

CNC Mill 5400



Part of the Manufacturing
Technology Cluster

Student Guide/Portfolio

FIRST EDITION

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BEGINNING LEVEL

Mill Level 4 Software Programming Sheet #1**Program Information**

Program Name	
Author	
Material	
Drawing No.	
Width (X)	
Depth (Y)	
Height (Z)	

Tools Used

Tool #	Description	Diameter	Radius
9			

PART Program

Line #	Instruction	Comment
00001		
00002		
00003		
00004		
00005		
00006		
00007		
00008		
00009		
00010		
00011		
00012		
00013		

Activity 1 – You Are the Programmer

For this section, refer to your completed **Mill Level 4 Software Programming Sheet #1** as you work on the computer.

1. From the *File* pull-down menu, select *New*. The *Program Setup* screen appears.
2. Delete *<UNTITLED>* from the *Program Name* field and leave it blank.
3. Delete *Teacher* from the *Author* field and enter your name.
4. In the *Drawing ID* field, the default, *Project #1*, should appear in the project field. If this is incorrect, highlight the text and center a project number.
5. In the *Material* section of the screen, select *Plastic*. If you are using wax, select *Wax*.
6. In the *Editor* portion of the screen, make sure *Line Mode* is selected.
7. In the *Units* portion of the screen, make sure *Inch* is selected.
8. In the *Coordinates* section, make sure *Absolute* is selected.
9. Enter the appropriate values in the X, Y, and Z fields. (X=2) (Y=2) (Z=0.5).
10. Click on the *OK* button. The *Line Editor* appears.

Entering the Part Program

Notice that the *Line Editor* is numbered, starting with 00001; this is your first line of code. You will use the line numbers on your **Mill Level 4 Software Programming Sheet #1** as a reference.

1. For the first line of instruction, begin by typing a backslash, “\”, followed by your name and class. The backslash tells the computer to ignore any information following it. You use this for information purposes only. If you did not type the backslash, the computer would not recognize or accept the information. Line 00001 should look like this:

```
\YOUR NAME CLASS
```

2. Press *Enter*. The cursor will move to line 00002.
3. Look at line 00002 on your **Mill Level 4 Software Programming Sheet #1**. You should have G70 written in the instruction. This tells the computer to use inches for measurement. Type “G70”, then press *Enter* for line 00002.
4. On line 00003, you will turn on the spindle motor with the M04 code and set the spindle speed to 2800 RPM. Type “M04 2800”, then press *Enter*.
5. On line 00004, you will set the feed rate at 4 inches per minute. Type “M07 4”, then press *Enter*.
6. Now enter your first **tool movement code** on line 00005. If you are moving in a straight line from one point to another, you use the Linear Interpolation command, which is G01. Type “G01”, then press *Enter*.
7. Using your **Mill Level 4 Software Programming Sheet #1**, continue entering the remaining lines of your program.

Saving the Program

8. From the *File* menu, select *Save as*. The *File, Save As...* dialog box opens.
9. In the *File name* field, enter your name and PART program (project) number. You can abbreviate if necessary. Your name will automatically be entered in the *Program Name* field on the *Program Setup* screen.
10. Notice that the *Save in* field shows you that the program will be saved in the M4 directory in the *Mill Level 4* program.

NOTE: Whenever you save a program, it is very important that you pay attention to the location of the program so that you can access it at any time.

11. Click on the *Save* button. The name you assigned to your program now appears on the *Line Editor* title bar.

Your program, which can be identified by your name and PART program (project) number, is now saved in the M4 directory with the other PART programs.

Compiling the Program

1. From the *Mill* pull-down menu, select *Compile*.

When the *CNC Compiler* opens, the program immediately performs a line-by-line check of your PART program.

The *Status* field should say "Success! No Errors Detected."

2. If an error is found, the *Line Editor* will highlight the line of code that is incorrect. You should then check your error against the information on your **Software Programming Sheet** and make the necessary changes. You must close the *Compiler* and re-open it each time an error is corrected. A mistake as simple as a missing space can cause an error.
3. When you are done, click on *OK*.
4. If any corrections were made, save the changes by selecting *Save* from the *File* menu.

Emulating the Program

The word *emulate* means to copy, or to simulate. With the *Mill Level 4* program, you can have the computer emulate the milling process that you programmed.

NOTE: Emulation helps programmers and manufacturing engineers to see if the program they entered is correct. This saves time because they don't have to make a test part, and it saves money because no materials will be wasted.

1. From the *Mill* pull-down menu, select *Emulator*. The *Mill 3D Emulator* opens.
2. Choose the top view (top-right button) from the View section and then click on the green start button in the Control section to see how your part will be machined on the mill.
3. Next, click on the front view (top-left button) in the view screen to see the depth of cut. Click on the green start button in the control section to see another view of how your part will be machined on the mill.
4. Click on the *Close* button (X) in the upper right corner of the Emulator screen to close the *Emulator*.
5. Click on the *Close* button (X) in the upper right corner of the Line Editor screen to close the *Line Editor*.

Mill Tool Setup

1. From the *Options* pull-down menu, select *Tool Setup*. The *Mill Tool Setup* screen appears.
2. Select *Tool Number 9* by clicking on the up and down arrows next to the *Tool Number* field. *1/4" End Mill* appears below the *Tool Number*.

The *Bit Diameter* field shows you that the bit diameter is 0.25 inch.

3. When you are done, click on the *OK* button.
4. Go to the next section in the multimedia presentation.

Activity 2 – Loading the Program

Do the following to open the PART program that you created in Activity 1.

1. From the *File* pull-down menu, select *Open*. The *File, Open...* dialog box appears.
2. Scroll until you find your program file.
3. Double-click on your program file.

The *Line Editor* appears with the PART program you previously created.

You are now ready to download your PART program to the CNC mill. Before you download your PART program, read the following sections:

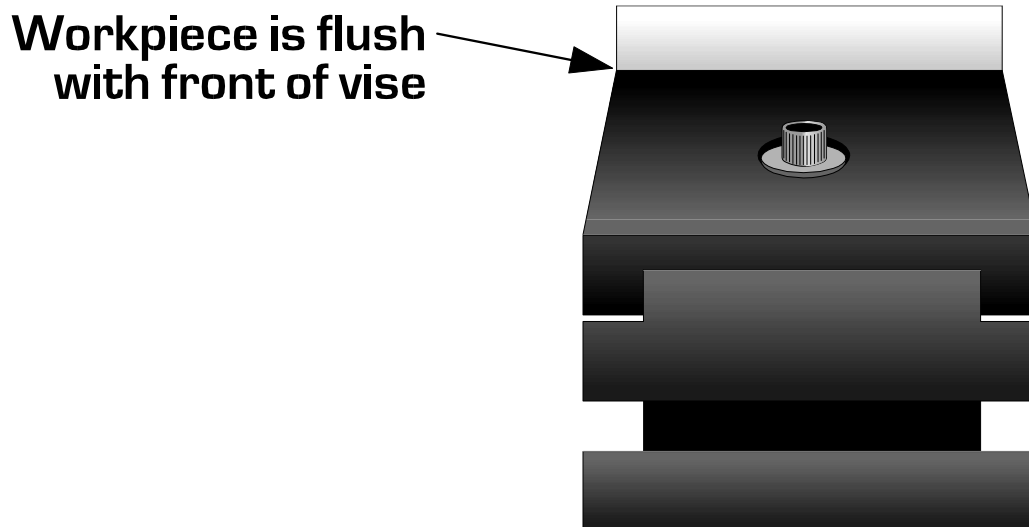
LOADING THE WORKPIECE and SETTING THE TOOL POSITION.

Loading the Workpiece

The first step in executing the program is to load the workpiece.

1. Turn on the power switch located on the side of the mill.
2. Open the safety door.
3. Clamp a piece of 2" x 2" x .5" (5.08 cm x 5.08 cm x 1.27 cm) Plexiglas (or wax) in the vise. Make sure it is secure and level, with one half of the Plexiglas above the top of the vise. Make sure the workpiece is flush with the jaws of the vise (use the machinist rule, or ruler, to position the workpiece correctly).

It should look like this:



Setting the Tool Position

Before running your PART program, you must position the milling tool. Your point of reference is known as the Program Reference Zero, or PRZ.

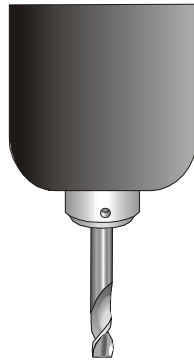
The PRZ is a reference point that enables the computer and the milling machine to locate the X, Y, and Z coordinates that you entered into your PART program.

Quadrant I of the **Cartesian Rectangular Ordinate System** is used in programming to define the PRZ. The PRZ is the point at which the X axis and Y axis intersect.

The PRZ on the workpiece is the point at which the X, Y, and Z axes intersect in the first quadrant.

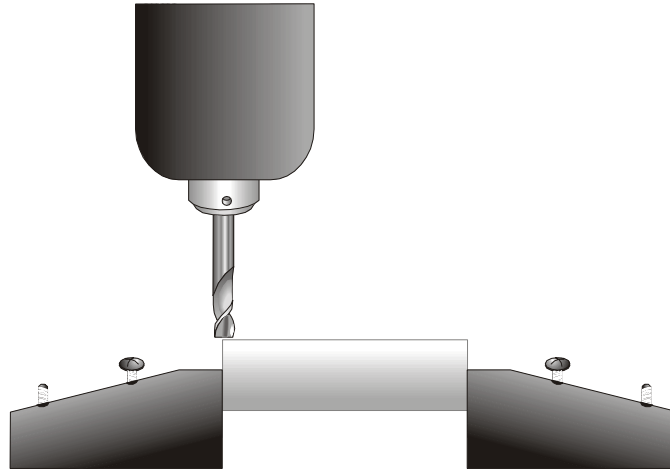
This means that you want to touch the front left corner of the workpiece with the tool.

1. Load a ¼" end mill into the spindle. (If necessary, loosen the small screw in the side of the spindle with an Allen wrench. After inserting the cutter, secure it by tightening the screw.)



2. Close the safety doors.
3. If locked, unlock the EMERGENCY STOP button and remove the key.

4. When you are ready to position the end mill on the front left edge of the workpiece press MAIN MENU on the CNC Mill control panel. Your choices are Manual, Remote, and Setup.
5. Use the +Z and -Z keys of the control panel keypad to position the cursor next to MANUAL, then press ENTER.
6. Using the +X, -X, +Z, -Z, +Y, and -Y keys of the control panel keypad, position the center of the 1/4" end mill on the left front corner edge of the workpiece.



7. Open the safety door and cover the workpiece with a 2-inch (5.08 cm) square piece of notebook paper. Close the safety door. Using the +Z and -Z keys, position the end of the cutter onto the top of the paper-covered workpiece, adjusting it so that the cutter is touching the paper, but the paper can be pulled free without ripping. Remove the paper.
8. Press Zero twice. This sets the PRZ for the X, Y, and Z axes to the current cutter position.
9. Press +Z to raise the headstock above the block.
10. Press the ESC key on the control panel to return to the MAIN MENU.

