Techno LC Series 4848 CNC Router Tutorial

What is the CNC Router?

The CNC (Computer Numerically Controlled) Router is a digitally driven, coordinate based prototyping and production machine. The CNC router mills material utilizing a cutting tool fixed in a rotary spindle which traverses along an overhead gantry system. The gantry moves the bit along the X, Y, and Z axis' based on coordinates developed in relation to a 3D Model in the form of a tool path. Unlike a rapid prototyper, which prints a part layer by layer (an additive process), the CNC will incrementally remove waste material revealing the part from within solid stock (a subtractive process).

Techno CNC Specifications

1) Work envelope: 48" (X and Y axes), 4-3/4" (Z axis)
2) Feed rate- 250 IPM max (inches per minute).
3) Work envelope: 48" (X and Y axes), 4-3/4" (Z axis)
4) Spindle speed- 18,000 RPM max.
5) Collet sizes, 1/8", 1/4", 3/8",1/2;" 10mm (for drilling mills)
6) Materials **APPROVED** for milling: MDF, plywood, solid lumber, foam, plaster, acrylic.
7) Materials **PROHIBITED** from milling- metals, ceramic, stone.

Tips for CAM File Preparation

1) Download the RhinoCAM tool library to use when making CAM files. Go to the Architecture home page > Student Groups & Resources link > Wood Shop/ Digital Fabrication Shop link > RhinoCAM Tool Library (most recent edition if multiple are available). Save the file, then drag it from your Downloads folder to the desktop. Open RhinoCAM, then upload the tool library. These tools are digital duplicates of our actual tool selection. Please note that speeds and feeds are set to a default setting for estimation purposes, and users will later use the feeds and speeds calculator to produce the actual settings during CAM file review.
2) DIMENSIONS: use accurate dimensions for materials, Rhino objects, and cut levels, as inconsistencies between the digital object dimensions and material thickness can result in errors such as cutting into the plenum board or machine bed, damaging cutting tools, and/ or inaccurate machining of workpiece. Calipers are available in the CNC room (Digital Fabrication Shop, Arch 109). for accurate measurements of your materials (*materials do not always correspond to labeled thickness)
3) MARGINS: projects that will be clamped to the CNC bed (compared to being held down by the vacuum) must fit within a 1-1/2" margin around the perimeter of the actual stock. **NO CUTTING CAN HAPPEN OUTSIDE OF THIS MARGIN**. This margin accounts for the position of clamps, screws, and other fasteners which can damage the tool if collisions occur. The margin ensures that no cutting occurs near your fasteners and provides perimeter support material. Add this 1-1/2" perimeter margin in your Rhino drawing.
   a) If this margin presents complications due to unique project requirements, you must confer with the tech before proceeding.
4) SUPPORT MATERIAL: there must be sufficient material remaining surrounding and attached to a part in order to prevent the part from being thrown from the bed. **If tight nesting of parts results in limited support material, users must speak with the tech in order to determine a solution.**

5) POST PROCESSOR: **YOU MUST SELECT "TechnoIsel"** from the Current Post Processor drop down menu. Selecting any other post processor will result in your file running incorrectly, which can damage your stock, the tool, router, and/ or the bed.

CAM File Review and Mill Scheduling

1) RhinoCAM files must be reviewed by the Woodshop Technician, and all editing complete, before being able to schedule a milling time slot. During review, proper feeds and speeds will be calculated in order to set the most accurate milling time estimate. Additional time will be added to your milling slot to account for set-up of the machine and cleaning. Email the tech at jasonf@temple.edu to schedule a review.
2) **Students do not need to learn to operate the CNC router in order to have projects milled**. They must still make their CAM files and schedule a review, and then schedule a milling slot for which they will sit with the CNC for the duration of the operation. The tech will prep the stock and load and run the file.
3) HOURS OF OPERATION: The CNC may only be operated during open woodshop hours (posted on door to Arch 110), as the dust collector must always be used when running the CNC.

