ShopBot Teaching Module

Our thanks to Jay Wiese for making his lesson plans available to other teachers. These instructions apply to Part Wizard 3

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Teacher Information

Thanks to Brady Watson and Bill Palumbo for their editorial assistance.

Considerable time was put into these lessons and they are being made available at no cost. If you find them useful (or even if you don't), please consider creating lessons of your own and submitting them to the ShopBot folks so that the rest of us can benefit from your experience. As professionals, we all know that funding for the purchase of effective educational materials is sometimes difficult to obtain. Share the wealth of your knowledge!

Each of these activities will likely require some modification to fit your needs.

Activity 1.5

You may choose to omit or modify this activity. It was included because students tend to click on Save without any idea where the files are being saved. The next day, they cannot find them.

Activity 2

You will need to go into the tool database and add a ¼" round nose bit to the database. To do this, you can select a .25" end mill, copy, then edit the parameters and rename the copied tool.

Place the car.stl file in a location where students can access it for use in MillWizard. Car.sbp is also included if you decide to skip the MillWizard activity and simply machine the prototype of the car body.

Activity 3

Machining the car body requires a ¼" round nose bit and a piece of rigid foam insulation measuring 2 X 2.5" X 4".

You may wish to purchase or build a low profile vise for securing material to the router table during machining. Use something with wooden or plastic jaws so that when a student accidentally machines the vise, no damage will result to the router bit. You may also use a vacuum hold down.

Activity 4

You will need to go into the tool database and add a 60 degree V bit and an edge profile bit. When setting up the edge profile tool, make sure the stepdown value is at least .25 to avoid an extra pass on the plaque edge.

Activity 5

Students must be provided with either a 2.5"X15" blank of MDF or wood. The machining of the letters requires a 60 degree V bit. As written, the machining of the edge is done with an ovalo or ogee bit.

Activity 6

If you find that students have enough time, they may embellish the design of the clock face.

Activity 7

The clock requires a 5.75" X 5.75" blank of MDF or wood. The pocket for the clock motor requires a .75" diameter straight bit. The front edge requires an ovalo bit and the clock face requires a 60 degree V bit. Clock motors can be purchased from Klockit.com among other places.

Activity 1
Introduction

You will spend the next nine periods using a CNC (**C**omputer **N**umerical **C**ontrol) router. Basically, here is what happens at this station. The computer is used to generate a list of instructions for the router. Those instructions are sent to a control box, which controls the movement of the CNC router. CAD (**C**omputer **A**ided **D**esign) software is used to create an accurate drawing or 3D model of your project, but the computer and router do not know how to look at that drawing and turn it into a finished project. This is where CAM (**C**omputer **A**ided **M**anufacturing) software comes in. CAM software will help you turn your drawing into a series of *tool paths* that the router will follow. You will be using a software package called Part Wizard to create both the CAD drawing and the toolpaths. Once you have established all of the paths for the router to follow, Part Wizard will create a list of instructions that will tell the router how to follow those paths. These instructions are known as NC (**N**umerical **C**ontrol) code. When you save these instructions in a format that the ShopBot will recognize, you are creating a **S**hop**B**ot **P**art file.

Safety

Because you are working with power equipment, there is always the potential for danger. Take time to review the following safety rules. These rules are also posted near the router.

1. Safety glasses must be worn at all times when the router is in operation.

2. Hearing protection must be worn at all times when the router is in operation.

3. Never leave the router unattended when in operation.

4. If you suspect that the ShopBot machine is not operating normally, quickly press one of the following to stop the router:

   the **red emergency stop** button on the ShopBot
   space bar, or the **S key** on the keyboard
   the **flashing yellow STOP** button on the computer monitor

5. Follow ALL directions carefully. Failure to do so can result in serious injury or damage to the equipment.

6. If you are not sure, **ASK THE INSTRUCTOR.**
7.

Clean up

Because the router generates a great deal of mess, make sure your station and the router room is cleaned up at the end of your period.

Follow-up Questions

On a separate sheet of paper answer the following questions:

1. What do the letters CAD stand for?

2. Briefly explain how the ShopBot machine knows where to move the router to create a part.

3. What does CAM software do?

4. What are the two absolutely essential pieces of safety gear that you must wear when operating the ShopBot machine?

Activity 1.5
Using the Network

Each day you must log into the network in order to make sure that your files are saved in your space on the server. If you fail to log in, your files will be lost and you will have to repeat the activity.

1. If the computer is on and you can see the Windows desktop, click on 

in the lower left then select 

2 After a few moments, you should see the Novel log on screen appear. In the User Name box, type your first name and last name (example jonathan doe). In the Password box, type your six digit student ID number including the leading zeros (example 012345).

3. Click on 

then 

You should see a drive with your name on it. This is where you will save **ALL** of your files. This is very important! If you fail to save your files to this location, they will be lost and you will have to repeat the activity to regenerate the file.

4. At the end of the period, make sure you log off.

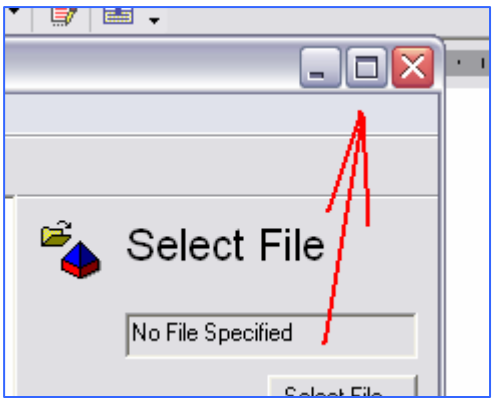
Activity 2
Rapid Prototyping

Introduction

In this activity you will work through the steps involved in **Rapid Prototyping**. Rapid Prototyping is used to quickly and inexpensively create a mock up or prototype of a product. Using CAM software called Mill Wizard, we will use an existing 3d computer model of an object to generate toolpaths that the tip of the cutting tool will follow back and forth to cut the surface of the object from a block of rigid foam.

1. Open the Mill Wizard software. 

2. Once Mill Wizard is running, make it fill the screen by clicking on the Maximize button in the upper right.

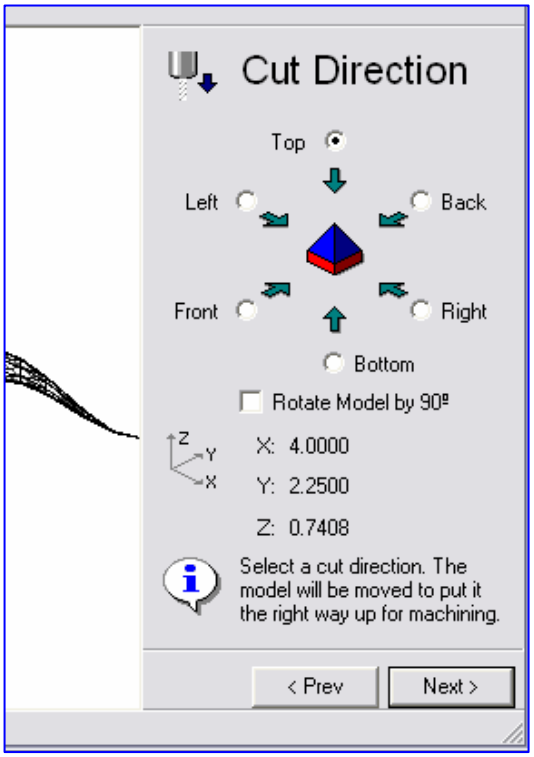


3. We need to open a 3D model. Click on 

4. Navigate to the desktop and select the file named ***car.stl***

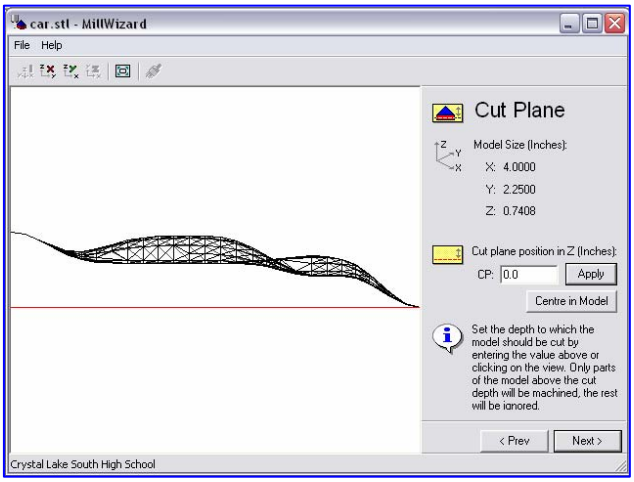
5. A rough looking body of a car should appear. Click on 

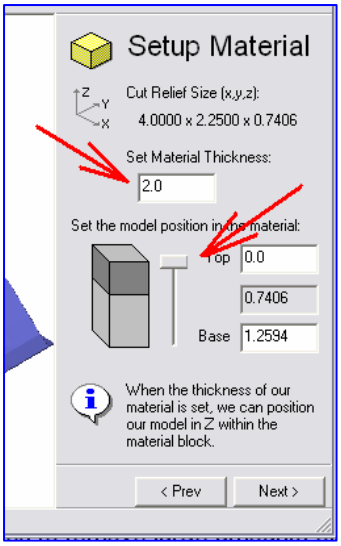
6. This cut direction screen will appear. This is where you tell Mill Wizard the direction from which the cutter will approach the material as you view from the front of the router. The X axis will run the length of the car. Make sure **Top** is selected then click Next >