Downloading Your Part Program

1. From the control panel on the CNC Mill *MAIN MENU*, use the -Z key to move the cursor next to REMOTE and press ENTER.

The mill's display now reads:

Ready to Download

<Esc> Abort

2. From the *Mill* pull-down menu, select *Download*. The *Serial Download* screen appears.

The *Remote Machine* field tells you that you are downloading to a 5400 Mill.

The *Status* field tells you that you are ready to transmit and the *Last Error* field tells you that there are no errors. If an error occurs, this field displays the error message code for the problem. If this happens, ask your instructor for help.

3. Click on the *OK* button.

Look at the display on the CNC mill's control panel and you will see "Downloading" and a rotating cursor indicating that your PART program is being downloaded to the mill.

When the *Download Complete* screen is displayed on the mill, your PART program has been downloaded.

Executing Your Program

You are now ready to execute your PART program. Remember to always wear safety glasses when operating the mill.

Once your PART program has been downloaded to the 5400 CNC Mill, the control panel's display will read:

Download Complete

<Enter> Machine Part

<Esc> Abort

1. Press ENTER to begin machining your PART program. As the program executes, the display will change to show the current X, Y and Z positions; spindle speed, feed rate, and G code.
2. Watch the mill closely and make sure that enough of the workpiece is protruding from the vise and that you will not have a tool crash. After the program has finished, the mill will return to its home position and then stop.
3. At your computer, close the *Line Editor* by clicking on the (X) in the upper right corner.

Cleanup

1. Open the safety doors and carefully remove the workpiece.
2. Press *Esc* to return to the *Mill* menu.
3. Press the EMERGENCY STOP button.
4. Turn off the power switch located on the side of the mill.
5. Clean up your area and return everything to its proper place. You may want to use a shop vacuum to carefully clean out the inside of the mill.

When you are finished, go to the next section in the multimedia presentation.

Mill Level 4 Software Programming Sheet #2

Program Information

Program Name	
Author	
Material	
Drawing No.	
Width (X)	
Depth (Y)	
Height (Z)	

Tools Used

Tool #	Description	Diameter	Radius
9			

PART Program

Line #	Instruction	Comment
00001		
00002		
00003		
00004		
00005		
00006		
00007		
00008		
00009		
00010		
00011		

PART Program (continued)

Line #	Instruction	Comment
00012		
00013		
00014		
00015		
00016		
00017		
00018		
00019		

Activity 3

1. Enter the program. Use your completed **Mill Level 4 Software Programming Sheet #2**. If necessary, refer to **ENTERING THE PROGRAM** in the **ACTIVITY 1** section.
2. Save the program. If necessary, refer to **SAVING THE PROGRAM** in the **ACTIVITY 1** section.
3. Compile the program. If necessary, refer to **COMPILING THE PROGRAM** in the **ACTIVITY 1** section.
4. Emulate the program. If necessary, refer to **EMULATING THE PROGRAM** in the **ACTIVITY 1** section.
5. Select the proper end mill. If necessary, refer to **MILL TOOL SETUP** in the **ACTIVITY 1** section.

When you are finished, go to the next section in the multimedia presentation.

Activity 4

1. Load the program. You are loading an existing program so, if necessary, refer to **LOADING THE PROGRAM** in the **ACTIVITY 2** section.
2. Load the workpiece. If necessary, refer to **LOADING THE WORKPIECE** in the **ACTIVITY 2** section.
3. Set the tool position. If necessary, refer to **SETTING THE TOOL POSITION** in the **ACTIVITY 2** section.
4. Download the program. If necessary, refer to **DOWNLOADING YOUR PROGRAM** in the **ACTIVITY 2** section.
5. Execute your program. If necessary, refer to **EXECUTING YOUR PROGRAM** in the **ACTIVITY 2** section.
6. Clean up your workstation. If necessary, refer to **CLEANUP** in the **ACTIVITY 2** section.

When you are finished, go to the next section in the multimedia presentation.

Mill Level 4 Software Programming Sheet #3

Program Information

Program Name	
Author	
Material	
Drawing No.	
Width (X)	
Depth (Y)	
Height (Z)	

Tools Used

Tool #	Description	Diameter	Radius
9			

PART Program

Line #	Instruction	Comment
00001		
00002		
00003		
00004		
00005		
00006		
00007		
00008		
00009		
00010		
00011		

PART Program (continued)

Line #	Instruction	Comment
00012		
00013		
00014		
00015		
00016		
00017		
00018		
00019		
00020		
00021		
00022		
00023		
00024		
00025		
00026		
00027		
00028		
00029		

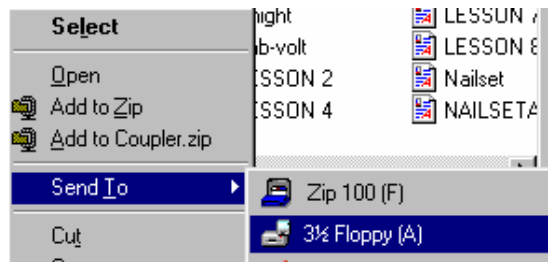
Activity 5

1. Enter your program. Use your completed **Mill Level 4 Software Programming Sheet #3**. If necessary, refer to **ENTERING THE PART PROGRAM** in the **ACTIVITY 1** section.
2. Save the program. If necessary, refer to **SAVING THE PROGRAM** in the **ACTIVITY 1** section.
3. Compile the program. If necessary, refer to **COMPILING THE PROGRAM** in the **ACTIVITY 1** section.
4. Emulate the program. If necessary, refer to **EMULATING THE PROGRAM** in the **ACTIVITY 1** section.
5. Select the proper end mill. If necessary, refer to **MILL TOOL SETUP** in the **ACTIVITY 1** section.
6. Load the workpiece. If necessary, refer to **LOADING THE WORKPIECE** in the **ACTIVITY 2** section.
7. Set the tool position. If necessary, refer to **SETTING THE TOOL POSITION** in the **ACTIVITY 2** section.
8. Download your program. If necessary, refer to **DOWNLOADING YOUR PROGRAM** in the **ACTIVITY 2** section.
9. Execute your program. If necessary, refer to **EXECUTING YOUR PROGRAM** in the **ACTIVITY 2** section.
10. Clean up your workstation. If necessary, refer to **CLEANUP** in the **ACTIVITY 2** section.

Saving to a Floppy Disk

When all lesson activities have been completed, your PART programs should be saved to a floppy disk and then removed from the .M4 directory. Your PART programs can be downloaded to *Mill Level 4* at any time in the future if necessary. Follow the steps below.

1. Get a blank floppy disk from your instructor and label it with the names you assigned to the programs when they were initially created. Be sure to include your name.
2. Place the floppy disk in your computer floppy disk drive.
3. From the *File* pull-down menu, select *Open*. The File, Open window appears and shows all the PART programs stored in the M4 directory.
4. Right-click on one of your program files. A pop-up menu appears. Select *Send To* and then click *3½ Floppy (A)*. Your computer will now download a copy of the program file to your floppy disk.



5. After the PART program has successfully copied to your floppy disk, right-click again on the program file. From the pop-up menu, click *Delete*. A *Confirm File Delete* dialog box appears. Click *Yes*. Your PART program is now permanently deleted from the directory.
6. Repeat these steps for each program file you have stored in the M4 directory.
7. When you are done, remove the floppy disk.

Go to the next section in the multimedia presentation.

ADVANCED LEVEL

Mill Level 4 Software Programming Sheet #1**Program Information**

Program Name	
Author	
Material	
Drawing No.	
Width (X)	
Depth (Y)	
Height (Z)	

Tools Used

Tool #	Description	Diameter	Radius
9			

PART Program

Line #	Instruction	Comment
00001		
00002		
00003		
00004		
00005		
00006		
00007		
00008		
00009		
00010		
00011		

PART Program (continued)

Line #	Instruction	Comment
00012		
00013		
00014		
00015		
00016		
00017		
00018		
00019		
00020		
00021		
00022		
00023		
00024		
00025		
00026		
00027		
00028		
00029		

Activity 1 – You Are the Programmer

For this section, refer to your completed **Mill Level 4 Software Programming Sheet #1** as you work on the computer.

1. From the *File* pull-down menu, select *New*. The *Program Setup* screen appears.
2. Delete <UNTITLED> from the *Program Name* field and leave it blank.
3. Delete *Teacher* from the *Author* field and enter your name.
4. In the *Drawing ID* field, the default, *Project #1* should appear in the project field. If this is incorrect, highlight the text and enter a project number.
5. In the *Material* section of the screen, select *Plastic*. If you are using wax, select *Wax*.
6. In the *Editor* portion of the screen, make sure *Line Mode* is selected.
7. In the *Units* portion of the screen, make sure *Inch* is selected.
8. In the *Coordinates* section, make sure *Absolute* is selected.
9. Enter the appropriate values in the X, Y, and Z fields. (X=2) (Y=2) (Z=0.5).
10. Click on the *OK* button. The *Line Editor* appears.

Complete the next section, **ENTERING THE PROGRAM**.

Entering the Program

Notice that the *Line Editor* is numbered, starting with 00001; this is your first line of code. You will use the line numbers on your **Mill Level 4 Software Programming Sheet #1** as a reference.

1. For the first line of instruction, begin by typing a backslash, “\”, followed by your name and class. The backslash tells the computer to ignore any information following it. You use this for information purposes only. If you did not type the backslash, the computer would not recognize or accept the information. Line 00001 should look like this:

```
\YOUR NAME CLASS
```

2. Press *Enter*. The cursor will move to line 00002.
3. Look at line 00002 on your **Mill Level 4 Software Programming Sheet #1**. You should have G70 written in the instruction. This tells the computer to use inches for measurement. Type “G70”, then press *Enter* for line 00002.
4. Using your **Mill Level 4 Software Programming Sheet #1**, continue entering the remaining lines of your program.

Saving the Program

1. From the *File* menu, select *Save as*. The *File, Save As...* dialog box opens.
2. In the *File name* field, enter your name and PART program (project) number. You can abbreviate if necessary. Your name will automatically be entered in the *Program Name* field on the *Program Setup* screen.

Notice that the *Save in* field shows you that the program will be saved in the M4 directory in the *Mill Level 4* program.

NOTE: Whenever you save a program, it is very important that you pay attention to the location of the program so that you can access it at any time.

3. Click on the *Save* button. The name you assigned to your program now appears on the *Line Editor* title bar.

Your program, which can be identified by your name and PART program (project) number, is now saved in the M4 directory with the other PART programs.

Compiling the Program

1. From the *Mill* pull-down menu, select *Compile*.

When the *CNC Compiler* opens, the program immediately performs a line-by-line check of your PART program.

The *Status* field should say “Success! No Errors Detected.”

If an error is found, the *Line Editor* will highlight the line of code that is incorrect. You should then check your error against the information on your **Software Programming Sheet** and make the necessary changes. You must close the *Compiler* and re-open it each time an error is corrected. A mistake as simple as a missing space can cause an error.

