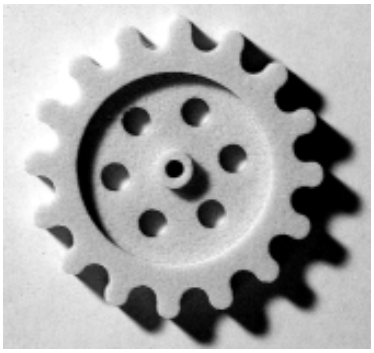
# Project 1: Machine a Gear

## Introduction:

The best way to begin to learn about CNC machines is to watch one in action! For this project, the part has already been created in SurfCAM and converted to CNC programming code, ready for the machine to cut. All you need to do is to turn on the machine and watch in amazement as it makes the part.



All of the projects in this guide use foam blocks. The foam is strong enough to stand up to clamping and machining, but soft enough to not damage the milling machine if it feeds too quickly. Even at that, keep your hand near the "Panic Button", just in case, especially when cutting a part for the first time. There could be bugs hiding in the program that will make it do unexpected things!

## Objectives:

**Run a CNC program**

1. Open a CNC program
2. Verify a CNC program
3. Run a CNC program
4. Restart a program
5. Exit the program

**Cut a part**

1. Turn on the milling machine
2. Clamp a part down
3. Use the manual mode
4. Index the cutter
5. Set axes to "0"
6. Use the emergency STOP
7. Shut down the mill

## Inventory:

*If you are missing anything, check with your instructor.*

**Equipment**

1/8" end mill installed in the machine
Support block
Low temp glue gun (go ahead and plug it in now)

**Supplies**

3" x 3" x 1/4" foam block

## Vocabulary

CNC
Step
Continuous
Manual Mode
End Mill

That's a lot to learn for your first day on the job! Just remember to read the instructions carefully. There are lots of pictures and diagrams to help you.

***STOP!*** *Before going any further, take the safety quiz. You will not be allowed to use the machine until you can pass it with a score of 100%*

---

***Velocity*** *is a* ***CNC*** *(Computer Numerical Control) program, which allows the computer to control the milling machine. It has lots of controls in the window. By the time you are finished with this book, you'll understand how to use them.*

**Step 1:** Start the **Velocity** program.

a. If the computer is off, turn it on.

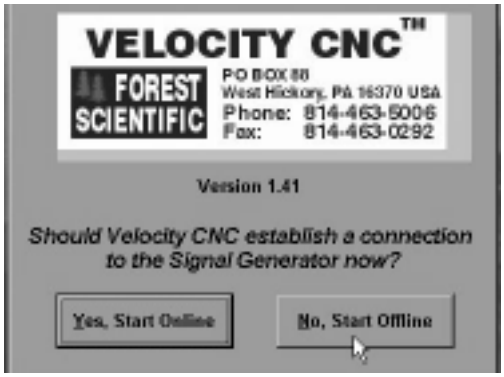
b. Double-click the **Velocity** icon to start the program.