Safety Rules

1) TRAINING: all students who would like to operate the CNC Router must first attend a demo. Then they must operate the CNC router under the tech's supervision until they can demonstrate they can independently operate the machine.
2) STATE OF MIND: CNC users cannot use the machine if they are sleep deprived, fatigued, or under the influence of alcohol or drugs.
3) INSPECT EQUIPMENT: If equipment does not appear to be operating properly, stop working, and report it immediately to the tech.
4) Keep the table clean and free of tools and loose materials.
5) PERSONAL PROTECTIVE EQUIPMENT (PPE): **CNC users must wear a face shield and hearing protection at all times while the CNC is running**.
   a) As significant dust can be produced during operations, **use of a dust mask is suggested, but it is voluntary**. If you develop any sensitivities or reactions to wearing a dust mask, then you will need to be evaluated by a physician. At this point you may also need to use an N95 respirator (or higher rated), which will require test fitting by Temple's Environmental Health and Radiation Services (EHRS).
6) Be careful handling cutting tools as they are extremely sharp. Handle them by the solid shaft as much as possible. You may want to wear work gloves. Store tools in their plastic cases when not in use.
7) Do not exceed recommended feed or spindle speeds as this can result in tool breakage and produce a projectile.
8) The dust collector must be used when the router is operating.
9) The CNC can NEVER be left running unattended. A user must stay with the machine, **within arm's reach of the emergency stop button** for the entire operation, in order to prevent any emergencies, such as the tool cutting into the table, or fire, from excessive friction. If you need to leave and no one is available to watch the operation, pause the job.
10) Never rest your hands, feet, or lean on the table while the router is running.
11) Never attempt to make any adjustments to the router, stock, or table while the router is running.

CNC Router Guidelines

1) NEVER CUT OR SCREW INTO PLENUM BOARD OR ALUMINUM TABLE. If you are to pierce the bottom side of your stock (or come within 0.1"), then you must use a spoiler board to provide distance from these two surfaces (your own or the shop's).
2) NEVER cut or screw into the shop supplied bleeder board when using the vacuum table, as suction could be lost and workpiece becomes unsecured. If you choose to screw or cut into your own bleeder board, you must further secure the bleeder board to the bed using clamp.
3) All through hole drilling must use a drill, never a flat end or ball mill.
4) Always pull curtain open to minimize spread of dust onto computers.
5) You cannot use desktop computer while machine is running, (CNC uses the computer for operation). Any use of the computer will pause the operation.
6) The entire CNC room must be vacuumed after each use. **Failure to clean sufficiently will result in loss of operating privileges**.

Securing Stock to Table ("bed")

1) Move gantry to "Home" position so the bed is unobstructed for positioning of stock.
2) Determine whether the stock will be secured to the bed by clamping, the vacuum pump, screws, or some combination of the three.
3) USING CLAMPS TO SECURE STOCK: if you are to pierce the bottom of your stock, or come within 0.100" of the bottom of the stock, you must use clamps to secure the stock to the bed. Cutting through stock can diminish suction from the vacuum pump and cause the stock to be thrown if this is the only means for securing. A spoiler board must be put underneath the stock to prevent cutting into the bed.
4) USING THE VACUUM PUMP TO SECURE STOCK: for stock that will not be cut through, the vacuum pump can be used. Plugs under the stock must be removed. Gaskets under the stock must be positioned in the plenum board to avoid any leakage. Open or close the vacuum ports to be used. The stock can be put directly on the plenum board, or a bleeder board can be used to facilitate suction.
5) USING SCREWS TO SECURE STOCK: **using screws to secure stock should only occur under unique project requirements**, as cutting into screws will break tools. A 2" margin must be made around the perimeter. If any screws are to be located internally, then there must be 2" clearance around each screw (4" diameter), and a full scale drawing must be used to properly locate the screws onto the stock. **The tech must be consulted before using screws to secure stock**.
6) Refer to the flowchart below for additional information on securing stock to the bed.

Inserting Tool into Spindle

1) Set router over plenum board, and set to highest Z height for clearance to insert tool. If tooling should fall, it is less likely to break over plenum board then the concrete floor or aluminum bed.
2) Remove collet nut from spindle; either by hand or with wrenches if necessary

3) Insert collet into collet nut- collet is seated correctly when the faces of nut and collet are flush
4) Insert the solid shank end of the cutting tool into the bottom of the collet (inserting cutting edge first can damage edge)
   a) Use the shortest tool possible, in order to minimize breakage and deflection caused by excessive stick-out. Keep flute fadeout out of the collet (transition between flutes and shank).
5) COLLET TYPES- 1/8" and 1/4" = half-grip collets; 3/8" and 1/2" = full grip collets
6) Thread the nut on to the spindle and then tighten with wrenches.
7) When finished milling, remove cutting tools from spindle, and return to the case.
8) Refer to the graphic below for examples of proper and improper colleting.