2. If any corrections were made, select *Save* from the *File* pull-down menu.
3. When you are done, click on *OK*.

Emulating the Program

The word *emulate* means to copy, or to simulate. With the *Mill Level 4* program, you can have the computer emulate the milling process that you programmed.

NOTE: Emulation helps programmers and manufacturing engineers to see if the program they entered is correct. This saves time because they don't have to make a test part, and it saves money because no materials will be wasted.

1. From the *Mill* pull-down menu, select *Emulator*. The *Mill 3D Emulator* opens.
2. Choose the top view (top-right button) from the *View* section and then click on the green start button in the *Control* section to see how your part will be machined on the mill.
3. Next, click on the front view (top-left button) in the view screen to see the depth of cut. Click on the green start button in the control section to see another view of how your part will be machined on the mill.
4. Click on the *Close* button (X) in the upper right corner of the *Emulator* screen to close the *Emulator*.
5. Click on the *Close* button (X) in the upper right corner of the *Line Editor* screen to close the *Line Editor*.

Mill Tool Setup

1. From the *Options* pull-down menu, select *Tool Setup*. The *Mill Tool Setup* screen appears.
2. Select *Tool Number 9* by clicking on the up and down arrows next to the *Tool Number* field. *1/4" End Mill* appears below the *Tool Number*.

The *Bit Diameter* field shows you that the bit diameter is 0.25 inch.

3. When you are done, click on the *OK* button.

Go to the next section in the multimedia presentation.

Activity 2 – Loading the Program

Do the following to load the PART program that you entered in ACTIVITY 1.

1. From the *File* pull-down menu, select *Open*.
2. The *File, Open...* dialog box appears.
3. Scroll until you find your program file.
4. Double-click on your program file.
5. The *Line Editor* appears with the PART program you previously entered.

You are now ready to download your PART program to the CNC mill.

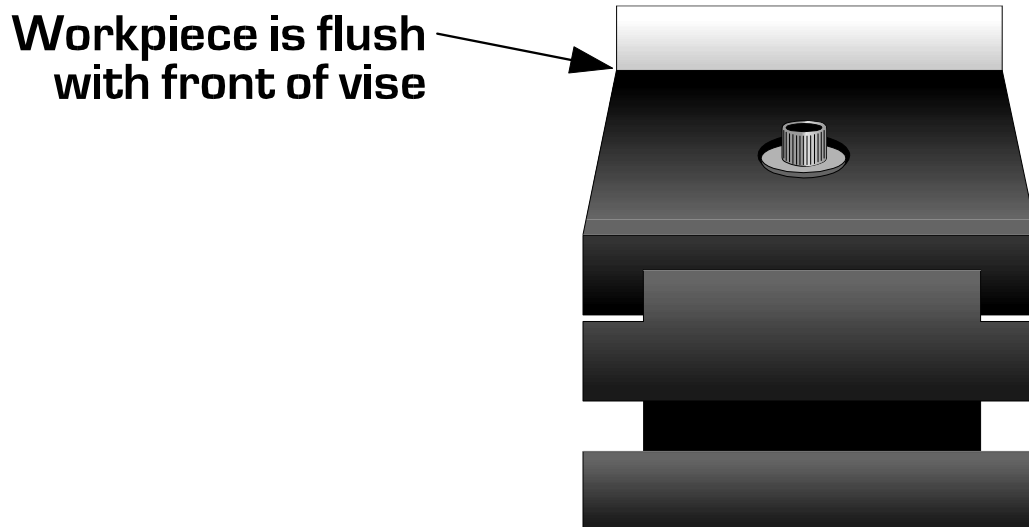
Before you download your PART program, read the following sections, **LOADING THE WORKPIECE** and **SETTING THE TOOL POSITION**.

Loading the Workpiece

The first step in executing the program is to load the workpiece.

1. Turn on the power switch located on the side of the mill.
2. Open the safety door.
3. Clamp a piece of 2" x 2" x .5" (5.08 cm x 5.08 cm x 1.27 cm) Plexiglas in the vise. Make sure it is secure and level, with one half of the Plexiglas above the top of the vise. Make sure the workpiece is flush with the jaws of the vise (use the machinist rule, or ruler, to position the workpiece correctly).

It should look like this:



Setting the Tool Position

Before running your PART program, you must position the milling tool. Your point of reference is known as the Program Reference Zero, or PRZ.

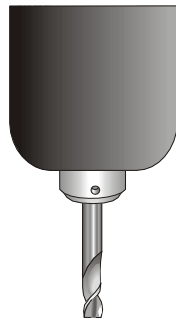
The PRZ is a reference point that enables the computer and the milling machine to locate the X, Y, and Z coordinates that you entered into your PART program.

Quadrant I of the **Cartesian Rectangular Ordinate System** is used in programming to define the PRZ. The PRZ is the point at which the X axis and Y axis intersect.

The PRZ on the workpiece is the point at which the X, Y, and Z axes intersect in the first quadrant.

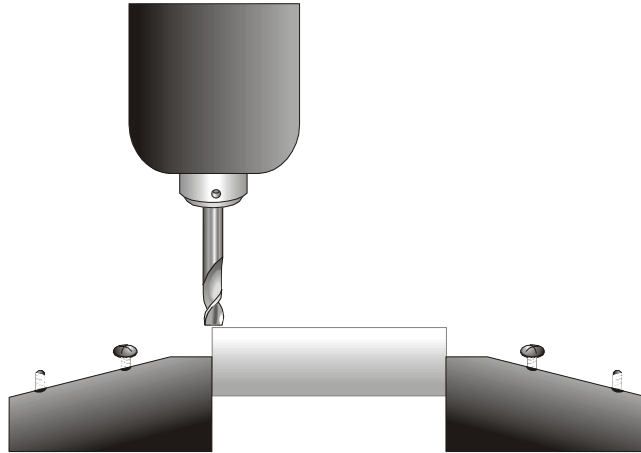
This means that you want to touch the front left corner of the workpiece with the tool.

1. Load a ¼" end mill into the spindle. (If necessary, loosen the small screw in the side of the spindle with an Allen wrench. After inserting the cutter, secure it by tightening the screw.)



2. Close the safety doors.
3. If locked, unlock the EMERGENCY STOP button and remove the key.
4. When you are ready to position the end mill on the front left edge of the workpiece, press MAIN MENU on the CNC Mill control panel. Your choices are Manual, Remote, and Setup.
5. Use the +Z and -Z keys of the control panel keypad to position the cursor next to MANUAL, then press ENTER.

- Using the +X, -X, +Z, -Z, +Y, and -Y keys of the control panel keypad, position the center of the $\frac{1}{4}$ " end mill on the left front corner edge of the workpiece.



- Open the safety door and cover the workpiece with a 2-inch square piece of notebook paper. Close the safety door. Using the +Z and -Z keys, position the end of the cutter onto the top of the paper-covered workpiece, adjusting it so that the cutter is touching the paper, but the paper can be pulled free without ripping. Remove the paper.
- Press ZERO twice. This sets the PRZ for the X, Y, and Z axes to the current cutter position.
- Press +Z to raise the headstock above the block.
- Press the ESC key on the control panel to return to the MAIN MENU.

Downloading Your Part Program

1. From the control panel on the CNC MILL MAIN MENU, use the -Z key to move the cursor next to REMOTE and press ENTER.
2. The mill's display now reads:

Ready to Download

<Esc> Abort

3. From the *Mill* pull-down menu, select *Download*. The *Serial Download* screen appears.

The *Remote Machine* field tells you that you are downloading to a 5400 Mill.

The *Status* field tells you that you are ready to transmit and the *Last Error* field tells you that there are no errors. If an error occurs, this field displays the error message code for the problem. If this happens, ask your instructor for help.

4. Click on the *OK* button.

Look at the display on the mill's control panel and you will see "Downloading" and a rotating cursor indicating that your PART program is being downloaded to the mill.

When the *Download Complete* screen is displayed on the mill, your PART program has been downloaded.

5. Close the *Line Editor* by clicking on the (X) in the upper right corner.

Executing Your Program

You should have your program loaded, the workpiece loaded, and the PRZ set. You are now ready to execute your PART program. Remember to always wear safety glasses when operating the mill.

1. Press ENTER on the mill control panel keypad. As the program executes, the display line will change as it moves from line to line.
2. Watch the mill closely and make sure enough of the workpiece is protruding from the vise and that you will not have a tool crash. After the program has finished, the mill will return to its home position and then stop.

Go to the next section, **CLEANUP**.

Cleanup

1. Open the safety doors and carefully remove the workpiece.
2. Press *Esc* to return to the *Mill* menu.
3. Press the EMERGENCY STOP button.
4. Turn off the power switch located on the side of the mill.
5. Clean up your area and return everything to its proper place. You may want to use a shop vacuum to carefully clean out the inside of the mill.

When you are finished, go to the next section in the multimedia presentation.

Mill Level 4 Software Programming Sheet #2

Program Information

Program Name	
Author	
Material	
Drawing No.	
Width (X)	
Depth (Y)	
Height (Z)	

Tools Used

Tool #	Description	Diameter	Radius
9			
5			

PART Program

Line #	Instruction	Comment
00001		
00002		
00003		
00004		
00005		
00006		
00007		
00008		
00009		
00010		

PART Program (continued)

Line #	Instruction	Comment
00011		
00013		
00014		
00015		
00016		
00017		
00018		
00019		
00020		
00021		
00022		
00023		
00024		
00025		
00026		
00027		
00028		
00029		
00030		
00031		
00032		
00033		
00034		
00035		
00036		
00037		
00038		

PART Program (continued)

Line #	Instruction	Comment
00039		
00040		
00041		
00042		
00043		
00044		
00045		
00046		
00047		
00048		
00049		
00050		
00051		
00052		
00053		
00054		
00055		
00056		
00057		
00058		
00059		
00060		
00061		
00062		
00063		
00064		

Activity 3 – You Are the Programmer

For this section, refer to your completed **Mill Level 4 Software Programming Sheet #2** as you work on the computer.

1. From the *File* pull-down menu, select *New*. The *Program Setup* screen appears.
2. Delete <UNTITLED> from the *Program Name* field and leave it blank.
3. Delete *Teacher* from the *Author* field and enter your name.
4. In the *Drawing ID* field, the default, *Project #1*, should appear in the project field. If this is incorrect, highlight the text and enter a project number.
5. In the *Material* section of the screen, select *Plastic*. If you are using wax, select *Wax*.
6. In the *Editor* portion of the screen, make sure *Line Mode* is selected.
7. In the *Units* portion of the screen, make sure *Inch* is selected.
8. In the *Coordinates* section, make sure *Absolute* is selected.
9. Enter the appropriate values in the X, Y, and Z fields. (X=2) (Y=2) (Z=0.5).
10. Click on the *OK* button. The *Line Editor* appears.

Complete the next section, **ENTERING THE PART PROGRAM**.

Entering the Program

Notice that the *Line Editor* is numbered, starting with 00001; this is your first line of code. You will use the line numbers on your **Mill Level 4 Software Programming Sheet #2** as a reference.