*Note: If the Velocity icon is not on the desktop, check with your instructor.*

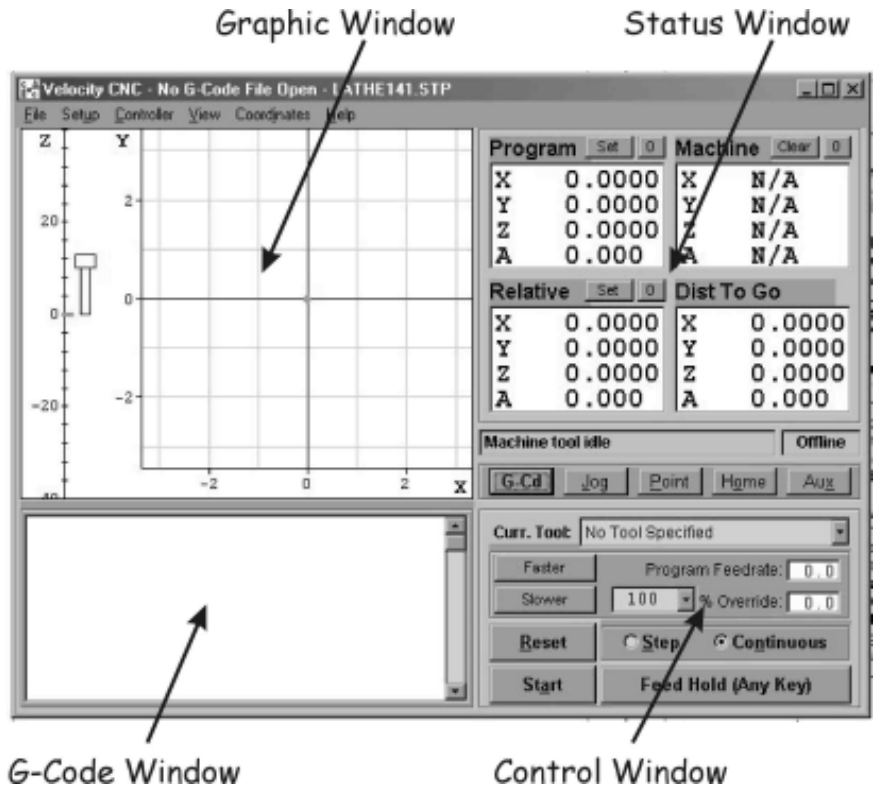

c. When the next screen appears, select **No, Start Offline**.

*This tells the computer that the milling machine hasn't been turned on yet. You will go on line later.*

**Machinist's Note:** Starting offline tells the computer that the milling machine has not been turned on yet. You will go online later.



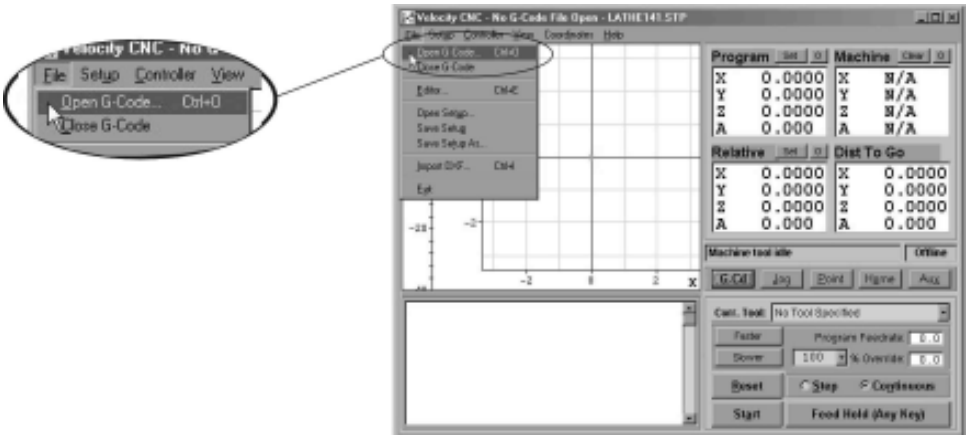
*The Velocity program screen looks like this:*




**Machinist's Note:**
The Velocity program has a lot of controls and indicators. You don't need to learn all of them to start out.

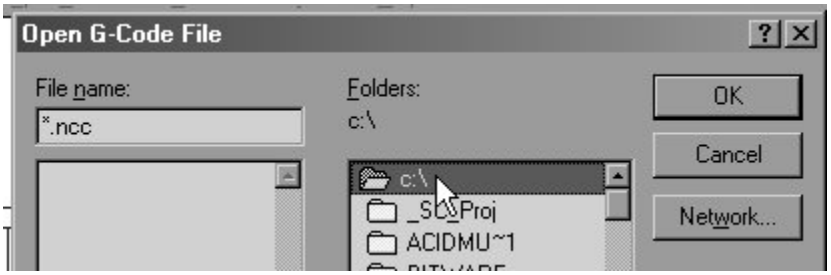
**Step 2.** Open the file for the first project.

a. From the **File** menu, select **Open G-Code**.