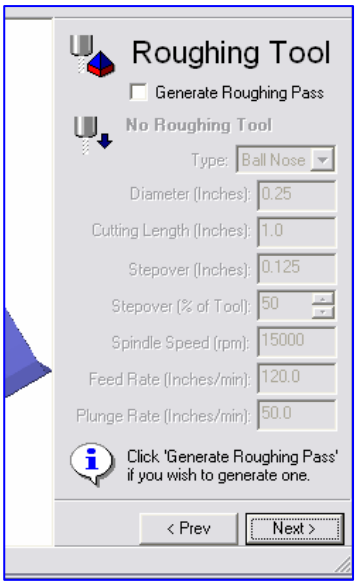
7. The next screen to appear allows you to change the size of the car body. This would allow you to use the same model to create a prototype ranging in size from a Hot Wheels car to a kid-sized pedal car. Do not change the size. Simply click on Next >

8. The Cut Plane window will appear. **IF** we were going to machine the top half of the car then flip it over and machine the bottom half, we would set the cut plane half way up the body. We will machine the entire body from the top, so **make sure the cut plane (red line) is at the bottom of the car body**. Click on Next >

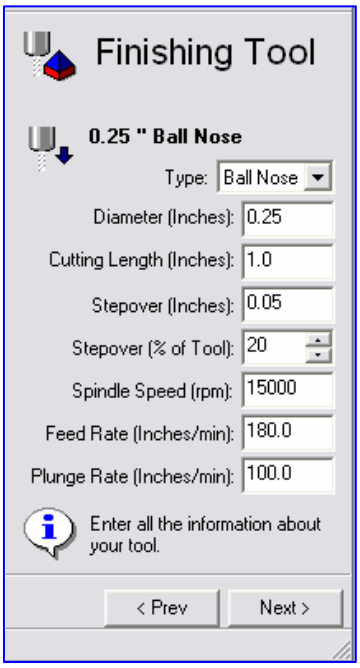




9. You will now see the Setup Material screen. This is where you will tell Part Wizard the size of the material and that you want to machine the car body from the upper most part of your material. Make sure that the slider is at the **top** and **Set Material Thickness = 2.0** Click on Next >

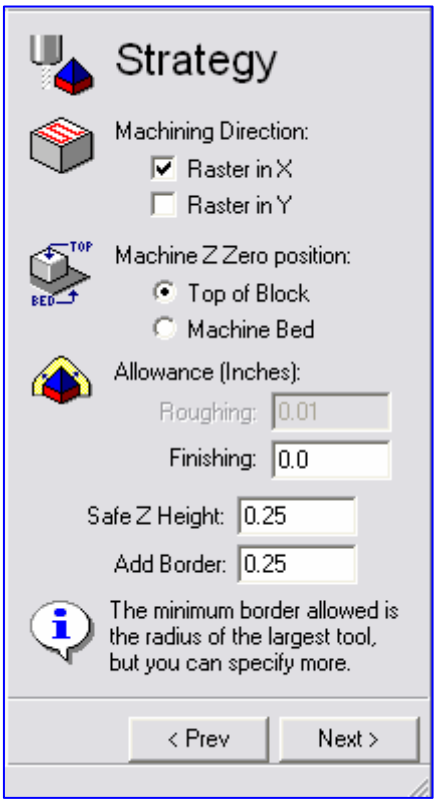


10. Usually you have to cut several passes to remove large amounts of material just to get close to the final shape of the prototype. These passes are called roughing passes because they cut away material until the rough shape is achieved. Because you will be machining a soft foam material, you will not need a roughing pass. Make sure there is ***NO*** x in the **Generate Roughing Pass** check box. Click on Next >

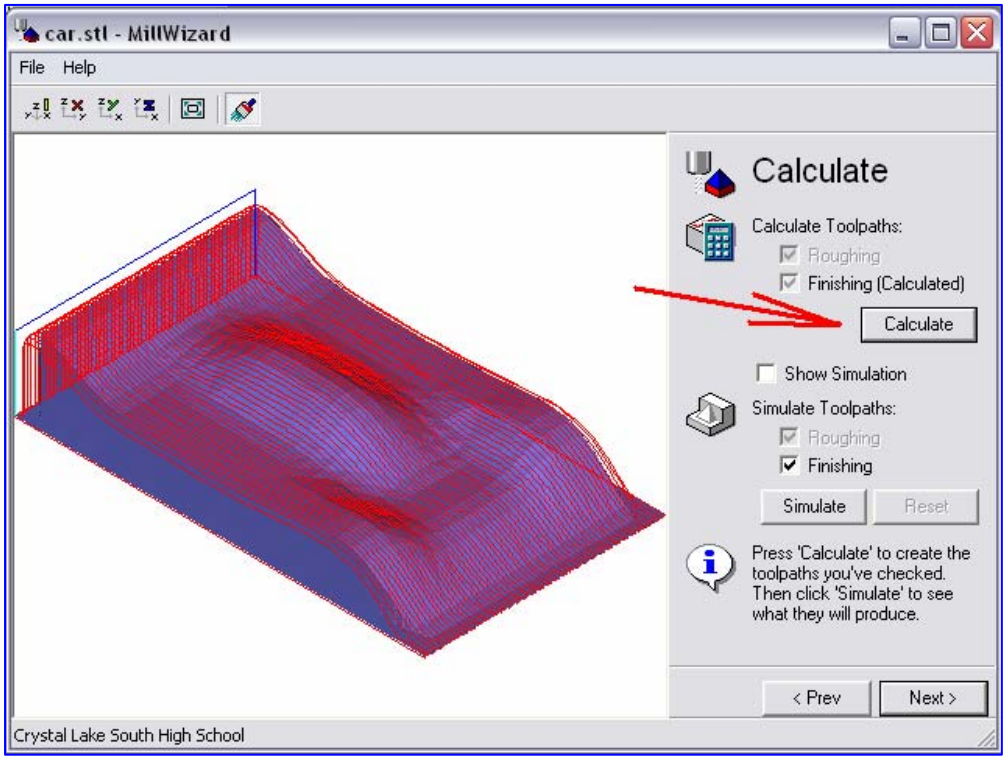


11. Now you will select the cutting tool that will be used for the finishing pass. This is the cutting pass that will remove material right down to the shape of the 3d computer model that you loaded earlier. Make sure the information is filled out exactly as it appears in this illustration. When finished, click on Next >

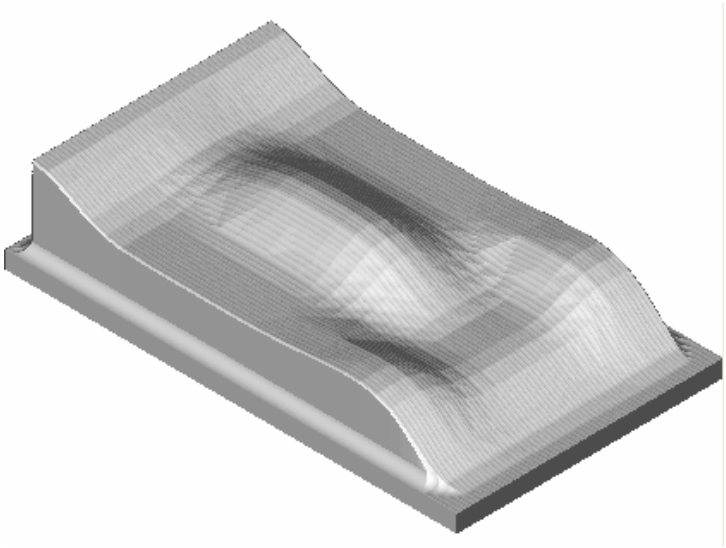
12. The Strategy screen will appear. This is where you specify direction of the cutting passes through your material. Remember that the X axis runs from front to back of the car. Select Raster in X because this will cut parallel passes along the length of the car. Make sure all other settings are as shown here then click on Next >



13. Now you are ready to generate the toolpath. Click on the **CALCULATE** button. You should now see the toolpath being generated back and fourth on the surface of the car body. When finished, your car body should appear as shown here.

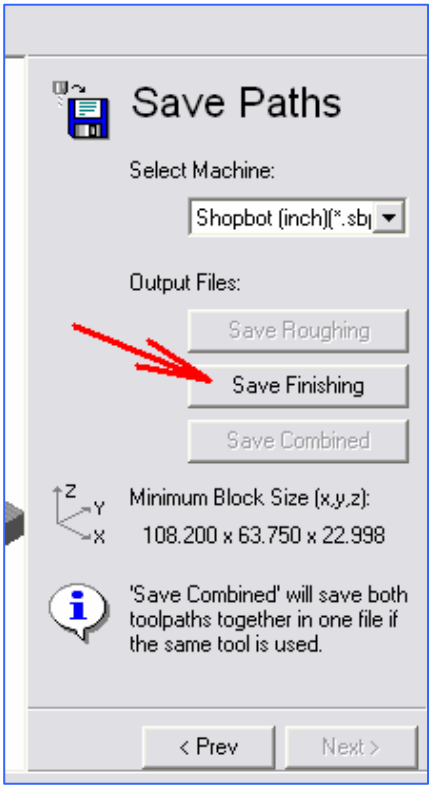


14. Click on the **SIMULATE** button and Mill Wizard will generate an image of what your car body will look like when you are finished machining it on the router. Notice the ridges that run from front to back. If you wanted to make your prototype smoother, you would have to tell Mill Wizard to make each pass of the toolpath closer together, this is called “step over.” It is like when you cut the grass. You overlap the previous pass a little bit. The trade off is that it would take much longer to machine the prototype, so we will just move on by clicking Next >



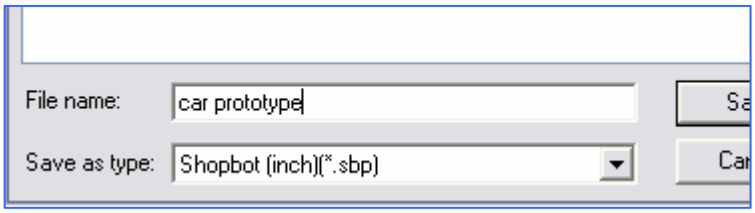
15. Finally, you will generate and save NC code in the form of a ShopBot Part File (SBP). Under **Select Machine:** you should scroll down and select ***Shopbot (inch)(*.sbp)*** This will make sure that Mill Wizard generates NC code that the Shopbot router will understand.