You will be inserting your program in front of the alphabet subroutines. The subroutines must be listed after the final M30 code of the base program. Instructions for doing this are provided in the section titled **ALPHA PROGRAM**.

1. For the first line of instruction, begin by typing a backslash, “\”, followed by your name and class. The backslash tells the computer to ignore any information following it. You use this for information purposes only. If you did not type the backslash, the computer would not recognize or accept the information. Line 00001 should look like this:

```
\YOUR NAME CLASS
```

2. Press *Enter*. The cursor will move to line 00002.
3. Using your **Mill Level 4 Software Programming Sheet #2**, continue entering the remaining lines of your program.

Saving the Program

1. From the *File* menu, select *Save as*. The *File, Save As...* dialog box opens.
2. In the *File name* field, enter your name and PART program (project) number. You can abbreviate if necessary. Your name will automatically be entered in the *Program Name* field on the *Program Setup* screen.

Notice that the *Save in* field shows you that the program will be saved in the M4 directory in the *Mill Level 4* program.

NOTE: Whenever you save a program, it is very important that you pay attention to the location of the program so that you can access it at any time.

3. Click on the *Save* button. The name you assigned to your program now appears on the *Line Editor* title bar.

Your program, which can be identified by your name and PART program (project) number, is now saved in the M4 directory with the other PART programs.

Alpha Program

The *Alpha* program contains the text creation subroutines, which will be called upon by the M97 commands you entered in your PART program. Follow the steps below to copy the *Alpha* program to the *Line Editor*.

1. Close the *Line Editor*.
2. From the *File* pull-down menu, select *Open*. The *File, Open...* screen appears.
3. Double-click on the *Alpha* program.
4. From the *Edit* pull-down menu, select *Select All*. From the *Edit* pull-down menu, select *Copy*.
5. Close the *Line Editor (Alpha program)*.
6. From the *File* pull-down menu, select *Open*.
7. The *File, Open...* dialog box appears.
8. Scroll until you find your program file that you have just entered.
9. Double-click on your program file. The *Line Editor* appears with the PART program you previously entered.
10. Scroll down to the end of the program. Click on the next available line.
11. From the *Edit* pull-down menu, select *Paste*.
12. From the *File* pull-down menu, select *Save*.

The *Alpha* program can now be called upon when text is needed.

13. Compile the program. If necessary, refer to **COMPILING THE PROGRAM** in the **ACTIVITY 1** section.
14. Emulate the program. If necessary, refer to **EMULATING THE PROGRAM** in the **ACTIVITY 1** section.
15. Select the proper end mill. If necessary, refer to **MILL TOOL SETUP** in the **ACTIVITY 1** section.

16. Load the workpiece. If necessary, refer to **LOADING THE WORKPIECE** in the **ACTIVITY 2** section.
17. Set the tool position. If necessary, refer to **SETTING THE TOOL POSITION** in the **ACTIVITY 2** section.
18. Download the program. If necessary, refer to **DOWNLOADING YOUR PROGRAM** in the **ACTIVITY 2** section.
19. Execute your program. If necessary, refer to **EXECUTING YOUR PROGRAM** in the **ACTIVITY 2** section.

How to Make a Tool Change

At line 00044, you will have to make a tool change. When the mill has completed machining with the current tool, the mill will move the tool to the programmed tool change position. The mill control panel will say *Tool Change. Fit Tool 5 then press <Enter>*.

1. Open the safety doors.
2. Remove the holder with the ¼" end mill using the holder bars to loosen the holder from the spindle, and install the holder with the 1/16" end mill.
3. Insert one holder bar into the hole in the holder and the other collet bar into the hole in the spindle above the holder.
4. Holding the spindle and still using the top holder bar, twist the bar in the collet clockwise until the holder is loose.
5. Remove the holder with the 1/4" end mill.
6. Install the holder with the 1/16" end mill.
7. When the holder is completely on, use the holder bars to snug the holder onto the spindle. **DO NOT OVERTIGHTEN!**
8. Close the safety doors.
9. Press the ENTER key on the mill control panel to tell the mill that the tool has been changed.
10. On line 00057, you will have to make another tool change. Following the above steps, remove the holder with the 1/16" end mill and install the holder with the ¼" end mill.

Completing the Program

1. After the program has finished, open the safety door and carefully remove the workpiece.
2. Press *Esc* to return to the *Mill* menu.
3. Press the EMERGENCY STOP button.
4. Turn off the power switch located on the left side of the mill.
5. Clean up your area and return everything to its proper place.

When you are finished, go to the next section in the multimedia presentation.

Activity 4

Before completing this activity, check with your instructor to see if you should download this PART program from a master floppy disk or enter it manually.

Complete the next section, **YOU ARE THE PROGRAMMER.**

You Are the Programmer

1. Click on the *File* menu and select *New*. The *Program Setup* screen appears.
2. Delete *<UNTITLED>* from the *Program Name* field and leave it blank.
3. Delete *Teacher* from the *Author* field and enter your name.
4. In the *Drawing No.* field, the default, *Project #1*, should appear. If this is incorrect, highlight the text and enter a project number.
5. In the *Material* section of the screen, select *Wax*. If you are using plastic, select *Plastic*.
6. In the *Editor* portion of the screen, make sure *Line Mode* is selected.
7. In the *Units* portion of the screen, make sure *Inch* is selected.
8. In the *Coordinates* section, make sure *Absolute* is selected.
9. Enter the appropriate values in the X, Y, and Z fields. (X=6) (Y=3) (Z=0.5).
10. Click on the *OK* button. The *Line Editor* appears.

Complete the next section, **ENTERING THE PROGRAM.**

Entering the Part Program

1. Click anywhere in the *Line Editor*. A cursor appears next to *Line 00001*. On this line, enter a backslash (\), then your name.
2. Use the *Enter* key to go to the next line.
3. Enter the following program, starting on Line 00002. Make sure that you and your partner use spaces where indicated.

NOTE: It is a good idea to save the program periodically since it is so large. To initially save your program, refer to **SAVING THE PROGRAM** in the **ACTIVITY 3** section. Once you have done this, at random intervals, select *Save* from the *File* pull-down menu. Save again when the entire program has been entered.

Double-check your work when you are done.

```
00001 \your name
00002 \class
00003 G70
00004 M06 9
00005 M04 2800
00006 G94 6
00007 G00
00008 X2.35 Y1.125 G00
00009 G01
00010 Z.1
00011 Z-.1
00012 X.35
00013 G00
00014 Z-.2
00015 X2.35
00016 Z-.25
00017 X.5
00018 Z.1 G00
00019 X2.35 Y1.875 G00
00020 G01
00021 Z-.1
00022 X.35
00023 Z-.2
00024 X2.35
00025 Z-.25
```

```
00026 X.35
00027 G00
00028 Z.1 G00
00029 X1.725 Y.5 G00
00030 G01
00031 Z-.1
00032 Y2.5
00033 Z-.2
00034 Y.5
00035 Z-.25
00036 G00
00037 Z.1 G00
00038 X0.975 Y.5 G00
00039 G01
00040 Z-.1
00041 Y2.5
00042 Z-.2
00043 Y.5
00044 Z-.25
00045 Y2.5
00046 G00
00047 Z.1 G00
00048 X3.25 Y.75 G00
00049 G01
00050 Z-.1
00051 X2.75
00052 G01
00053 Y2.25
00054 X4
00055 X3.25 Y.75
00056 Z-.2
00057 X2.75
00058 Y2.25
00059 X4
00060 X3.25 Y.75
00061 Z-.25
00062 X2.75
00063 Y2.25
00064 X4
00065 X3.25 Y.75
00066 G00
00067 Z.1 G00
00068 X2.977 Y.909 G00
00069 G01
00070 Z.15
00071 X2.813 Y.813 Z-.1
```

00072 X3.211
00073 X3.261 Y.911
00074 X2.813
00075 Y1.009
00076 X3.31
00077 X3.359 Y1.107
00078 X2.813
00079 Y1.205
00080 X3.408
00081 X3.457 Y1.304
00082 X2.813
00083 Y1.402
00084 X3.506
00085 X3.555 Y1.5
00086 X2.813
00087 Y1.598
00088 X3.604
00089 X3.653 Y1.696
00090 X2.813
00091 Y1.795
00092 X3.702
00093 X3.752 Y1.893
00094 X2.813
00095 Y1.991
00096 X3.801
00097 X3.85 Y2.089
00098 X2.813
00099 Y2.187
00100 X3.899
00101 G00
00102 Z.1 G00
00103 X2.977 Y.909 G00
00104 G01
00105 Z.05
00106 X2.813 Y.813 Z-.2
00107 X3.211
00108 X3.261 Y.911
00109 X2.813
00110 Y1.009
00111 X3.31
00112 X3.359 Y1.107
00113 X2.813
00114 Y1.205
00115 X3.408
00116 X3.457 Y1.304
00117 X2.813

00118 Y1.402
00119 X3.506
00120 X3.555 Y1.5
00121 X2.813
00122 Y1.598
00123 X3.604
00124 X3.653 Y1.696
00125 X2.814
00126 Y1.795
00127 X3.702
00128 X3.752 Y1.893
00129 X2.813
00130 Y1.991
00131 X3.801
00132 X3.85 Y2.089
00133 X2.813
00134 Y2.187
00135 X3.899
00136 G00
00137 Z.1 G00
00138 X2.977 Y.909 G00
00139 G01
00140 Z0
00141 X2.813 Y.813 Z-.25
00142 X3.211
00143 X3.261 Y.911
00144 X2.813
00145 Y1.009
00146 X3.31
00147 X3.359 Y1.107
00148 X2.813
00149 Y1.205
00150 X3.408
00151 X3.457 Y1.304
00152 X2.813
00153 Y1.402
00154 X3.506
00155 X3.555 Y1.5
00156 X2.813
00157 Y1.598
00158 X3.604
00159 X3.543 Y1.696
00160 X2.813
00161 Y1.795
00162 X3.702
00163 X3.752 Y1.893

```
00164 X2.813
00165 Y1.991
00166 X3.801
00167 X3.85 Y2.089
00168 X2.813
00169 Y2.187
00170 X3.899
00171 G00
00172 Z.1 G00
00173 X.833 Y.833 Z.1 G00
00174 G81
00175 X.6 Y.75 Z-.25 G00
00176 X1.35 Z-.25 G00
00177 X2.1 Z-.25 G00
00178 Y1.5 Z-.25 G00
00179 X1.35 Z-.25 G00
00180 X.6 Z-.25 G00
00181 Y2.25 Z-.25 G00
00182 X1.35 Z-.25 G00
00183 X2.1 Z-.25 G00
00184 X4.5 Y2.5 Z-.25 G00
00185 X4.25 Y2 Z-.25
00186 X4.75 Z-.25 G00
00187 X4 Y1.5 Z-.25 G00
00188 X4.5 Z-.25 G00
00189 X5 Z-.25 G00
00190 X3.75 Y1 Z-.25 G00
00191 X4.25 Z-.25 G00
00192 X4.75 Z-.25 G00
00193 X5.25 Z-.25 G00
00194 X3.5 Y.5 Z-.25 G00
00195 X4 Z-.25 G00
00196 X4.5 Z-.25 G00
00197 X5 Z-.25 G00
00198 X5.5 Z-.25 G00
00199 G80
00200 G01
00201 Z1 G00
00202 X0 Y0 G00
00203 M04 0
00204 M30
```

Congratulations! You made it! If you didn't save when you finished, do it now.