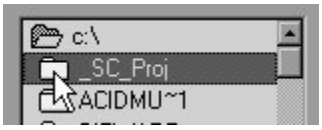



*Note: this manual shows commands from drop-down menus like this:*
**File=> Open G-Code**

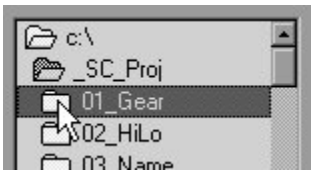
b. In the **Folders** window, double-click c:\



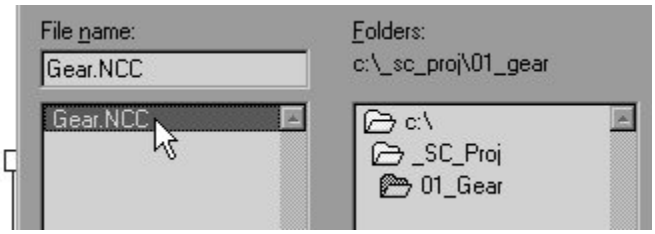

c. Open (double-click) the folder **_SC_Proj**.




d. Open the folder **01_Gear**.

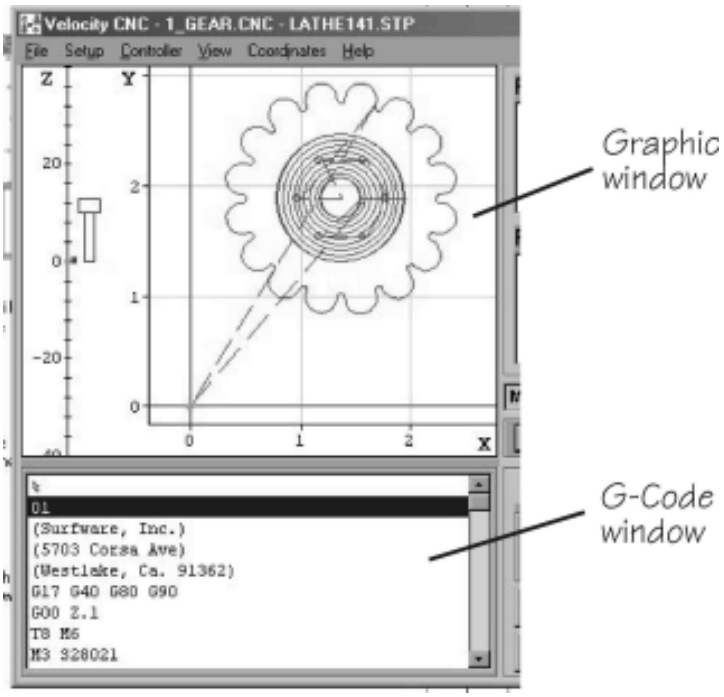



e. Select the file **Gear.NCC**.




f. Click on the **OK** button.

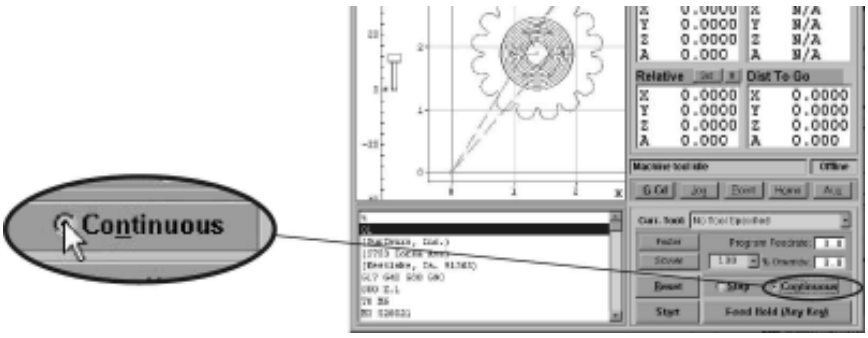
*The program file for this activity will appear on the screen.*




*Velocity gives the machinist the chance to **Verify** the program (run a simulation on the computer). If there are any major problems with the program, you can fix them before actually cutting the part. This cuts down the chance of damaging the machine or wasting material.*