    Click on the **Save Finishing** button to save the NC code for your finishing pass.



16. This step is VERY IMPORTANT. If you fail to save your file correctly, you may have to repeat the entire process from the start!

When the Save As window appears, NAVIGATE TO YOUR FOLDER ON THE SERVER. In the File name box, type ***car prototype***. Make sure that ***Shopbot (inch)(*.sbp)*** appears in the Save as type box. If it does not, cancel and go back to the previous step and be sure to select the correct machine. If your looks like this one, then click on



17. If you are sure that you saved your file correctly, exit Mill Wizard. In the next activity, you will machine the car body on the CNC router.

Activity 3
Machine Your Car

Whenever you machine a part, you **must** do three things if you expect the CNC router to machine your part correctly.

A. Secure your material to the router table
B. Position the router bit precisely at the origin
C. Zero the X, Y, and Z coordinates

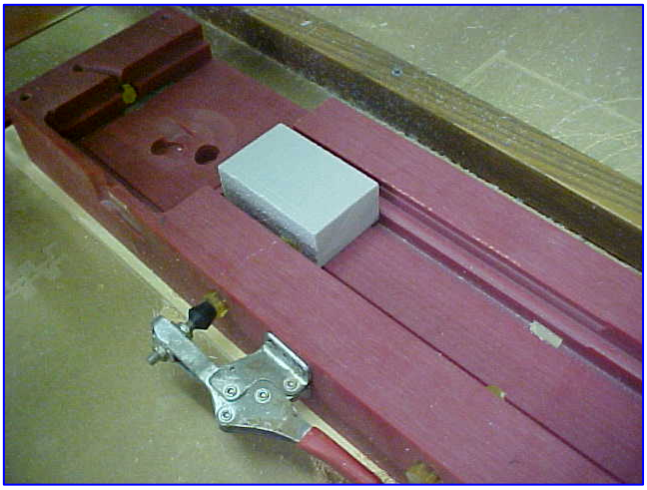
Only after these three steps have been performed correctly do you load your NC part file.

Secure your material

1. Ask the teacher for a piece of 2 X 2.5 X 4 material for your car.

2. Ask the teacher to install a 1/4” round nose bit in the router.

4. Place your material in the vise as shown. Gently tighten the clamp until you feel it click into place. Check to see that your material is secure by gently trying to move it with your hand.

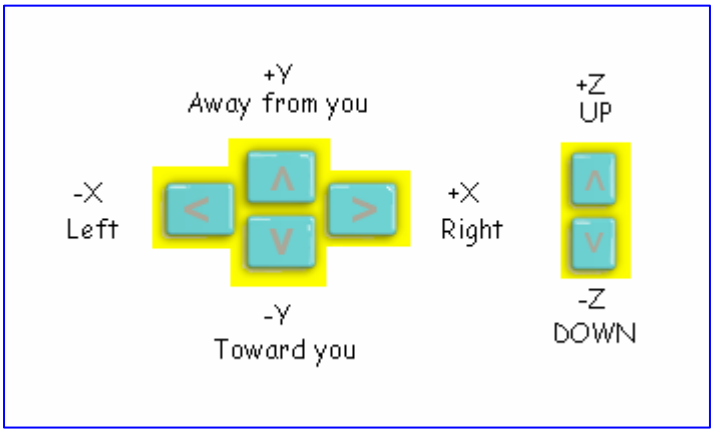


Position the Router and Assigning the Origin

5. On the computer connected to the ShopBot, launch the ShopBot control software.

6. The next task is to position the router at the origin where the NC instructions are expecting it to be. Press K on the keyboard. You should see the ShopBot KeyPad screen appear. These controls allow you to manually control the router.

7. Take a moment to look at the router. The X, Y, and Z axis are labeled. Make sure you understand which way the router will move BEFORE you start pushing buttons. Be careful when you press keys to move the carriages on the Shopbot because the machine will coast for a moment after you take your finger off the key!!!!



8. Use the blue X axis and Y axis arrow buttons to position the **CENTER** of the router bit directly over the near left corner. This is the location that you specified as the origin in the previous activity. Next, use the blue Z axis buttons to move the cutter down until it is about 1/8 inch above the surface of your material. Now you will sneak up on the surface by moving in very small increments. Click on the Fixed button. Tap the **–Z** button until the router bit just barely touches the surface. Close the keyboard control window.

Assign the Origin

9. Once the cutting tool is properly positioned you must zero the X Y and Z axis. To do this, select **[Z]ero** from the menu. Then select **zero [3] axes (X,Y & Z)** Notice that the coordinate readout on the right all indicate .000

10. The ShopBot is now ready to machine a part. Before you begin, ***CALL THE INSTRUCTOR TO YOUR STATION TO INSPECT THE SETUP ON THE ROUTER.***

11. Check the clock. *The car body takes about five minutes to machine!* Now you are ready to open an NC file. From the menu, select **[F]ile** then **[P]art file execute**. Navigate to your folder on the server and select the file named **car.sbp** that you created in the previous activity, then click the Open button.

12. Remember to keep an eye on the router. If you made a mistake when you created your toolpaths, it could do something crazy. Be prepared to press the red **S** key on the keyboard or the **giant yellow flashing STOP button** on the monitor or the **red emergency stop button** on the Shopbot if something goes wrong.

13. ***PUT ON HEARING PROTECTION AND SAFETY GLASSES!!!!!*** BE SAFE.

14. **Turn on the router and dust collector.**

15. Click on the **START** button.

14. When the router finishes cutting, it will rise up from the material and wait. Turn off the router and the dust collector.

15. Remove your material from the holding fixture.

16. Clean up!!!!!!!!!!!!!!!!!!!

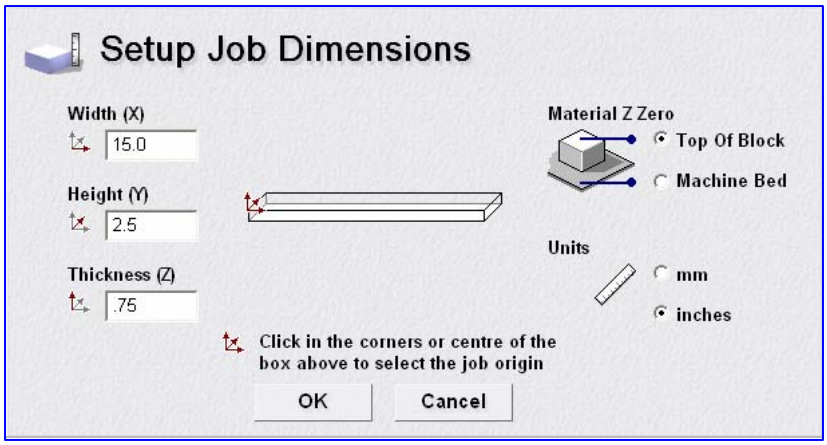
Activity 4
Designing a Name Plaque Using Part Wizard

In this activity you will create a drawing of a name plaque which will include text and an outline of the plaque. You will use the text and outline to generate tool paths. A tool path is like a road map containing a set of lines that the router will follow to produce your design. The tool paths will then be used to generate a list of directions that tell the CNC router how to machine your plaque.

1. Open the **PartWizard** program. You will use this program to generate and layout the text for your sign as well as the edge of your plaque. Maximize the window so that it fills the screen.

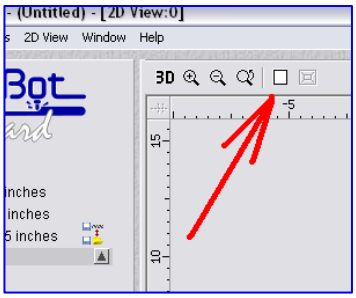
2. Click on the **Create New Mode**l icon.

3. Next, you should see the **Setup Job Dimensions** dialog box. This is where you tell the software the size of the material you will be machining. Input the numbers shown below even though your plaque may end up being smaller.



IMPORTANT: You must tell the software where the origin is on the material. The origin is where the X,Y,Z coordinates are all zero. Click on the near left corner of the material so that the origin icon appears on the corner as shown. Click OK.

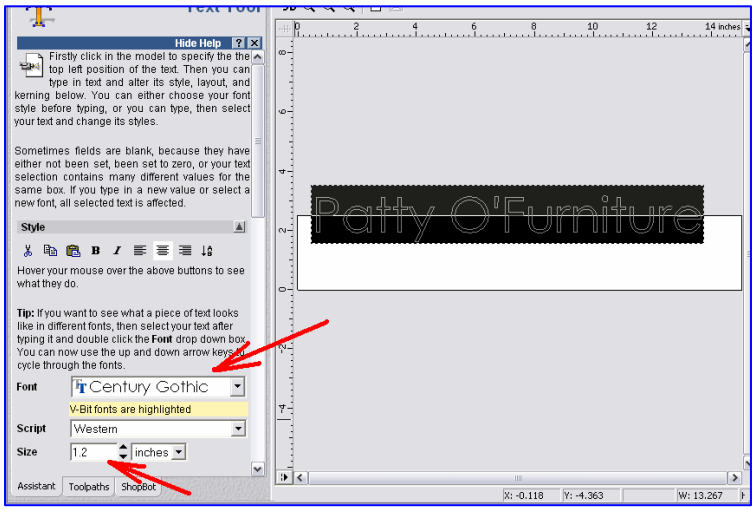
The white rectangle you see represents your plaque material. To zoom in so that it fills the screen, click on the Zoom Extents button.