4. Compile the program. If necessary, refer to **COMPILING THE PROGRAM** in the **ACTIVITY 1** section.

5. Emulate the program. If necessary, refer to **EMULATING THE PROGRAM** in the **ACTIVITY 1** section.
6. Close the *Line Editor*.
7. Return the floppy disk to your instructor if one was provided.

Go to the next section in the multimedia presentation.

Activity 5

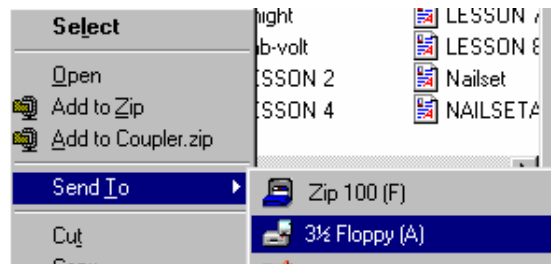
1. Load the program. If necessary, refer to **LOADING THE PROGRAM** in **ACTIVITY 2**.
2. In order to load the 6" x 3" x 0.5" (15.24 cm x 7.62 cm x 1.27 cm) workpiece onto the bed of the 5400 CNC Mill, you must first remove the 2" x 2" (5.08 cm x 5.08 cm) vise. To do this, use your Allen key to loosen the L-shaped hold-down brackets. Once loose, remove the vise from the mill.
3. Next, place the 6" x 3" x 0.5" workpiece on the bed, carefully aligning the front edge so that it is parallel with the front edge of the bed surface.
4. Place one L-shaped bracket on the left side of the workpiece in the rear T-slot on the bed, and place the second bracket on the right side in the front T-slot. Tighten the brackets with the Allen key so that the workpiece is firmly held in place on the bed.
5. Set the tool position. If necessary, refer to **SETTING THE TOOL POSITION** in **ACTIVITY 2**.
6. Download the program. If necessary, refer to **DOWNLOADING YOUR PROGRAM** in **ACTIVITY 2**.
7. Execute the program. If necessary, refer to **EXECUTING YOUR PROGRAM** in **ACTIVITY 2**.
8. Clean up. If necessary, refer to **CLEANUP** in **ACTIVITY 2**.

When you are finished, go to the next section in the multimedia presentation.

Saving to a Floppy Disk

When all lesson activities have been completed, your PART programs should be saved to a floppy disk and then removed from the M4 directory. Your PART programs can be downloaded to *Mill Level 4* at any time in the future if necessary. Follow the steps below.

1. Get a blank floppy disk from your instructor and label it with the names you assigned to the programs when they were initially created. Be sure to include your name.
2. Place the floppy disk in your computer floppy disk drive.
3. From the *File* pull-down menu, select *Open*. The File, Open window appears and shows all the PART programs stored in the M4 directory.
4. Right-click on one of your program files. A pop-up menu appears. Select *Send To* and then click *3½ Floppy (A)*. Your computer will now download a copy of the program file to your floppy disk.



5. After the PART program has successfully copied to your floppy disk, right-click again on the program file. From the pop-up menu, click *Delete*. A *Confirm File Delete* dialog box appears. Click *Yes*. Your PART program is now permanently deleted from the directory.
6. Repeat these steps for each program file you have stored in the M4 directory.
7. When you are done, remove the floppy disk.

Go to the next section in the multimedia presentation.

COMPREHENSIVE LEVEL

Mill Level 4 Software Programming Sheet #1**Program Information**

Program Name	
Author	
Material	
Drawing No.	
Width (X)	
Depth (Y)	
Height (Z)	

PART Program

Line #	Instruction	Comment
00001		
00002		
00003		
00004		
00005		
00006		
00007		
00008		
00009		
00010		
00011		
00012		
00013		

Activity 1 – You Are the Programmer

For this section, refer to your completed **Mill Level 4 Software Programming Sheet #1** as you work on the computer.

1. From the *File* pull-down menu, select *New*. The *Program Setup* screen appears.
2. Delete <UNTITLED> from the *Program Name* field and leave it blank.
3. Delete *Teacher* from the *Author* field and enter your name.
4. In the *Drawing ID* field, the default, *Project #1*, should appear in the project field. If this is incorrect, highlight the text and enter a project number.
5. In the *Material* section of the screen, select *Plastic*. If you are using wax, select *Wax*.
6. In the *Editor* portion of the screen, make sure *Line Mode* is selected.
7. In the *Units* portion of the screen, make sure *Inch* is selected.
8. In the *Coordinates* section, make sure *Absolute* is selected.
9. Enter the appropriate values in the X, Y, and Z fields. (X=2) (Y=2) (Z=0.5).
10. Click on the *OK* button. The *Line Editor* appears.

Complete the next section, **ENTERING THE PART PROGRAM**.

Entering the Program

Notice that the *Line Editor* is numbered, starting with 00001; this is your first line of code. You will use the line numbers on your **Mill Level 4 Software Programming Sheet #1** as a reference.

1. For the first line of instruction, begin by typing a backslash, “\”, followed by your name and class. The backslash tells the computer to ignore any information following it. You use this for information purposes only. If you did not type the backslash, the computer would not recognize or accept the information. Line 00001 should look like this:

\YOUR NAME CLASS

2. Press *Enter*. The cursor will move to line 00002.
3. Look at line 00002 on your **Mill Level 4 Software Programming Sheet #1**. You should have G70 written in the instruction. This tells the computer to use inches for measurement. Type “G70”, then press *Enter* for line 00002.
4. Using your **Mill Level 4 Software Programming Sheet #1**, continue entering the remaining lines of your program.
5. On line 00003, you will turn on the spindle motor with the M04 code and set the spindle speed to 2800 RPM. Type “M04 2800”, then press *Enter*.
6. On line 00004, you will set the feed rate at 4 inches per minute. Type “M07 4”, then press *Enter*.
7. Now enter your first **tool movement code** on line 00005. If you are moving in a straight line from one point to another, you use the Linear Interpolation command, which is G01. Type “G01”, then press *Enter*.
8. Using your **Mill Level 4 Software Programming Sheet #1**, continue entering the remaining lines of your program.

Saving the Program

1. From the *File* menu, select *Save as*. The *File, Save As...* dialog box opens.
2. In the *File name* field, enter your name and PART program (project) number. You can abbreviate if necessary. Your name will automatically be entered in the *Program Name* field on the *Program Setup* screen.

Notice that the *Save in* field shows you that the program will be saved in the M4 directory in the *Mill Level 4* program.

NOTE: Whenever you save a program, it is very important that you pay attention to the location of the program so that you can access it at any time.

3. Click on the *Save* button. The name you assigned to your program now appears on the *Line Editor* title bar.

Your program, which can be identified by your name and PART program (project) number, is now saved in the M4 directory with the other PART programs.

Compiling the Program

1. From the *Mill* pull-down menu, select *Compile*.

When the *CNC Compiler* opens, the program immediately performs a line-by-line check of your PART program.

The *Status* field should say "Success! No Errors Detected."

If an error is found, the *Line Editor* will highlight the line of code that is incorrect. You should then check your error against the information on your **Software Programming Sheet** and make the necessary changes. You must close the *Compiler* and re-open it each time an error is corrected. A mistake as simple as a missing space can cause an error.

2. If any corrections were made, select *Save* from the *File* pull-down menu.
3. When you are done, click on *OK*.

Emulating the Program

The word *emulate* means to copy, or to simulate. With the *Mill Level 4* program, you can have the computer emulate the milling process that you programmed.

NOTE: Emulation helps programmers and manufacturing engineers to see if the program they entered is correct. This saves time because they don't have to make a test part, and it saves money because no materials will be wasted.

1. From the *Mill* pull-down menu, select *Emulator*. The *Mill 3D Emulator* opens.
2. Choose the top view (top-right button) from the *View* section and then click on the green start button in the *Control* section to see how your part will be machined on the mill.
3. Next click on the front view (top-left button) in the view screen to see the depth of cut. Click on the green start button in the control section to see another view of how your part will be machined on the mill.
4. Click on the *Close* button (X) in the upper right corner of the Emulator screen to close the *Emulator*.
5. Click on the *Close* button (X) in the upper right corner of the Line Editor screen to close the Line Editor.

Mill Tool Setup

1. From the *Options* pull-down menu, select *Tool Setup*. The *Mill Tool Setup* screen appears.
2. Select *Tool Number 9* by clicking on the up and down arrows next to the *Tool Number* field. *¼" End Mill* appears below the *Tool Number*. The *Bit Diameter* field shows you that the bit diameter is 0.25 inch.
3. When you are done, click on the *OK* button.

Go to the next section in the multimedia presentation.

Mill Level 4 Software Programming Sheet #2

Program Information

Program Name	
Author	
Material	
Drawing No.	
Width (X)	
Depth (Y)	
Height (Z)	

Tools Used

Tool #	Description	Diameter	Radius
9			

PART Program

Line #	Instruction	Comment
00001		
00002		
00003		
00004		
00005		
00006		
00007		
00008		
00009		
00010		
00011		

PART Program (continued)

Line #	Instruction	Comment
00012		
00013		
00014		
00015		
00016		
00017		
00018		
00019		
00020		
00021		
00022		
00023		
00024		
00025		
00026		
00027		
00028		
00029		

Activity 2 – You Are the Programmer

For this section, refer to your completed **Mill Level 4 Software Programming Sheet #2** as you work on the computer.

1. From the *File* pull-down menu, select *New*. The *Program Setup* screen appears.
2. Delete <UNTITLED> from the *Program Name* field and leave it blank.
3. Delete *Teacher* from the *Author* field and enter your name.
4. In the *Drawing ID* field, the default, *Project #1*, should appear in the project field. If this is incorrect, highlight the text and enter a project number.
5. In the *Material* section of the screen, select *Plastic*. If you are using wax, select *Wax*.
6. In the *Editor* portion of the screen, make sure *Line Mode* is selected.
7. In the *Units* portion of the screen, make sure *Inch* is selected.
8. In the *Coordinates* section, make sure *Absolute* is selected.
9. Enter the appropriate values in the X, Y, and Z fields. (X=2) (Y=2) (Z=0.5).
10. Click on the *OK* button. The *Line Editor* appears.

Complete the next section, **ENTERING THE PART PROGRAM**.

Entering the Part Program

Notice that the *Line Editor* is numbered, starting with 00001; this is your first line of code. You will use the line numbers on your **Mill Level 4 Software Programming Sheet #1** as a reference.