**Step 3:** Verify the program.

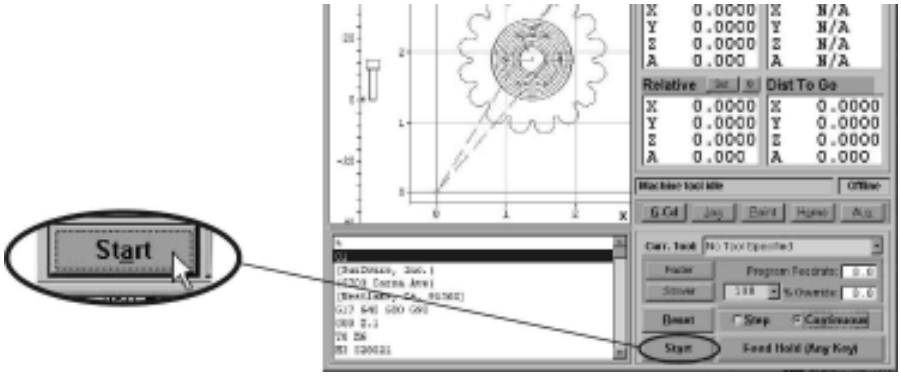
a. Click on the **Continuous** button.




**Machinist's Note:**
Always verify a part on the computer before running it on the machine.

*The Continuous mode runs the program from start to finish.*

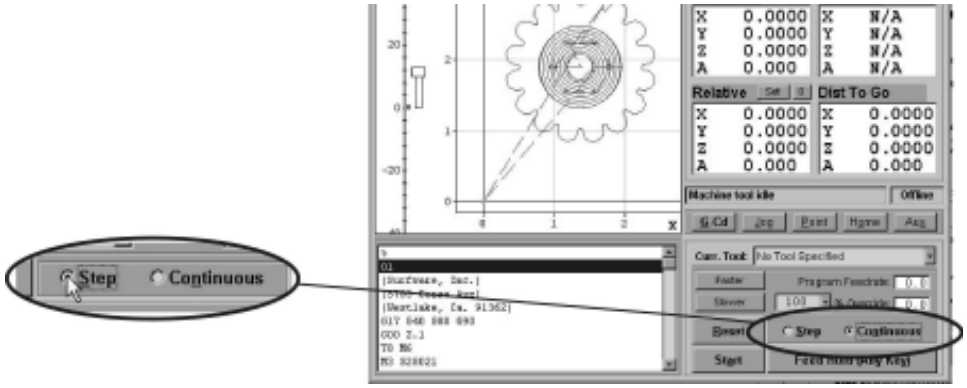
b. Click on the **Start** button.




*The program quickly shows you the path that the tool will follow.*

***Machinist's Note:***
*The Step mode is useful when you need to view a detailed analysis of the program, or to find out which step is causing a problem.*

c. Click on the **Step** button.




*The Step mode runs the G-code program one line at a time.*

*Note: The Start button has the **a** underlined. This tells you that **[Alt] [A]** does the same thing as clicking on that button.*

d. Click on the **Start** button.


or **[Alt] [A]**

*In the Step mode, each time you click on the start button, the program advances one line.*

e. Continue to push the 

button until the program has gone through the first ten steps. Notice the numbering system at the beginning of each of the G-code lines.

f. While holding down the [Alt] key, press [A].
*As long as you keep both keys pressed, the program will run.*

g. Continue to hold down the [Alt] [A] until the program is complete.

h. Return the program to the beginning by clicking the **Reset** button in the control window.



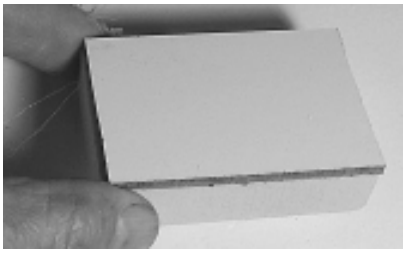
**Step 4:** Make sure you have a 1/8" end mill installed in the machine. If you are not sure, have your instructor check it and, if necessary install the correct bit. Later, you will learn how to do this yourself.


**Machinist's Note**

The **end mill** is the tool that does the actual cutting. End mills look a lot like drill bits, but they are flat on the bottom and have sharp edges on the side. This allows them to cut sideways.