6. Now it is time to create your text. Click on the **Text** button. 

7. To position your text, click near the upper left of the plaque. Don't worry about the exact location. You can reposition your text later.

8. Type your name or whatever you would like to appear on the plaque. When finished, use the cursor to highlight the text that you just typed. Click the **Font** dropdown box. Select any of the yellow highlighted fonts near the top of the list to change the appearance of your text. In the Size box change the height of your text to 1.2



9. When satisfied with the appearance of your text, scroll to the bottom of the Text Tool screen and click on the 

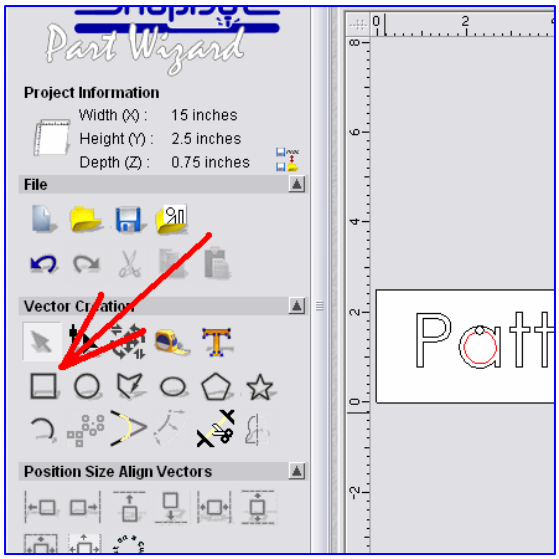
button.

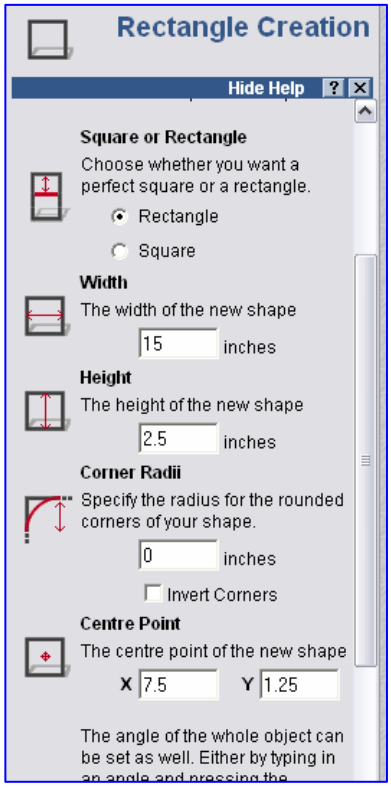
10. Your text should now appear magenta in color and with a dashed rectangle around it. To center your text, click on the **Center In Page** tool

11. Once centered, click outside the dashed rectangle to deselect the text.

12. Now would be a good time to save your work just in case you experience a power outage, tornado, alien invasion, or whatever. From the menu at the top of the screen, click on **File** then **Save**. When the Save window appears, navigate to your folder on the server as you did in Actvity 1.5. In the **File name** box type ***Your Name* Plaque**. For example: *Bob Jones Plaque* or *Sue Smith Plaque*.

12. Now you will create a rectangle that will be used to create toolpaths for the edge of the plaque. Click on the **Rectangle Tool.**



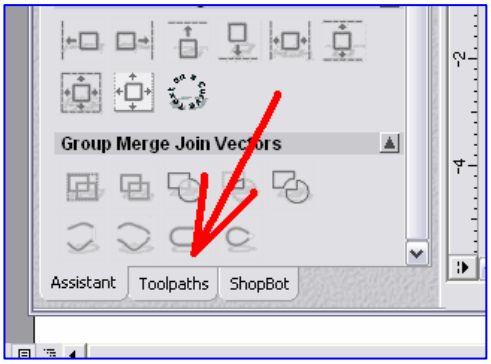


13. The Rectangle Creation Assistant screen will appear on the left. Fill in the numbers as shown in the illustration. This will provide an edge for a 15 inch wide plaque. Scroll down and click Preview

15. Scroll to the bottom of the Rectangle Creation assistant and click on Create then click on Close

So far, you have created a drawing of what your plaque will look like. The next task is to generate tool paths which are like a 3D road map that the cutting tool will follow.

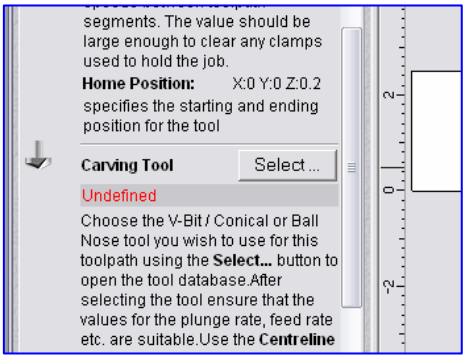
17. Click on the Toolpaths tab in the lower left of your screen.



18. Click on your text to select it. Your text should turn magenta.

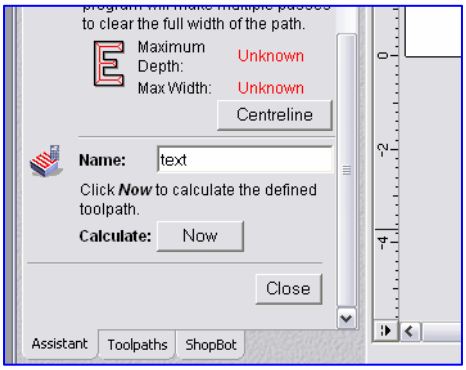
19. For a hand carved look, we will use a V bit. Click on the V-bit Carving icon. 

20. In order to carve, you must select the correct router bit. Scroll down through the V-Bit Carving screen until you see the **Carving Tool** section. Click Select ...

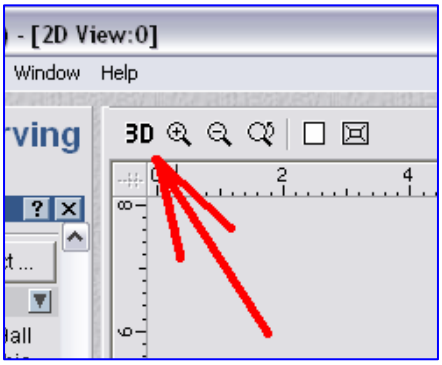


21. When the Tool Groups Window appears, scroll down and click on **V-Bit 1/2 Inch 60 degree.** Notice that all the information relating to the selected bit is included in the program. Then, click Select ...

22. You should see the V-Bit carving screen again. Scroll to the bottom of the V-Bit carving screen. In the Name box type the word **text.** This will be the name of the toolpath. Click on Centreline Then click on Calculate Now to create the toolpath.

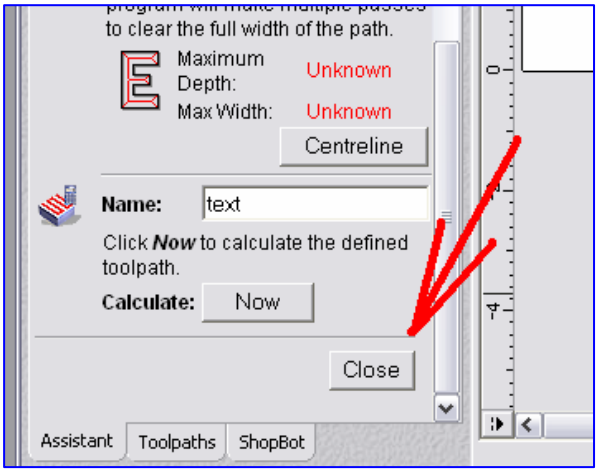


23. Based on the router bit you chose, Part Wizard now performs the calculations to create a line that the tip of the router bit will follow to carve out your letters. To view this toolpath in 3D, click on the **3D** button in the upper left of the preview screen.

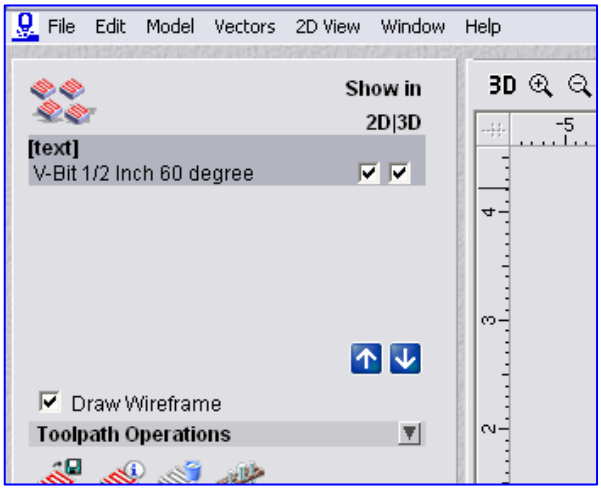


24. Return to the 2D view by clicking on the **2D** button located in the same spot.

25. Click on  at the bottom of the V-Bit Carving assistant screen.



26. You should now see this screen. Notice that the toolpath you just created is listed in the upper left. You also see the router bit that you chose for that cut.



27. Next you will create a toolpath that the router will follow to shape the edge of the plaque. You will use the rectangle that you created to do this. Select the rectangle by clicking on it. Now click on the **Machine Along Vector** button. 