1. For the first line of instruction, begin by typing a backslash, “\”, followed by your name and class. The backslash tells the computer to ignore any information following it. You use this for information purposes only. If you did not type the backslash, the computer would not recognize or accept the information. Line 00001 should look like this:

\YOUR NAME CLASS

2. Press *Enter*. The cursor will move to line 00002.
3. Look at line 00002 on your **Mill Level 4 Software Programming Sheet #2**. You should have G70 written in the instruction. This tells the computer to use inches for measurement. Type “G70”, then press *Enter* for line 00002.
4. On line 00003, you will turn on the spindle motor with the M04 code and set the spindle speed to 2800 RPM. Type “M04 2800” then press *Enter*.

Using your **Mill Level 4 Software Programming Sheet #2**, continue entering the remaining lines of your program.

Saving the Program

1. From the *File* menu, select *Save as*. The *File, Save As...* dialog box opens.
2. In the *File name* field, enter your name and PART program (project) number. You can abbreviate if necessary. Your name will automatically be entered in the *Program Name* field on the *Program Setup* screen.

Notice that the *Save in* field shows you that the program will be saved in the M4 directory in the *Mill Level 4* program.

NOTE: Whenever you save a program, it is very important that you pay attention to the location of the program so that you can access it at any time.

3. Click on the *Save* button. The name you assigned to your program now appears on the *Line Editor* title bar.

Your program, which can be identified by your name and PART program (project) number, is now saved in the M4 directory with the other PART programs.

Compiling the Program

1. From the *Mill* pull-down menu, select *Compile*.

When the *CNC Compiler* opens, the program immediately performs a line-by-line check of your PART program. The *Status* field should say “Success! No Errors Detected.”

2. If an error is found, the *Line Editor* will highlight the line of code that is incorrect. You should then check your error against the information on your **Software Programming Sheet** and make the necessary changes. You must close the *Compiler* and re-open it each time an error is corrected. A mistake as simple as a missing space can cause an error.
3. If any corrections were made, select *Save* from the *File* pull-down menu.
4. When you are done, click on *OK*.

Emulating the Program

The word *emulate* means to copy, or to simulate. With the *Mill Level 4* program, you can have the computer emulate the milling process that you programmed.

NOTE: Emulation helps programmers and manufacturing engineers to see if the program they entered is correct. This saves time because they don't have to make a test part, and it saves money because no materials will be wasted.

1. From the *Mill* pull-down menu, select *Emulator*. The *Mill 3D Emulator* opens.
2. Choose the top view (top-right button) from the *View* section and then click on the green start button in the *Control* section to see how your part will be machined on the mill.
3. Next, click on the front view (top-left button) in the view screen to see the depth of cut. Click on the green start button in the control section to see another view of how your part will be machined on the mill.
4. Click on the *Close* button (X) in the upper right corner of the *Emulator* screen to close the *Emulator*.

Mill Tool Setup

1. From the *Options* pull-down menu, select *Tool Setup*. The Mill Tool Setup screen appears.
2. Select *Tool Number 9* by clicking on the up and down arrows next to the *Tool Number* field. *1/4" End Mill* appears below the *Tool Number*.

The *Bit Diameter* field shows you that the bit diameter is 0.25 inch.

3. When you are done, click on the *OK* button.
4. From the *File* pull-down menu, select *Save*.

Go to the next section in the multimedia presentation.

Activity 3 – Loading the Program

Do the following to load the PART program that you entered in ACTIVITY 2.

1. From the *File* pull-down menu, select *Open*.
2. The *File, Open...* dialog box appears.
3. Scroll until you find your program file.
4. Double-click on your program file. The *Line Editor* appears with the PART program you previously entered.

You are now ready to download your PART program to the CNC mill.

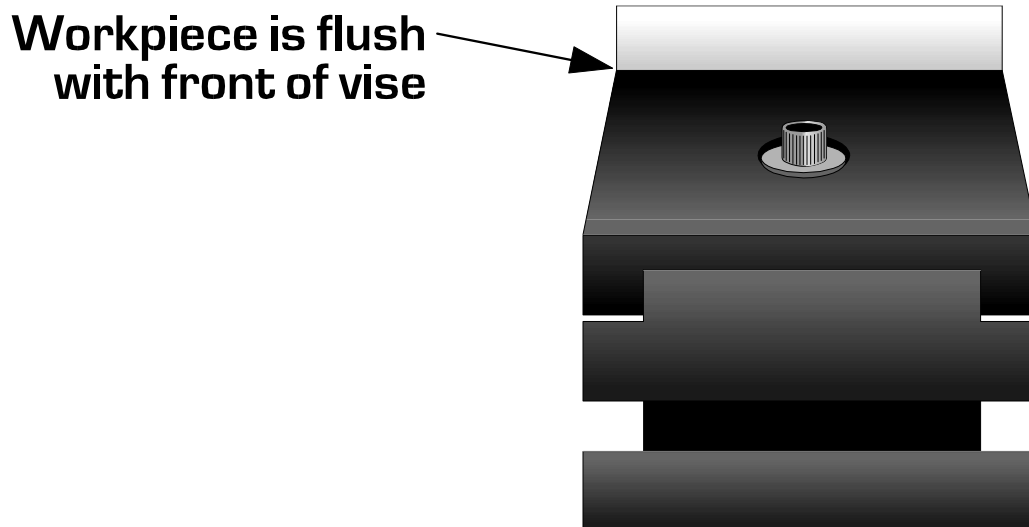
Before you download your PART program, read the following sections, **LOADING THE WORKPIECE** and **SETTING THE TOOL POSITION**.

Loading the Workpiece

The first step in executing the program is to load the workpiece.

1. Turn on the power switch located on the side of the mill.
2. Open the safety door.
3. Clamp a piece of 2" x 2" x .5" Plexiglas in the vise. Make sure it is secure and level, with one half of the Plexiglas above the top of the vise. Make sure the workpiece is flush with the jaws of the vise (use the machinist rule, or ruler, to position the workpiece correctly).

It should look like this:



Setting the Tool Position

Before running your PART program, you must position the milling tool. Your point of reference is known as the Program Reference Zero, or PRZ.

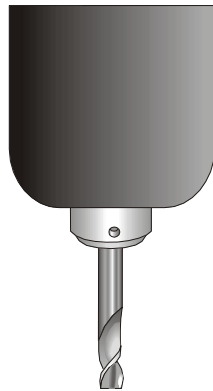
The PRZ is a reference point that enables the computer and the milling machine to locate the X, Y, and Z coordinates that you entered into your PART program.

Quadrant I of the **Cartesian Rectangular Ordinate System** is used in programming to define the PRZ. The PRZ is the point at which the X axis and Y axis intersect.

The PRZ on the workpiece is the point at which the X, Y, and Z axes intersect in the first quadrant.

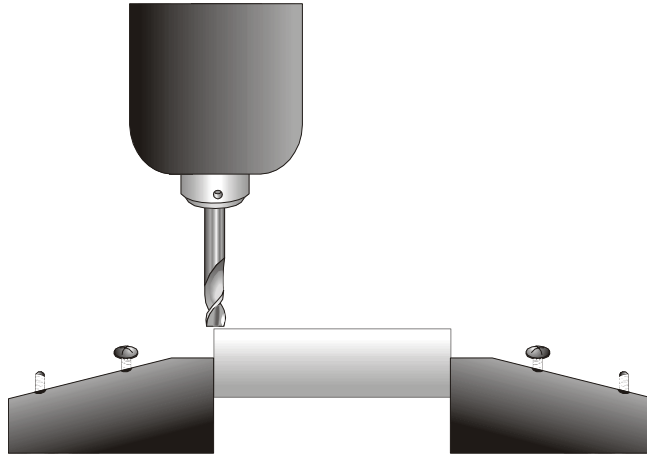
This means that you want to touch the front left corner of the workpiece with the tool.

1. Load a ¼" end mill into the spindle. (If necessary, loosen the small screw in the side of the spindle with an Allen wrench. After inserting the cutter, secure it by tightening the screw.)



2. Close the safety doors.
3. If locked, unlock the EMERGENCY STOP button and remove the key.
4. When you are ready to position the end mill on the left front edge of the workpiece, press MAIN MENU on the CNC Mill control panel. Your choices are Manual, Remote, and Setup.
5. Use the +Z and -Z keys of the control panel keypad to position the cursor next to MANUAL, then press ENTER.

- Using the +X, -X, +Z, -Z, +Y, and -Y keys of the control panel keypad, position the center of the $\frac{1}{4}$ " end mill on the left front edge of the workpiece.



- Open the safety door and cover the workpiece with a 2-inch square piece of notebook paper. Close the safety door. Using the +Z and -Z keys, position the end of the cutter onto the top of the paper-covered workpiece, adjusting it so that the cutter is touching the paper, but the paper can be pulled free without ripping. Remove the paper.
- Press *Zero* twice. This sets the PRZ for the X, Y, and Z-axes to the current cutter position.
- Press +Z to raise the headstock above the block.
- Press the ESC key on the control panel to return to the MAIN MENU.

Saving the Program

1. From the *File* menu, select *Save as*. The *File, Save As...* dialog box opens.
2. In the *File name* field, enter your name and PART program (project) number. You can abbreviate if necessary. Your name will automatically be entered in the *Program Name* field on the *Program Setup* screen.

Notice that the *Save in* field shows you that the program will be saved in the M4 directory in the *Mill Level 4* program.

NOTE: Whenever you save a program, it is very important that you pay attention to the location of the program so that you can access it at any time.

3. Click on the *Save* button. The name you assigned to your program now appears on the *Line Editor* title bar.

Your program, which can be identified by your name and PART program (project) number, is now saved in the M4 directory with the other PART programs.

After you have completed downloading your PART program to the mill and you have machined the part, you will learn how to save your program to a floppy disk and then remove it from the CONTROL program.

Downloading Your Program

1. From the control panel on the CNC Mill MAIN MENU, use the -Z key to move the cursor next to REMOTE and press ENTER.
2. The mill's display now reads:

Ready to Download

<Esc> Abort

3. From the *Mill* pull-down menu, select *Download*. The *Serial Download* screen appears. The *Remote Machine* field tells you that you are downloading to a 5400 Mill. The *Status* field tells you that you are ready to transmit and the *Last Error* field tells you that there are no errors. If an error occurs, this field displays the error message code for the problem. If this happens, ask your instructor for help.
4. Click on the *OK* button.

Look at the display on the mill's control panel and you will see "Downloading" and a rotating cursor indicating that your PART program is being downloaded to the mill.

When the *Download Complete* screen is displayed on the mill, your PART program has been downloaded.

Executing Your Program

You should have your program loaded, the workpiece loaded, and the PRZ set. You are now ready to execute your PART program. Remember to always wear safety glasses when operating the mill.

1. Press ENTER on the mill control panel keypad. As the program executes, the display line will change as it moves from line to line.
2. Watch the mill closely and make sure that enough of the workpiece is protruding from the vise and that you will not have a tool crash. After the program has finished, the mill will return to its home position and then stop.
3. At your computer, close the *Line Editor* by clicking on the (X) in the upper right corner.