**Step 5:** Clamp the foam block in place.

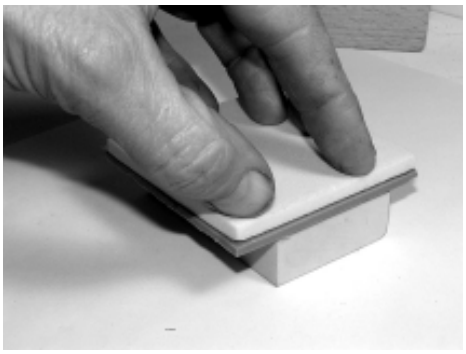
a. Locate the clamp block. This is a block of foam with a piece of wood attached to it.



b. Put on safety goggles.

c. Use hot glue to attach your workpiece to the clamping block.

*Note: Use just a little glue on each corner of the block, or it will be hard to remove when you are finished.*

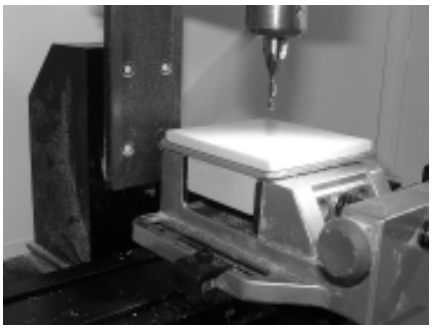


d. Open the safety cover.

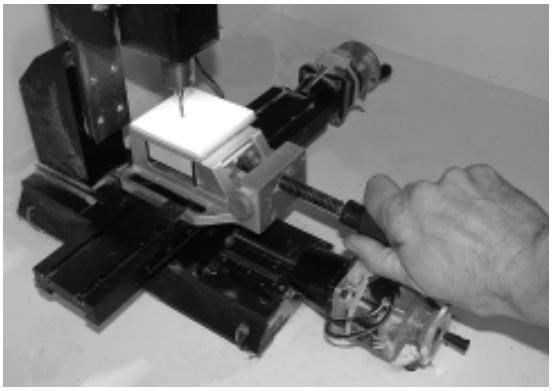
e. Open the vise as wide as it will go.

f. Set the clamp block in the vise.

*Note: The spacers hold your work above the vise so you can cut out a part without hitting the vise with the end mill.*



g. Tighten the vise to secure the clamp block.



**Machinist's Note:**
Make sure the part sits flat on the top of the vise. Otherwise the depth of your cuts may be uneven.

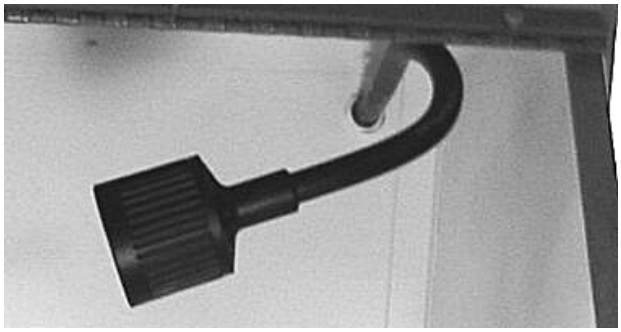
**Step 6:** Turn on the milling machine.

a. Pull out the **"emergency stop"** button to make sure it is not engaged.


b. Turn the **"main power"** key clockwise to start the machine..


*The Main Power light (just above the key) should come on.*

c. The halagen lamp should light up the work area. If necessary, adjust the goose neck to improve visibility.



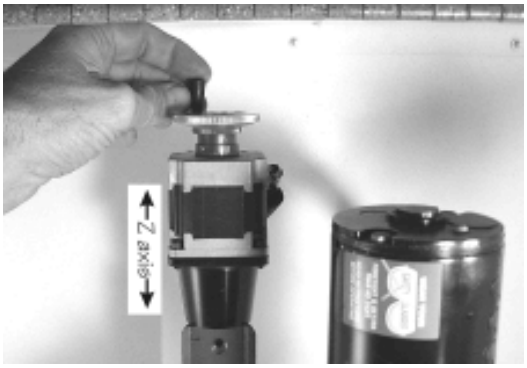
**Machinist's Note:**
*Indexing the cutter sets a reference point that tells the machine where to start. All other cutter reference points refer to the index point, so it is important to get it right.*

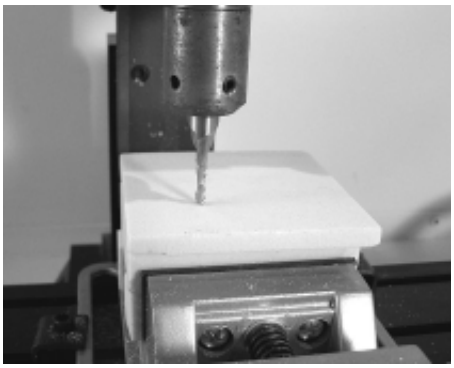
**Step 7:** Index the cutter to the front left corner of the block.

a. Turn the control key to the **Manual** (horizontal) position.

