based on the shared edges from the other four surfaces.

6. Return tool to the home position
   Once a part is complete it is important to return the tool back to its home position. This makes it easier to remove the part from the machine. The user should make sure not to code movements that run into the part, so we will move the tool away from the part with a series of moves.
   Copy the following code > Plot Code

```plaintext
38 //Return to Home
39 N280 G00 x15 y10 z.1 //Moves the tool to the right of part
40 N290 G00 x15 y10 z30 //Moves the tool above the part
41 N300 G00 x-30 y-30 z30 //Return to Home Position
```

7. Machine shutdown
Code: Curves, Arcs, and Circles
To create curves, arcs, or circles, the user needs to choose one of two methods. Method 1: use the radius for its formation; Method 2: use offset values from the start point. For both methods the user needs to program the proper G-code axes (G17=XY, G18=ZX, G19=ZY) - this will place the tool at the correct orientation to create the curve, arc or circle based upon its view plane. Not every machine has the ability to rotate the tool into the different axis positions, so read the instruction manual of a particular machine before trying to run a series of code.

Method 1 Using R (radius)
Next we will modify the existing code by adding curves. There are two types of curved edges we can code:

- G02: Clockwise interpolation
- G03: Counter-clockwise interpolation

The direction of the curve (concave vs convex) is dependent upon the direction of the tool. For example: tool moves in a counter clockwise direction (x0 y0 z.1 to x10 y0 z.1)
a. Change the cube code to the G03 counter-clockwise interpolation.

b. Change the following lines of code to create an arc on the top edge of the front surface; notice how this is a G02 (clockwise). This is because the tool is moving in a clockwise direction from line N130 to line N140.

Method 2 Offset Values: I, J, K

Coding a curve, arc, or circle by radius does not always ensure the proper size in G-Code. Options using code I, K, J allow the user to check the location of curve, arc, or circle by setting values from the start point to locate the center of the object.

The following shows the relationship between axis (x, y, z) and offset value (I,J,K)

I = x-axis
J = y-axis
K = z-axis

Codes I, J, K represent the offset distance from the starting point for the curve, arc, or circle in the direction of motion. The I, J, K value can be either positive or negative based on the starting point and direction of the tool.
a. Change the Code to the following
//Cube Print 10mm x 10mm x 10mm
//1st Wall Front Face
N120 G03 x10 y0 z1.1 I5 //I=X-Axis Radius 5 (-5 because of direction of tool; Tool is moving to the right from previous point making the directional motion negative
N130 G01 x10 y0 z10.1
N140 G02 x0 y0 z10.1 I-5 //I=X-Axis Radius 5 (-5 because of direction of tool; Tool is moving to the left from previous point making directional motion negative
N150 G01 x0 y0 z1.1

Extra assignment: Add an arc of 5 mm that is 180 degrees on the right face of the cube. Decide the following: 1) choose y or z direction; 2) concave or convex arc.