Cleanup

1. Open the safety door and carefully remove the workpiece.
2. Press *Esc* to return to the *Mill* menu.
3. Press the EMERGENCY STOP button.
4. Turn off the power switch located on the side of the mill.
5. Clean up your area and return everything to its proper place. You may want to use a shop vacuum to carefully clean out the inside of the mill.

When you are finished, go to the next section in the multimedia presentation.

Mill Level 4 Software Programming Sheet #3

Program Information

Program Name	
Author	
Material	
Drawing No.	
Width (X)	
Depth (Y)	
Height (Z)	

Tools Used

Tool #	Description	Diameter	Radius
9			
5			

PART Program

Line #	Instruction	Comment
00001		
00002		
00003		
00004		
00005		
00006		
00007		
00008		
00009		
00010		

PART Program (continued)

Line #	Instruction	Comment
00011		
00012		
00013		
00014		
00015		
00016		
00017		
00018		
00019		
00020		
00021		
00022		
00023		
00024		
00025		
00026		
00027		
00028		
00029		
00030		
00031		
00032		
00033		
00034		
00035		
00036		
00037		

PART Program (continued)

Line #	Instruction	Comment
00038		
00039		
00040		
00041		
00042		
00043		
00044		
00045		
00046		
00047		
00048		
00049		
00050		
00051		
00052		
00053		
00054		
00055		
00056		
00057		
00058		
00059		
00060		
00061		
00062		
00063		
00064		

Activity 4 – Entering the Part Program

For this section, refer to your completed **Mill Level 4 Software Programming Sheet #3** as you work on the computer.

1. From the *File* pull-down menu, select *New*. The *Program Setup* screen appears.
2. Delete <UNTITLED> from the *Program Name* field and leave it blank.
3. Delete *Teacher* from the *Author* field and enter your name.
4. In the *Drawing ID* field, the default, *Project #1*, should appear in the project field. If this is incorrect, highlight the text and enter a project number.
5. In the *Material* section of the screen, select *Plastic*. If you are using wax, select *Wax*.
6. In the *Editor* portion of the screen, make sure *Line Mode* is selected.
7. In the *Units* portion of the screen, make sure *Inch* is selected.
8. In the *Coordinates* section, make sure *Absolute* is selected.
9. Enter the appropriate values in the X, Y, and Z fields. (X=2) (Y=2) (Z=0.5).
10. Click on the *OK* button. The *Line Editor* appears.

Entering the Program

Notice that the *Line Editor* is numbered, starting with 00001; this is your first line of code. You will use the line numbers on your **Mill Level 4 Software Programming Sheet #3** as a reference.

You will be inserting your program in front of the alphabet subroutines. The subroutines must be listed after the final M30 code of the base program. Instructions for doing this are provided in the section titled **ALPHA PROGRAM**.

1. For the first line of instruction, begin by typing a backslash, “\”, followed by your name and class. The backslash tells the computer to ignore any information following it. You use this for information purposes only. If you did not type the backslash, the computer would not recognize or accept the information. Line 00001 should look like this:

\YOUR NAME CLASS

2. Press *Enter*. The cursor will move to line 00002.
3. Using your **Mill Level 4 Software Programming Sheet #3**, continue entering the remaining lines of your program.
4. Save the program. If necessary, refer to **SAVING THE PROGRAM** in **ACTIVITY 2**.

Alpha Program

The *Alpha* program contains the text creation subroutines, which will be called upon by the M97 commands you entered in your PART program. Follow the steps below to copy the *Alpha* program to the *Line Editor*.

1. Close the *Line Editor*.
2. From the *File* pull-down menu, select *Open*. The *File, Open...* screen appears.
3. Double-click on the *Alpha* program.
4. From the *Edit* pull-down menu, choose *Select All*. From the *Edit* pull-down menu, select *Copy*.
5. Close the *Line Editor (Alpha program)*.
6. From the *File* pull-down menu, select *Open*. The *File, Open...* dialog box appears.
7. Scroll until you find your program file that you entered in Lesson 7.
8. Double-click on your program file. The *Line Editor* appears with the PART program you previously entered.
9. Scroll down to the end of the program. Click on the next available line.
10. From the *Edit* pull-down menu, select *Paste*.
11. From the *File* pull-down menu, select *Save*.
12. The *Alpha* program can now be called upon when text is needed.
13. Compile the program. If necessary, refer to **COMPILING THE PROGRAM** in **ACTIVITY 1**.
14. Emulate the program. If necessary, refer to **EMULATING THE PROGRAM** in **ACTIVITY 1**.
15. Select the proper end mill. If necessary, refer to **MILL TOOL SETUP** in the **ACTIVITY 1**.
16. Load the workpiece. If necessary, refer to **LOADING THE WORKPIECE** in the **ACTIVITY 3** section.
17. Set the tool position. If necessary, refer to **SETTING THE TOOL POSITION** in the **ACTIVITY 3** section.

18. Download the program. If necessary, refer to **DOWNLOADING YOUR PROGRAM** in the **ACTIVITY 3** section.
19. Execute the program. If necessary, refer to **EXECUTING YOUR PROGRAM** in **ACTIVITY 3** section.

How to Make a Tool Change

At line 0044, you will have to make a tool change. When the mill has completed machining with the current tool, the mill will move the tool to the programmed tool change position. The mill control panel will say *Tool Change. Fit Tool 2 then press <Enter>*.

1. Open the safety doors.
2. Remove the holder with the 1/4" end mill using the holder bars to loosen the holder from the spindle, and install the holder with the 1/16" end mill.
3. Insert one holder bar into the hole in the holder and the other collet bar into the hole in the spindle above the holder.
4. Holding the spindle and still using the top holder bar, twist the bar in the collet clockwise until the holder is loose.
5. Remove the holder with the 1/4" end mill.
6. Install the holder with the 1/16" end mill.
7. When the holder is completely on, use the holder bars to snug the holder onto the spindle. **DO NOT OVERTIGHTEN!**
8. Close the safety doors.
9. Press the ENTER key on the mill control panel to tell the mill that the tool has been changed.
10. On line 0057, you will have to make another tool change. Following the above steps, remove the holder with the 1/16" end mill and install the holder with the 1/4" end mill.

Completing the Program

1. After the program has finished, open the safety door and carefully remove the workpiece.
2. Press *Esc* to return to the *Mill* menu.
3. Press the EMERGENCY STOP button.
4. Turn off the power switch located on the side of the mill.
5. Clean up your area and return everything to its proper place.

When you are finished, go to the next section in the multimedia presentation.

Activity 5

Before completing this activity, check with your instructor to see if you should download this PART program from a master floppy disk or enter it manually.

- Complete the next section, **YOU ARE THE PROGRAMMER**

You Are the Programmer

1. Click on the *File* menu and select *New*. The *Program Setup* screen appears.
2. Delete *<UNTITLED>* from the *Program Name* field and leave it blank.
3. Delete *Teacher* from the *Author* field and enter your name.
4. In the *Drawing No.* field, the default, *Project #1*, should appear. If this is incorrect, highlight the text and enter a project number.
5. In the *Material* section of the screen, select *Wax*. If you are using plastic, select *Plastic*.
6. In the *Editor* portion of the screen, make sure *Line Mode* is selected.
7. In the *Units* portion of the screen, make sure *Inch* is selected.
8. In the *Coordinates* section, make sure *Absolute* is selected.
9. Enter the appropriate values in the X, Y, and Z fields. (X=6) (Y=3) (Z=0.5).
10. Click on the *OK* button. The *Line Editor* appears.

Complete the next section, **ENTERING THE PART PROGRAM.**

Entering the PART Program

1. Click anywhere in the *Line Editor*. A cursor appears next to Line 00001. On this line, enter a backslash (\), then your name.
2. Use the *Enter* key to go to the next line.
3. Enter the following program, starting on Line 00002. Make sure that you and your partner use spaces where indicated.

NOTE: It is a good idea to save the program periodically since it is so large. To initially save your program, refer to **SAVING THE PROGRAM** in the **ACTIVITY 1** section. Once you have done this, at random intervals, select *Save* from the *File* pull-down menu. Save again when the entire program has been entered.

4. Double-check your work when you are done.

```
00001 \your name
00002 \class
00003 G70
00004 M06 9
00005 M04 2800
00006 G94 6
00007 G00
00008 X2.35 Y1.125 G00
00009 G01
00010 Z.1
00011 Z-.1
00012 X.35
00013 G00
00014 Z-.2
00015 X2.35
00016 Z-.25
00017 X.5
00018 Z.1 G00
00019 X2.35 Y1.875 G00
00020 G01
00021 Z-.1
00022 X.35
00023 Z-.2
00024 X2.35
00025 Z-.25
00026 X.35
00027 G00
```

```
00028 Z.1 G00
00029 X1.725 Y.5 G00
00030 G01
00031 Z-.1
00032 Y2.5
00033 Z-.2
00034 Y.5
00035 Z-.25
00036 G00
00037 Z.1 G00
00038 X0.975 Y.5 G00
00039 G01
00040 Z-.1
00041 Y2.5
00042 Z-.2
00043 Y.5
00044 Z-.25
00045 Y2.5
00046 G00
00047 Z.1 G00
00048 X3.25 Y.75 G00
00049 G01
00050 Z-.1
00051 X2.75
00052 G01
00053 Y2.25
00054 X4
00055 X3.25 Y.75
00056 Z-.2
00057 X2.75
00058 Y2.25
00059 X4
00060 X3.25 Y.75
00061 Z-.25
00062 X2.75
00063 Y2.25
00064 X4
00065 X3.25 Y.75
00066 G00
00067 Z.1 G00
00068 X2.977 Y.909 G00
00069 G01
00070 Z.15
00071 X2.813 Y.813 Z-.1
00072 X3.211
00073 X3.261 Y.911
```

00074 X2.813
00075 Y1.009
00076 X3.31
00077 X3.359 Y1.107
00078 X2.813
00079 Y1.205
00080 X3.408
00081 X3.457 Y1.304
00082 X2.813
00083 Y1.402
00084 X3.506
00085 X3.555 Y1.5
00086 X2.813
00087 Y1.598
00088 X3.604
00089 X3.653 Y1.696
00090 X2.813
00091 Y1.795
00092 X3.702
00093 X3.752 Y1.893
00094 X2.813
00095 Y1.991
00096 X3.801
00097 X3.85 Y2.089
00098 X2.813
00099 Y2.187
00100 X3.899
00101 G00
00102 Z.1 G00
00103 X2.977 Y.909 G00
00104 G01
00105 Z.05
00106 X2.813 Y.813 Z-.2
00107 X3.211
00108 X3.261 Y.911
00109 X2.813
00110 Y1.009
00111 X3.31
00112 X3.359 Y1.107
00113 X2.813
00114 Y1.205
00115 X3.408
00116 X3.457 Y1.304
00117 X2.813
00118 Y1.402
00119 X3.506