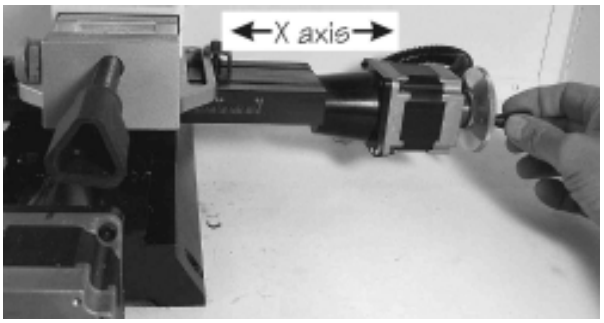

*This allows you to move the machine by hand.*

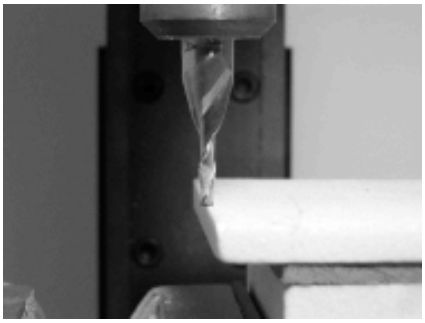
b. Turn the top crank (Z-axis) to move the cutter down until it just touches the styrofoam block.



c. Turn the crank on the right (X-axis) to move the part until the cutter is centered on the left edge of the foam block.



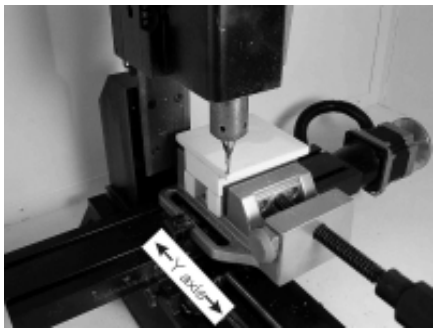



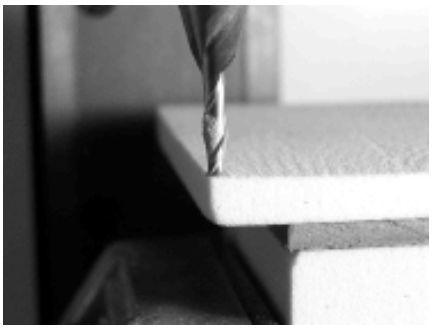
d. Turn the crank on the front (Y-axis) to move the part until the cutter is centered on the front left

*Note: The mill will not operate unless the safety cover is closed.*

**Machinist's Note:**
All movements of the mill use the "zero" point as a reference. For example, the point x=1, Y=0, Z=.5 is 1" to the right and 1/2" above the zero point.

corner of the foam block.



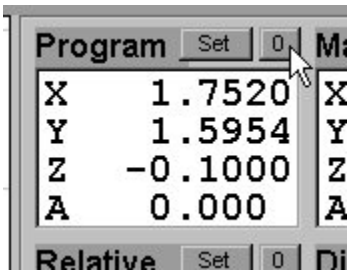



e. Close the safety cover.

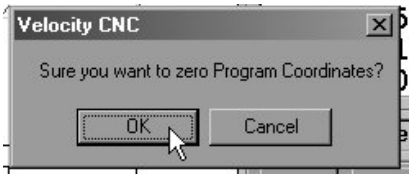
Now that the machine is indexed on the corner, the next step is to set this as the "zero" point with the software.

**Step 8:** Zero all axes.

a. In the **Program** area of the **Status** window, click on the **0** (zero) icon.




b. When the program asks whether you wish to zero all program coordinates, click on the **OK** button.