28. The Machine Vectors assistant screen will appear. In the Finish Depth box type **0.25**

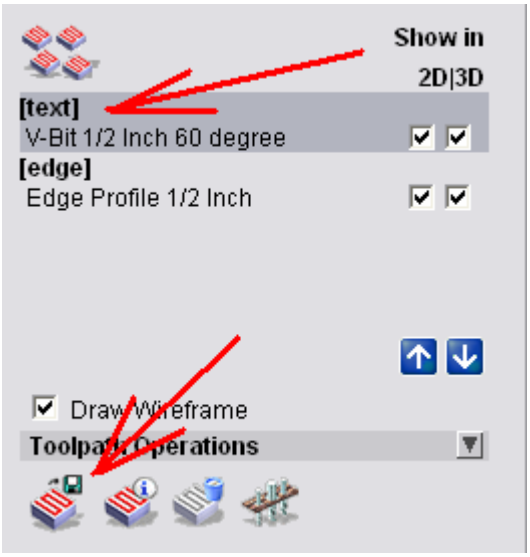
29. Scroll down to Profiling Tool and click on 

. In the **Tool Groups Database** window, click on the **Edge Profile ½ Inch** cutting tool then click the **Select** button.

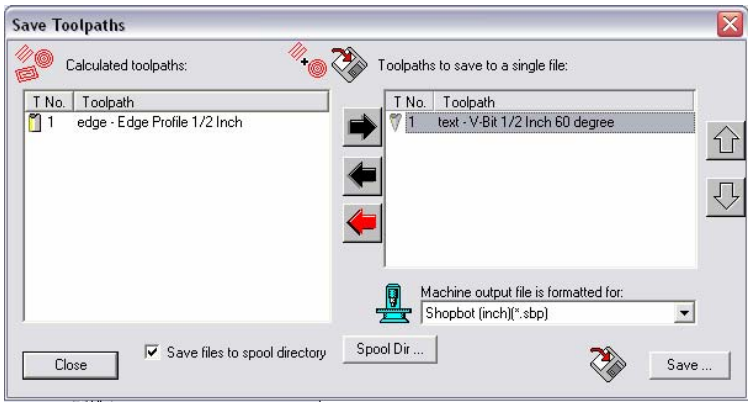
30. Scroll to the bottom of the **Machine Vectors** assistant screen and in the **Name** box type **edge**. Click on the Calculate 

You should now see small arrowheads on the rectangle that tell you which way the router will move while machining the edge. Click on 

31. The final step before machining is to generate the NC (Numerical Control) code that will serve as the instructions telling the router how to cut your plaque. First you will save the text toolpath by clicking on text in the list of toolpaths. Then click on the Save Toolpaths button. 



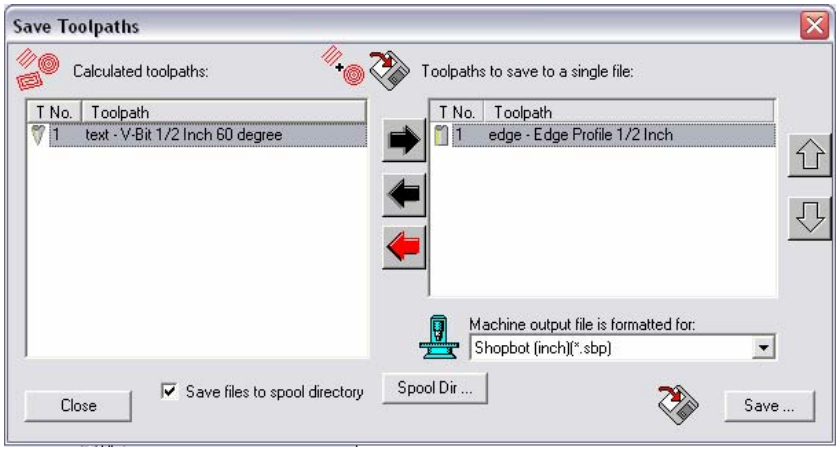
32. When the Save Toolpaths window appears, make sure it looks like this:



The toolpath on the right (text) is the one that will be saved as NC code. If the screen does not look like above, use the black arrows in the middle of the window to move the toolpaths into the proper position. Click Save ...

33. The **Save As** window will appear. Navigate to your folder on the server. In the **File name** box type **plaque text**. Click Save

34. You will be returned to the Save Toolpaths dialog box. Now you will save NC code for the edge toolpath. Empty the right column by clicking on the red left arrow. Move the edge toolpath to the save column by selecting it then clicking on the right arrow.



Make sure the screen appears as shown above. The toolpath on the right (edge) is the one that will be saved as NC code. Click Save ...

The **Save As** window will appear. Navigate to your folder on the server. In the **File name** box type **plaque edge.** Click Save

35. In the next activity you will machine your plaque. Save your Part Wizard file to your space on the server then exit the program.

36. If you check in your space on the server, you will see two file types related to your plaque:

filename.art This is your PartWizard

filename.sbp These are your **S**hop**B**ot **P**art files which contain the NC code that instructs the machine how to cut your plaque.

Activity 5
Machine Your Plaque

Whenever you machine a part, you **must** do three things if you expect the CNC router to machine your part correctly.

A. Secure your material to the router table
B. Position the router bit precisely at the origin
C. Zero the X, Y, and Z coordinates

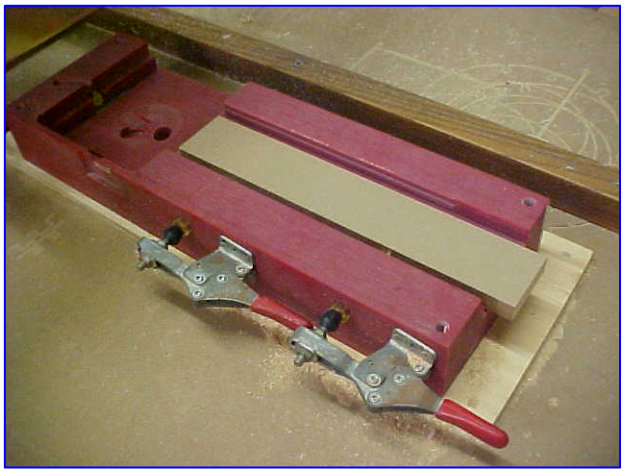
Only after these three steps have been performed correctly do you load your NC part file.

Secure your material

1. Ask the teacher for a piece of 2.5” X 11” or 2.5” X 15” material depending on the size of your plaque.

2. Ask the teacher to install a 60 degree V-bit in the router.

4. Place your material in the vise as shown. Gently tighten the two clamps until you feel them click into place. Check to see that your material is secure by trying to move it with your hand.

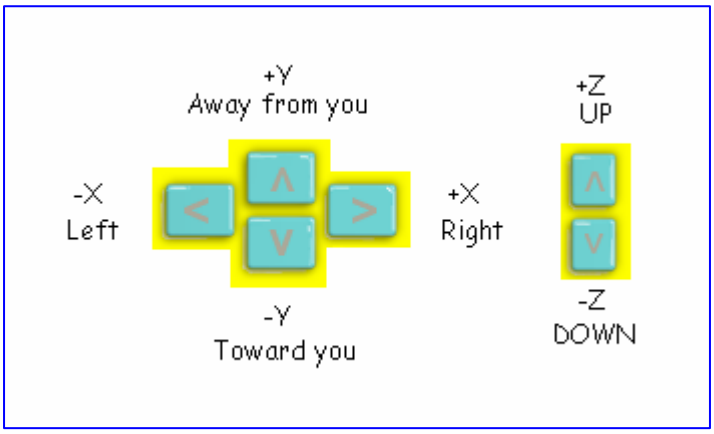


Position the Router and Assigning the Origin

5. On the computer connected to the ShopBot, launch the ShopBot control software.

6. The next task is to position the router at the origin where the NC instructions are expecting it to be. Press K on the keybord. You should see the ShopBot KeyPad screen appear. These controls allow you to manually control the router.

7. Take a moment to look at the router. The X, Y, and Z axis are labeled. Make sure you understand which way the router will move BEFORE you start pushing buttons. Be careful when you press keys to move the carriages on the Shopbot because the machine will coast for a moment after you take your finger off the key!!!!



8. Use the blue X axis and Y axis arrow buttons to position the center of the router bit directly over the near left corner. This is the location that you specified as the origin in the previous activity. Next, use the blue Z axis buttons to move the cutter down until it is about 1/8 inch above the surface of your material. Click on the Fixed button. Click on the –Z button to move the router down until the router bit just barely touches the surface. Close the keyboard control window.

Assign the Origin

9. Once the cutting tool is properly positioned you must zero the X Y and Z axis. To do this, select **[Z]ero** from the menu. Then select **zero [3] axes (X,Y & Z)** Notice that the coordinate readout on the right all indicate .000

10. The ShopBot is now ready to machine a part. Before you begin, ***CALL THE INSTRUCTOR TO YOUR STATION TO INSPECT THE SETUP ON THE ROUTER.***

11. Check the clock. *Ask the instructor if there is enough time to machine the plaque!* Now you are ready to open an NC file. From the menu, select **[F]ile** then **[P]art file execute**. Navigate to your folder on the server and select the file named **plaque text.sbp** that you created in the previous activity, then click 

12. Remember to keep an eye on the router. If you made a mistake when you created your toolpaths, it could do something crazy. Be prepared to press the red **S** key or the **spacebar** on the keyboard or the **giant yellow flashing STOP button** on the monitor or the **red emergency stop button** on the Shopbot if something goes wrong.

13. ***PUT ON HEARING PROTECTION AND SAFETY GLASSES!!!!!***

14. **Turn on the router and dust collector.**

15. Click on the **START** button.

14. When the router finishes cutting, it will rise up from the material and wait. Turn off the router and the dust collector.