00120 X3.555 Y1.5
00121 X2.813
00122 Y1.598
00123 X3.604
00124 X3.653 Y1.696
00125 X2.814
00126 Y1.795
00127 X3.702
00128 X3.752 Y1.893
00129 X2.813
00130 Y1.991
00131 X3.801
00132 X3.85 Y2.089
00133 X2.813
00134 Y2.187
00135 X3.899
00136 G00
00137 Z.1 G00
00138 X2.977 Y.909 G00
00139 G01
00140 Z0
00141 X2.813 Y.813 Z-.25
00142 X3.211
00143 X3.261 Y.911
00144 X2.813
00145 Y1.009
00146 X3.31
00147 X3.359 Y1.107
00148 X2.813
00149 Y1.205
00150 X3.408
00151 X3.457 Y1.304
00152 X2.813
00153 Y1.402
00154 X3.506
00155 X3.555 Y1.5
00156 X2.813
00157 Y1.598
00158 X3.604
00159 X3.543 Y1.696
00160 X2.813
00161 Y1.795
00162 X3.702
00163 X3.752 Y1.893
00164 X2.813
00165 Y1.991

```
00166 X3.801
00167 X3.85 Y2.089
00168 X2.813
00169 Y2.187
00170 X3.899
00171 G00
00172 Z.1 G00
00173 X.833 Y.833 Z.1 G00
00174 G81
00175 X.6 Y.75 Z-.25 G00
00176 X1.35 Z-.25 G00
00177 X2.1 Z-.25 G00
00178 Y1.5 Z-.25 G00
00179 X1.35 Z-.25 G00
00180 X.6 Z-.25 G00
00181 Y2.25 Z-.25 G00
00182 X1.35 Z-.25 G00
00183 X2.1 Z-.25 G00
00184 X4.5 Y2.5 Z-.25 G00
00185 X4.25 Y2 Z-.25
00186 X4.75 Z-.25 G00
00187 X4 Y1.5 Z-.25 G00
00188 X4.5 Z-.25 G00
00189 X5 Z-.25 G00
00190 X3.75 Y1 Z-.25 G00
00191 X4.25 Z-.25 G00
00192 X4.75 Z-.25 G00
00193 X5.25 Z-.25 G00
00194 X3.5 Y.5 Z-.25 G00
00195 X4 Z-.25 G00
00196 X4.5 Z-.25 G00
00197 X5 Z-.25 G00
00198 X5.5 Z-.25 G00
00199 G80
00200 G01
00201 Z1 G00
00202 X0 Y0 G00
00203 M04 0
00204 M30
```

Congratulations! You made it! If you didn't save when you finished, do it now.

5. Compile the program. If necessary, refer to **COMPILING THE PROGRAM** in the **ACTIVITY 1** section.

6. Emulate the program. If necessary, refer to **EMULATING THE PROGRAM** in the **ACTIVITY 1** section.
7. Close the *Line Editor*.
8. Return the floppy disk to your instructor if one was provided.

Go to the next section in the multimedia presentation.

Activity 6

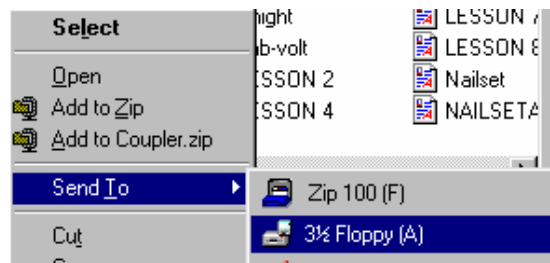
1. Load the program. If necessary, refer to **LOADING THE PROGRAM** in **ACTIVITY 3**.
2. In order to load the 6" x 3" x 0.5" workpiece onto the bed of the 5400 CNC Mill, you must first remove the 2" x 2" vise. To do this, use your Allen key to loosen the L-shaped hold-down brackets. Once loose, remove the vise from the mill.
3. Next, place the 6" x 3" x 0.5" workpiece on the bed, carefully aligning the front edge so that it is parallel with the front edge of the bed surface.
4. Place one L-shaped bracket on the left side of the workpiece in the rear T-slot on the bed, and place the second bracket on the right side in the front T-slot. Tighten the brackets with the Allen key so that the workpiece is firmly held in place on the bed.
5. Set the tool position. If necessary, refer to **SETTING THE TOOL POSITION** in **ACTIVITY 3**.
6. Download the program. If necessary, refer to **DOWNLOADING YOUR PROGRAM** in **ACTIVITY 3**.
7. Execute the program. If necessary, refer to **EXECUTING YOUR PROGRAM** in **ACTIVITY 3**.
8. Clean up. If necessary, refer to **CLEANUP** in **ACTIVITY 3**.

When you are finished, go to the next section in the multimedia presentation.

Saving to a Floppy Disk

When all lesson activities have been completed, your PART programs should be saved to a floppy disk and then removed from the M4 directory. Your PART programs can be downloaded to *Mill Level 4* at any time in the future if necessary. Follow the steps below.

1. Get a blank floppy disk from your instructor and label it with the names you assigned to the programs when they were initially created. Be sure to include your name.
2. Place the floppy disk in your computer floppy disk drive.
3. From the *File* pull-down menu, select *Open*. The File, Open window appears and shows all the PART programs stored in the M4 directory.
4. Right-click on one of your program files. A pop-up menu appears. Select *Send To* and then click *3½ Floppy (A)*. Your computer will now download a copy of the program file to your floppy disk.



5. After the PART program has successfully copied to your floppy disk, right-click again on the program file. From the pop-up menu, click *Delete*. A *Confirm File Delete* dialog box appears. Click *Yes*. Your PART program is now permanently deleted from the directory.
6. Repeat these steps for each program file you have stored in the M4 directory.
7. When you are done, remove the floppy disk.

Go to the next section in the multimedia presentation.

INDEPENDENT STUDY ACTIVITY

This will be a simple set of commands to set up the mill for spindle speed and feed rate, then to move the tool to three planned locations and return the tool to the home position.

Home position on the mill is located at the coordinates X=0, Y=0, Z=1. The tool will start and end at this location.

To program this part, use a spindle speed of 900 RPM, feed rate of 3" per minute, and operate in inches.

1. Launch the *Mill Level 4* software program by double-clicking on the *Mill Level 4* icon, located on your desktop. If you can't find the icon, ask your instructor for help
2. From the *File* pull-down menu, select *New*. The *Program Setup* screen opens.
3. Delete *<UNTITLED>* from the *Program Name* field and leave it blank.
4. Delete *Teacher* from the *Author* field and enter your name.
5. In the *Drawing ID* field, the default, *Project #1*, should appear in the project field. If this is incorrect, highlight the text and enter a project number.
6. In the *Material* section of the screen, select *Plastic*. If you are using wax, select *Wax*.
7. In the *Editor* portion of the screen, make sure *Line Mode* is selected.
8. In the *Units* portion of the screen, make sure *Inch* is selected.
9. In the *Coordinates* section, make sure *Absolute* is selected.
10. Enter the appropriate values in the X, Y, and Z fields. (X=2) (Y=2) (Z=0.5).
11. Click on the *OK* button. The *Line Editor* appears.
12. In the *Line Editor*, make line 1 a comment line by using the backslash, then typing the information you want.

00001\Project # - Date

13. Line 2 will set the program to operate in inches.

00002 G70

14. Line 3 will set the feed rate.

```
00003 M07 3
```

15. Line 4 will set the spindle speed. The M04 signals the computer that you want the spindle to start turning and the 900 sets the speed to 900 RPM.

```
00004 M04 900
```

You are now set to start programming tool movement. The position of the tool at the start of the program will be 1" above the face of the raw stock.

This position is defined by the control program loaded in the mill's computer.

16. To start the program, move the tool up to the corner of the workpiece just back from the surface. The command for move is G01.

```
00005 G01
```

17. Line 6 will give the computer the coordinates of where you want the center of the tool to move.

```
00006 X0 Y0 Z.05 R
```

18. Load the mill with a 1/8" (.125") end mill to do the drilling. All holes will be 1/8" in diameter.

The surface height of Z = .05 is the height that the tool will return to as it moves from one hole to the other. This will give the clearance needed above the surface of the part to prevent a tool crash.

19. To drill holes without a lot of code programming, enter the drilling cycle command, G81, on line 7.

```
00007 G81
```

20. Lines 8, 9, and 10 will give the location and depth of each hole.

```
00008 X1 Y.5 Z-.3  
00009 X1.5 Y1.5 Z-.3  
00010 X.5 Y1.5 Z-.3
```

21. On line 11, use the G80 code to finish the canned cycle. You do not want the computer to interpret the next coordinate for drill holes.

```
00011 G80
```

To finish the program, you need to move the tool a safe distance from the workpiece. Do this by using the G01 command and defining positions for X, Y, and Z that are clear of the work area.

22. Line 12 sets up the move code G01.

```
00012 G01
```

23. Line 13 positions the tool at home.

```
00013 X0 Y0 Z1 R
```

24. Terminate your program with the standard code for Stop and Home, M30.

```
00014 M30
```

25. Compile the program by selecting *Compile* from the *Mill* pull-down menu.

26. Emulate the program by selecting *Emulator* from the *Mill* pull-down menu.

27. Experiment with the various emulation features to become familiar with them.

28. If you'd like to save your program, place a floppy disk in your computer floppy disk drive. Select *Save as* from the *File* pull-down menu. When the File Save As window appears, select *3½ Floppy (A)* from the *Save in* drop-down menu. From the *File* pull-down menu, select *Exit*. If asked if you want to save your program, click *No*.

G AND M OPERATIONS

G Operations

G00	Rapid Positioning	RAPID
G01	Linear Interpolation	MOVE
G02	Arc Clockwise	ARC.CW
G03	Arc Counterclockwise	ARC.CCW
G04	Dwell	DWELL
G05	Arc Command Start	ARC
G50	Scale Coordinates Off	SCALE.ON
G51	Scale Coordinates On	SCALE.OFF
G70	Inch Programming	IN.
G71	Metric Programming	MM.
G80	Finish Canned Cycle	FINISH
G81	Drilling Cycle	DRILL
G82	Peck Drilling Cycle	PECK
G83	Pocket Milling Cycle	POCKET
G84	Cup Milling Cycle	CUP
G92	Axis Preset	SET.ZERO
G93	Axis Reset	ABS.ZERO

M Operations

M04	Spindle Speed Set	SPEED
M06	Tool Change	TOOL
M07	Set Feed Rate	FEED
M08	Coolant On	COOL.ON
M09	Coolant Off	COOL.OFF
M11	Set External Output High	OUTPUT.H
M12	Set External Output Low	OUTPUT.L
M13	Wait For Input High	INPUT.H
M14	Wait For Input Low	INPUT.L
M28	Repeat Loop (start)	DO
M29	Repeat Loop (end)	END.DO
M30	Stop and Home	END
M31	Stop and Repeat	RESTART
M68	Open Vise	WISE.O
M69	Close Vise	WISE.C
M97	Subroutine Call	CALL
M98	Subroutine Label	SUB
M99	Subroutine End	END.SUB