*The corner of the block is now set as the "zero" reference*

*position.*

**Step 9:** Go online.

When you go online, you are telling the computer that you wish to communicate with the milling machine.

a. From the **Controller** pull-down menu, select **Online**.


b. Read **all** of the safety rules.

c. Click on the **Agree** button to go online.


You ‘ve clamped down the part, indexed the mill, set all three axes to 0, verified the program, and gone online. Now you’re ready to cut foam!

**Step 10:** Set the machine to cut the part.

a. Click on the **Reset** button to make sure the program is at the beginning.

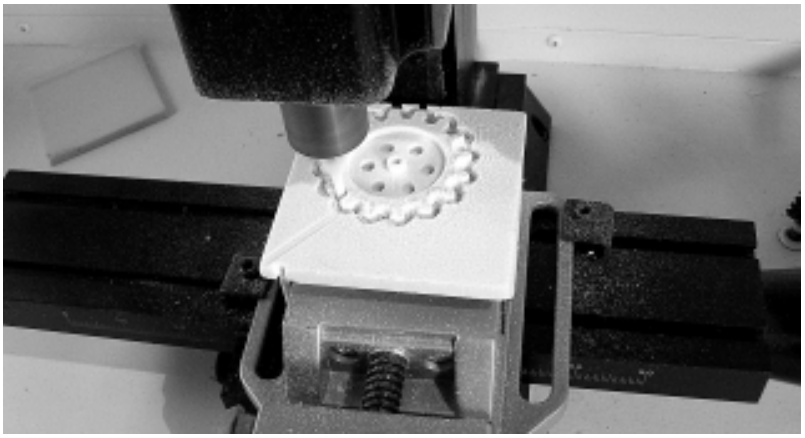

b. Set the spindle speed to **maximum**.

c. Turn the key to the **CNC** position.


**Step 11:** Cut the part

a. Click on the **Start** button to begin cutting.


b. Enjoy the show!



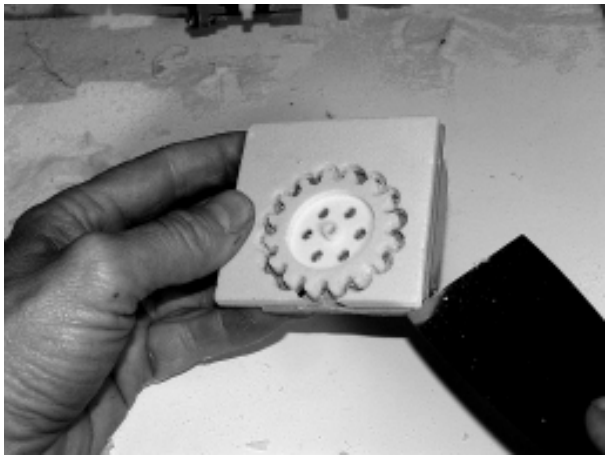
**Step 12:** Remove the part.

a. After the machine has stopped, press the **Stop** button to turn off the machine.

b. Open the safety cover.

c. Loosen the vise and remove the part.

d. Carefully pry your gear off of the clamp block.



e. Clean off any glue stuck to your gear.

**Machinist's Note:**
Use a putty knife to pry the part off the backing. Work the knife under an edge, then twist it slowly until the glue releases.

**Step 13:** Clean up the work area.

a. Use the vacuum cleaner to clean up all the dust and chips.

b. Unplug the glue gun.

c. Put away all materials.

d. Close the safety cover.

**Step 14:** Exit the Velocity program.

a. From the **File** drop-down menu, select **Exit.**


*Congratulations! You have just milled your first piece! There is a lot to setting up and using the CNC mill. In the next activity, you will learn how to design your own part using SurfCAM software.*

## *Questions:*

1: What is CNC Machining?

2: What does the computer do in a CNC machining system?

3: What is “Indexing”?

4: What is **continuous** mode when running a CNC program?

5: What is **step** mode when running a CNC program?

6: What tool is most commonly used on a milling machine for cutting?

7: Now that you’ve seen the milling machine in action, why do you think the safety shield is required?

*Internet Research: Locate the answers to the following questions:*

*What kind of gear did you machine in this project?*

*What are three kinds of gears?*

*What is the “pitch” of a gear?*

*What are three ways in which gears change mechanical action?*