15. Ask the teacher to install the edge profile bit in the router.

16. Because the edge profile bit will be a different length, you will have to tell the ShopBot control software where the surface of the material is again. Press K on the keybord to access the keyboard control screen. Use the –Z button and 

to move the router down until the router bit just touches the surface just as you did in step 8. Close the keyboard control window.

17. Select **[Z]ero** from the menu. Then select **zero [z] axis** Your X, Y, and Z axes should all be 0

18. From the menu, select **[F]ile** then **[P]art file execute**. Navigate to your folder on the server and select the file named **plaque edge.sbp** that you created in the previous activity, then click the Open button.

19. Remember to keep an eye on the router. Be prepared to press the red **S** key or the spacebar on the keyboard or the **giant yellow flashing STOP button** on the monitor or the **red emergency stop button** on the Shopbot if something goes wrong.

20. ***PUT ON HEARING PROTECTION AND SAFETY GLASSES!!!!!***

21. **Turn on the router and dust collector.**

22. Click on the **START** button.

23. When the router finishes cutting, it will rise up from the material and wait. Turn off the router and the dust collector.

24. **Wait until the router comes to a complete stop** before removing your material from the holding fixture.

25. Clean up!!!!!!!!!!!!!!!!!!!

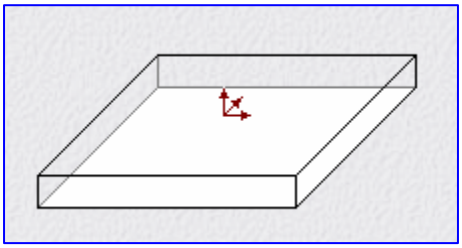
Activity 6
Creating a Clock Using Part Wizard

1. Open Part Wizard

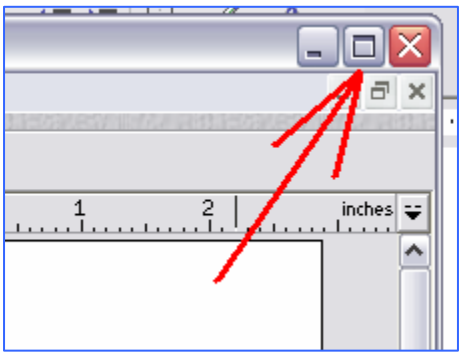
2. Click on Create New Model

3. When the Setup Job Dimensions window appears, enter the dimensions of the clock material as follows: Height = 5.75, Width = 5.75, Thickness = .75 Make sure the units are Inches and the Material Z Zero is on Top of Block

   IMPORTANT!!! Click in the center of the material preview image to set the origin (x 0, y 0, z 0) at the center of your material as shown here. Click on OK

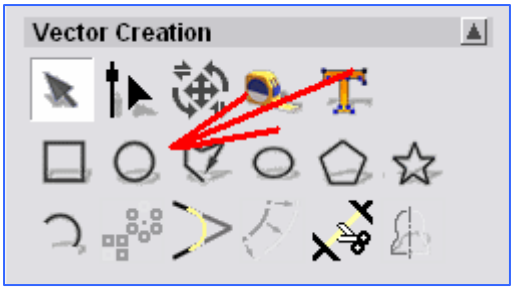


4. Click on the Maximize button to make the window fill the screen.

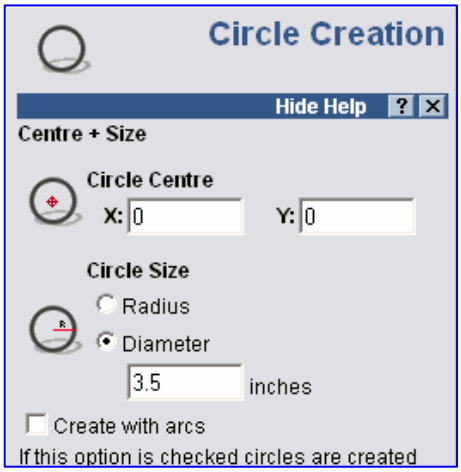


5. The white square on the screen represents your material. Position the pointer in the center of the preview area. Look at the ruler bar above and to the left. The sliding marker should be on Zero. This is important. This center position is where you will position the router when it is time to machine your clock.

Creating the Pocket for the Motor



6. To create a pocket on the back of the clock, you will draw a circle then generate toolpaths that clear out material within that circle. Click on the circle tool.



7. When the Circle Creation window appears, set the values as follows:
   Center point of the circle: **X=0, Y=0.**
   Click on the **Diameter** button
   Diameter = **3.5**

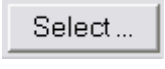
   Click on 

then 

8. You should now see your circle highlighted in magenta with a dashed square around it. If it is not highlighted, click on it. With the circle highlighted, you will now create the toolpath that will clear out the material within. Click on the **Toolpaths** tab in the lower left of your screen. 

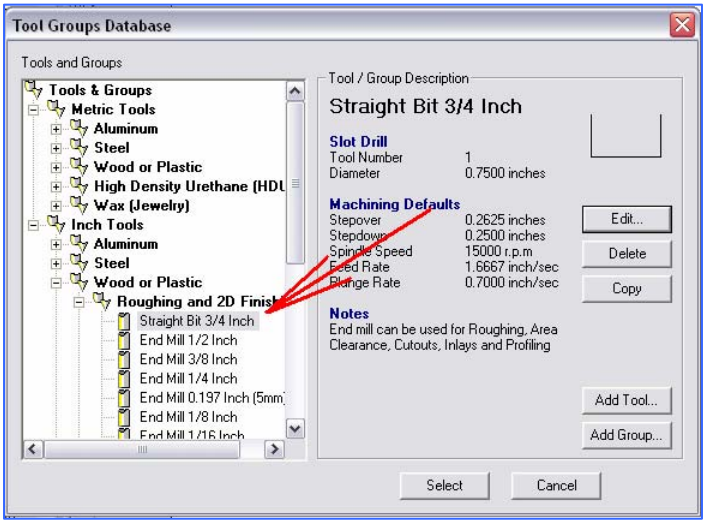
9. Click on the Area Clearance button 

10. When the 2D Area Clearance screen appears, set the values as follows:
    Start Depth = 0
    Finish Depth = .5

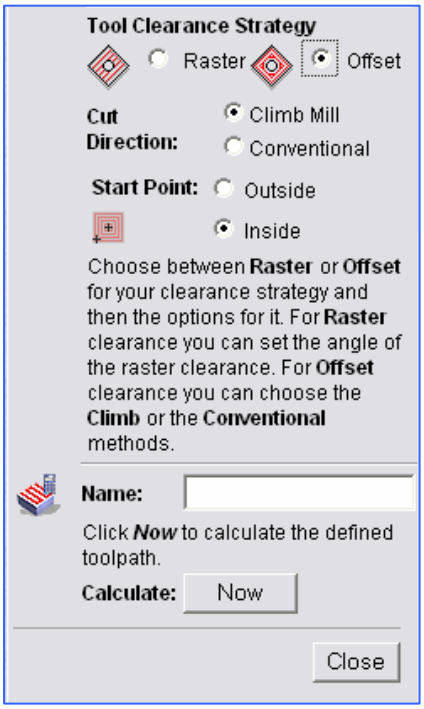
    Scroll down to Tool then click on 

From the Tool Groups Database, Select the ¾ **inch straight bit**

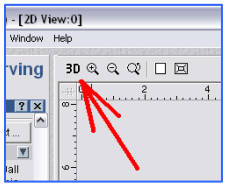
then click on Select ...



When returned to the 2D Area Clearance screen set the Tool Clearance strategy as shown here to the right. In the **Name** box type **motor pocket** then click on Calculate Now

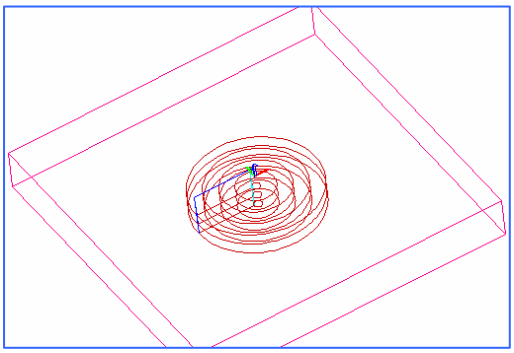


View your pocket toolpath in 3D by clicking on the 3D button.



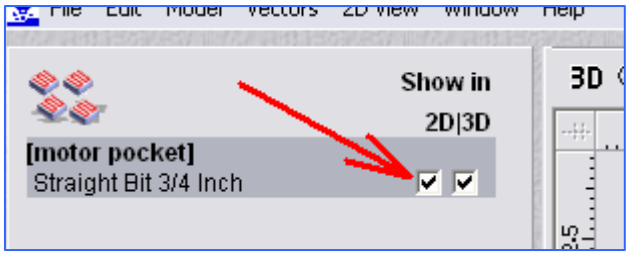
If your toolpath resembles the one shown here

then click on Close



11. At any time you can toggle between a 2D view and a 3D view of your project by clicking on the 3D / 2D button. Change back to a 2D view now.

12. We want to hide our pocket toolpath so that it does not clutter up the screen while you work on the clock face. Uncheck the **Show in 2D** box.



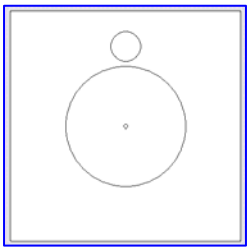
13. Click anywhere on the preview screen to deselect the circle.

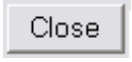
14. The next step is to create the clock face. Click on the Assistant tab. ***SAVE YOUR WORK AT THIS POINT!!*** **!From the menu, select Save As.** Navigate to your drive on the server. Name your file **Your Last Name Clock Project**. Example: Smith Clock Project

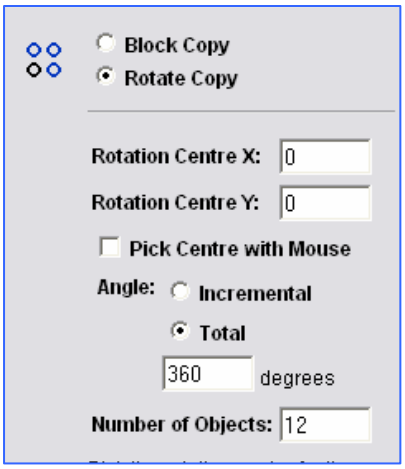
Designing the Clock Face

15. Start the face by drawing a circle that will mark the location of the hole for the clock motor shaft. Click on the circle tool  The center should be at X=0, Y=0. Set the Diameter to 0.1 Click 

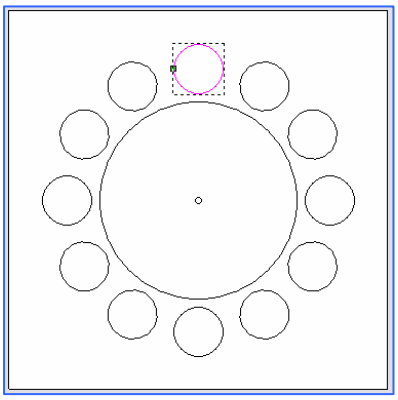
16. Create another circle with the center point at X=0, Y=2 Set the Diameter to 0.75 then click  then  Click anywhere on the preview screen to deselect the circle. Your clock face should now look like this.



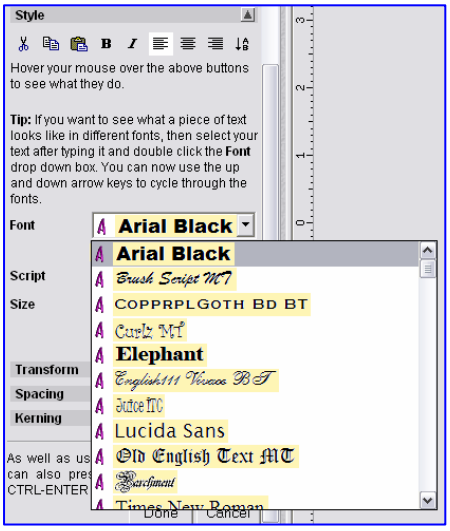
17. Select the small circle by clicking on it. You will now create 12 copies of the circle spaces evenly around the center of the clock face. Click on the **Block Copy / Rotate** button.  Make sure the Block and Rotate Copy settings are as follows: select **Rotate Copy,** Rotation Center **X=0, Y=0**, Angle: select **Total**, Degrees=360, Number of objects=12. Click on  then 



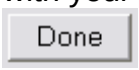
18. You should now see this. Click any empty area to deselect the circle.



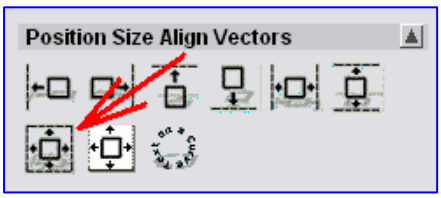
19. Now it is time to put some numbers on the clock. Click on the Text tool. 



From the Font dropdown, select Arial Black or Elephant from the yellow highlighted fonts. These are bold fonts that will be easy to read from across the room. Set the Size at 22 points.

Click inside the top circle then type 12. Don't worry if it is off center. You will adjust that in a moment. If the numbers do not fit in the circle, Spacing and Kerning settings may be off. Check with your instructor. Scroll down and click on 

20. The number you just created should still be highlighted. Hold down the Shift key and click on the circle surrounding the 12. With the 12 and its circle selected, click on the Center Vector tool. Use the arrow keys to position the number in the center of the circle. Click any empty area on the preview screen to deselect the number.



21. Repeat steps 19 and 20 for the remaining numbers on the clock face.

22. The final step in designing the clock face is to draw a line around the perimeter of the material. You will use this to generate a toolpath to cut a decorative edge on your clock face as you did on the plaque in Activity 4. Click on the **Rectangle** tool 

    When the Rectangle Creation window appears, input these values: **Width=5.75, Height=5.75, Corner Radii=0, Center Point X=0, Y=0, Angle=0** When finished, click on Create then Close

23. SAVE YOUR WORK to the server!!!

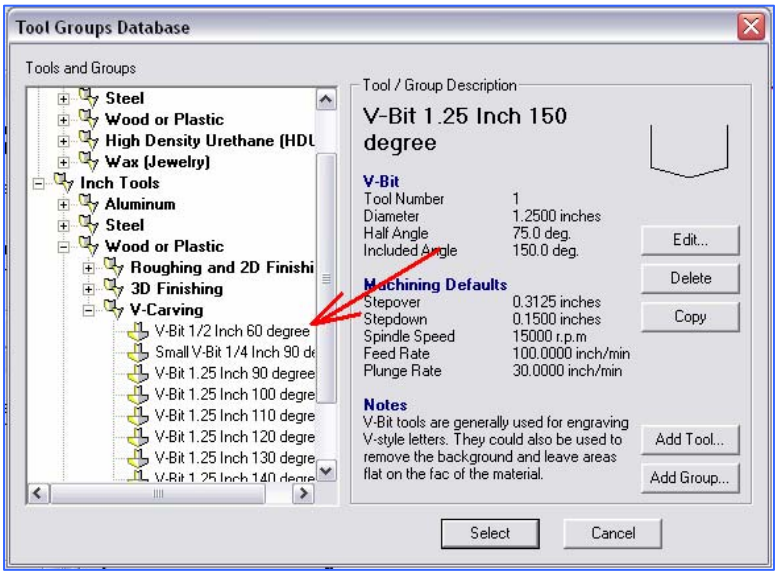
Generating the Clock Face Toolpaths

24. Click on the Toolpaths tab in the lower left of your screen. 

25. Your square around the edge should be selected. Click on the Machine Along Vectors tool.  Input the following values: Start Depth=0, Finish Depth=0.25

    Scroll down to Profiling Tool and click on Select ...

    When the Tool Groups Database appears, click on V-Bit ½ Inch 60 Degree then click Select ...



Scroll down to the **Name** box at the bottom of the Machine Vectors window and type **clock edge**. Click on Calculate 

then 

Notice the little arrowheads around the perimeter of the material. This shows you the direction that the router will move around the material when it cuts the decorative edge.

27. Click in an open area to deselect everything. Select all the numbers on the clock face by holding the **shift** key down while you click on each number.

28. Click on the V-Bit Carving tool. 

29. Scroll down to Carving Tool. The **V-Bit ½ Inch 60 Degree** should still be listed as the cutting tool. If it is not, select it from the Tool Group Database.

30. Scroll down to the **Name** box and name the toolpath **numbers**, then click on 

then Calculate 

then 

31. Click in an open area to deselect the numbers.

32. While holding down the **shift** key, select all of the small circles around the numbers, the tiny circle in the center. ***(Do not select the large circle in the center. This was used for the clock motor pocket)*** Then click on the Machine Along Vectors tool. 

33. Input the these values: Finish Depth=**0.08,** Profiling Tool=**V-Bit ½ Inch 60 Degree,** Name=**circles**

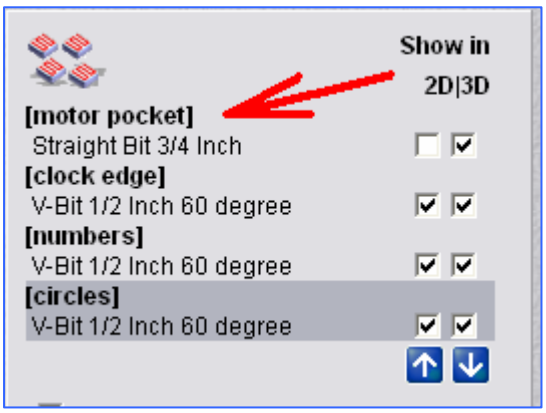
    Click on Calculate 

then 

Save Toolpaths and NC Code

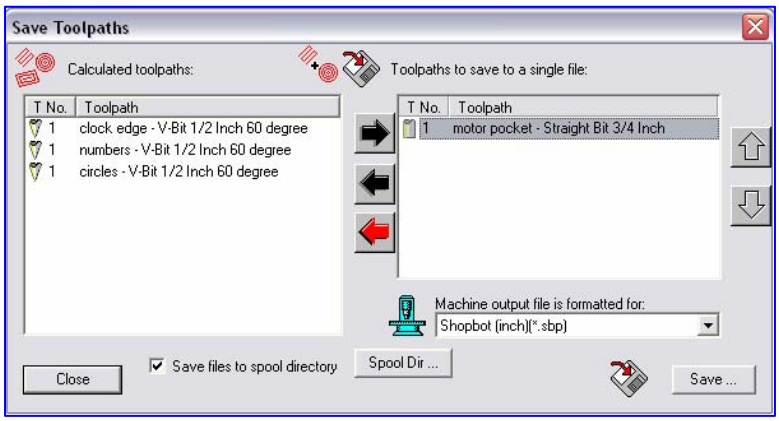
34. Click on the Toolpaths tab. 

    You should now see these four toolpaths listed. Click on the **[motor pocket]** toolpath to select it.



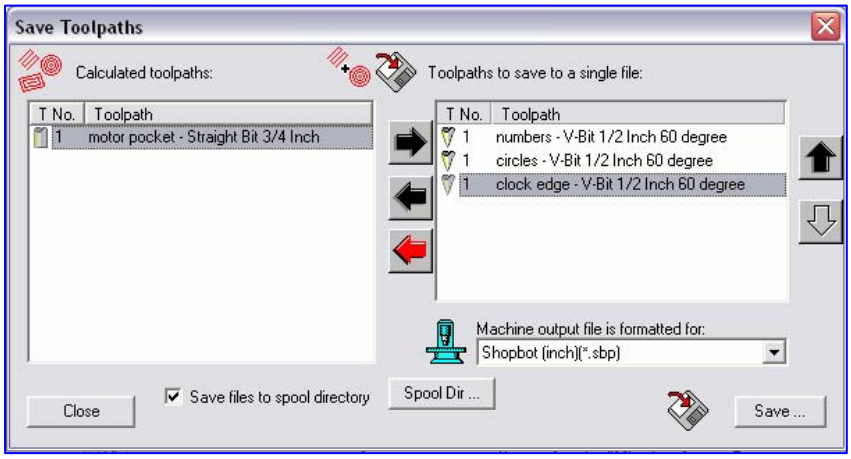
35. With **motor pocket** selected, click on the **Save Toolpaths** button. 

When the **Save Toolpaths** window appears, only toolpaths listed in the right column will be saved as NC code. Make sure motor pocket appears in the right column. Click on Save ...



36. The **Save As** window will appear. Navigate to your folder on the server. In the **File name box** type **motor pocke**t. Click on Save ...

37. You will be returned to the **Save Toolpaths** window. Highlight toolpaths and use the black arrows (as you did in Activity 4) to arrange the toolpaths as shown here. These three toolpaths can be saved as one NC file because they all use the same cutting tool. Click on Save ...



38. The **Save As** window will appear again. Navigate to your folder on the server. In the **File name** box type clock face. Click on Save ...

39. When returned to the **Save Toolpaths** window, click on Close

40. Save your PartWizard file as you did in Activity 4 then close **Part Wizard**. You are now ready to machine your clock.

Activity 7
Machine Your Clock

Whenever you machine a part, you **must** do three things if you expect the CNC router to machine your part correctly.

A. Secure your material to the router table
B. Position the router bit precisely at the origin
C. Zero the X, Y, and Z coordinates

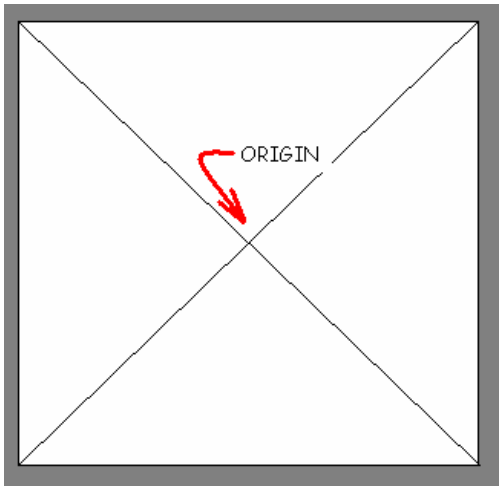
Only after these three steps have been performed correctly do you load your NC part file.

Secure your material

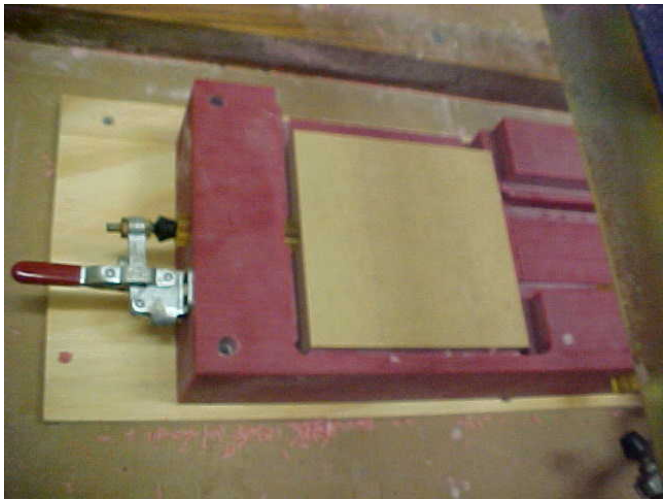
1. Ask the teacher for a piece of 5.75 X 5.75 material for your clock.

2. Ask the teacher to install a 3/4" straight bit in the router.

3. When you designed your clock face, you made sure that the origin (X=0, Y=0, Z=0) was at the center of the material. Use a straight edge to accurately draw an X from corner to corner of your material to locate the center as shown.



4. Place your material in the vise as shown. Gently tighten the clamp until you feel it click into place. Check to see that your material is secure by trying to move it with your hand.

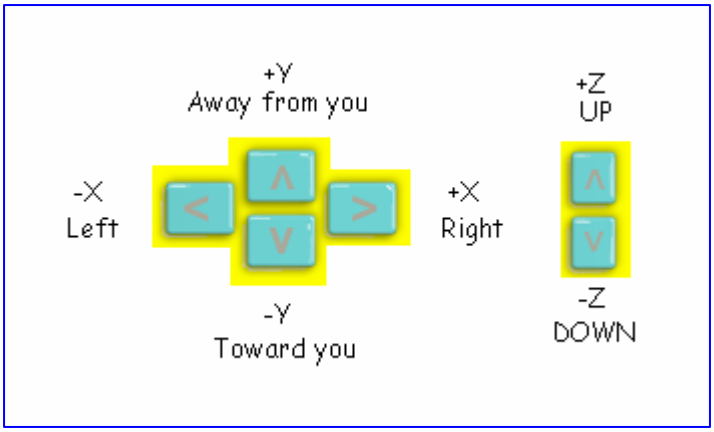


Position the Router and Assigning the Origin

5. On the computer connected to the ShopBot, launch the ShopBot control software.

6. The next task is to position the router at the origin where the NC instructions are expecting it to be. Press K on the keybord. You should see the ShopBot KeyPad screen appear. These controls allow you to manually control the router.

7. Take a moment to look at the router. The X, Y, and Z axis are labeled. Make sure you understand which way the router will move BEFORE you start pushing buttons. Be careful when you press keys to move the carriages on the Shopbot because the machine will coast for a moment after you take your finger off the key!!!!



8. Use the blue X axis and Y axis arrow buttons to position the center of the router bit directly over the X that you drew. Next, use the blue Z axis buttons to move the cutter down until it is about 1/8 inch above the surface of your material. Click on the Fixed button. This will move the router in very small increments so that you can move down until the router bit just barely touches the surface. Close the keyboard control window.

Assign the Origin

9. Once the cutting tool is properly positioned you must zero the X Y and Z axis. To do this, select **[Z]ero** from the menu. Then select **zero [3] axes (X,Y & Z)** Notice that the coordinate readout on the right all indicate .000

10. The ShopBot is now ready to machine a part. Before you begin, ***CALL THE INSTRUCTOR TO YOUR STATION TO INSPECT THE SETUP ON THE ROUTER.***

11. Check the clock. *Ask the instructor if there is enough time to machine the pocket!* Now you are ready to open an NC file. From the menu, select **[F]ile** then **[P]art file execute**. Navigate to your folder on the server and select the file named **POCKET.SBP** that you created in the previous activity, then click the Open button.

12. Remember to keep an eye on the router. If you made a mistake when you created your toolpaths, it could do something crazy. Be prepared to press the red **S** key on the keyboard or the **giant yellow flashing STOP button** on the monitor or the **red emergency stop button** on the Shopbot if something goes wrong.

13. ***PUT ON HEARING PROTECTION AND SAFETY GLASSES!!!!!***

14. **Turn on the router and dust collector.**

15. Click on the **START** button.

16. When the router finishes cutting, it will rise up from the material and wait. Turn off the router and the dust collector.

17. Remove your material from the holding fixture. If time permits, machine the face of the clock.

18. Carefully draw an X from corner to corner on the **front** of your material. Secure your material in the holding fixture with the uncut face up.

19. Ask the instructor to install a 60 degree V bit.

20. Repeat steps 6 through 8 to position the router so that the V bit barely touches the surface of your material. Once the cutting tool is properly positioned you must zero the X, Y and Z axis. To do this, select **[Z]ero** from the menu. Then select **zero [3] axes (X,Y & Z)** Notice that the coordinate readout on the right all indicate .000

21. Check the clock. *Ask the instructor if there is enough time to machine the face!* From the menu, select **[F]ile** then **[P]art file execute**. Navigate to your folder on the server and select the file named **clock face.sbp** that you created in the previous activity, then click the Open button.

22. Remember to keep an eye on the router. Be prepared to make an emergency stop if something goes wrong. ***PUT ON HEARING PROTECTION AND SAFETY GLASSES!!!!!*** **Turn on the router and dust collector** then click on the **START** button.

23. Loosen the clamp and remove your finished part from the vise.

24. Clean up!!!!!!!!!!!!!!!!!!!

Name_____

Router Checklist

1. _____ Answer questions from Activity 1

2. _____ Simulate race car body in Mill Wizard
Save toolpaths / NC code for car body

3. _____ Rapid prototype of car body

4. _____ Generate and save NC code for plaque text and edge.
Show instructor your toolpaths

5. _____ Machine the plaque

6. _____ Generate and save NC code for clock pocket
Show instructor your toolpaths

7. _____ Generate and save NC code for the clock face and edge.
Show instructor your toolpaths.

8. _____ Machine the clock face and pocket

9. _____ Assembled clock