Techno Interface (see graphic below)

1) JOGGING FUNCTIONS- used to move the router to a specific location, distance, or rate of speed.
   a) HOME button- moves router to the Machine Zero: zero at X-, Y+, and Z+ (this is the back left corner of the bed, away from the user at the computer). Axes can also be moved individually or in combination. This clears the plenum board for material loading.
   b) ZERO button- used to set starting location for one or all axes (use this primarily for X and Y only). Zero the X and Y to front left corner of plenum board (closest to computer). Zero point is center of tool axis.
      i) The Z axis can also be manually zeroed by jogging the tool into contact with a sheet of paper on top of the stock, or it can be zeroed using the touchpad.
   c) GOTO button- used to move the router to a specific coordinate set.
   d) TOOL button- used to set Z axis' Work Zero (or "Part Zero") using the touchpad. **Z Zero is most often set to the top of the stock.** Under some circumstances, Z Zero must be set to the table top. This also requires a change in Rhino for the object to be repositioned into positive Z space. **See the tech if you must zero to the table top**.
      i) Set touchpad on top of stock.
      ii) Jog router over touch pad. You can jog router down in Z to be closer to touch pad, but be careful not to crash tool into pad.
      iii) From interface, select Tool > Touch Off Z Zero Position > tool descends to touch tool against touch pad- retracts when contacted
         (1) If using vacuum to secure stock, turn it on prior to taking this measurement as the suction will pull the stock lower and give an accurate measurement.
         (2) Tool must be clean (especially free of carbon) or the touch pad may not detect the tool touching its surface, and could damage tool and/ or machine.
   e) JOG SPEED slider- adjust the rate of travel of the router in IPM (inches per minute). Up to 250/IPM.
   f) JOG STEP slider- used to set the increment of distance the router will move when it is set in "step" mode.
   g) Continuous and Step radio buttons- used to make the router move either uninterrupted, or one unit of distance per action.
   h) ARROW buttons (on interface) - move the router in the X, Y, and Z axes.
      i) The keyboard arrow keys can also be used to move the router in the X and Y axes. The + and - (minus) keys can be used to move the router in the Z axis.

2) FILE EXECUTION FUNCTIONS- cutting/editing operations.
   a) FILE button- to select NC file for cutting operation (post files separately to avoid confusion).
      i) *Program glitch- After first cutting operation, when selecting files for subsequent operations, an error message reading, "file not found" will appear. Close the message box for options window to appear.
   b) PREVIEW button - shows tool paths. Preview must be closed in order to continue using the interface.
   c) PREPROCESS button- prepares file for cutting operation
   d) START button- begins cutting operation
   e) Sequence for loading file: File > Preview > Preprocess > Start >
      i) * Program glitch- When you hit start, spindle rotation does not begin immediately, and a flashing error message appears reading, "Load Tool." ("Start" button changes to "Resume"). Start > "Load tool" message, select Resume > spindle begins rotation.
      ii)
   f) PAUSE button- used for temporary stops during cutting operations. Cutting will resume at location when paused.
      i) While paused, the router can be jogged to other positions for adjustments, and the job resumed.
   g) STOP button- ends cutting operation, resets to beginning of operation (cannot return to point in cutting operation when process was stopped). Use if you want to end the process prematurely or for emergency (can also hit emergency stop button on bed).
      i) The emergency shut-off switch located at the front left of the table is the quickest and most effective way to stop the router in an emergency.
      ii) SKIP button- allows the operation to be started at a point past the starting line of G-code, (usually necessary after a computer malfunction has reset the operation to the beginning). The operation can be restarted at either at a certain percentage of cutting time for the operation, or by scanning the G-code to find the approximate location when the operation was interrupted.
   h) SPINDLE- Keep set at default of "Auto" for cutting operation. **NEVER TURN "ON"**
   i) COOLANT- keep set at default of "Auto"- COOLANT IS NOT USED.

Glossary

BLEEDER BOARD- porous surface (usually sanded or milled MDF) placed atop plenum board to facilitate vacuum suction of work piece.

CHIP LOAD- a measurement of the thickness of material removed by each cutting edge during a cut. Refer to the G-Wizard feeds & speeds calculator for common material chip loads.

COLLET- a segmented sleeve that holds the shaft of a cutting tool. See attached image for proper seating.

FEED RATE- the velocity at which the cutter is moved against the workpiece.   Expressed in terms of inches per minute (IPM).

GANTRY- The horizontal support member of the CNC, on which the Spindle is mounted. The gantry moves along the Y-axis. The router moves laterally along the gantry to describe the X-axis.

MILLING- the machining process of using rotary cutters to remove material by advancing the cutter into the workpiece at a certain direction.

NESTING- the arrangement of parts within the stock to produce the most efficient use of the material.

ORIGIN- In Rhino, this is the world 0,0,0 coordinate. On the CNC router, you establish this point when you zero out the bit on the material. When you do this you must zero out all three coordinates. Once you have established this origin, the CNC will interpret that origin to be the position of the 0,0,0 origin in your Rhino file.

PLENUM BOARD- machine grooved MDF surface that is permanently mounted to the CNC bed. The surface is perforated for vacuum suction.

SPINDLE- the rotating motor that spins the cutting tool.

SPOILER BOARD- work surface placed atop plenum board used as a protective barrier for plenum board from cutting tools that pierce the work piece's bottom.
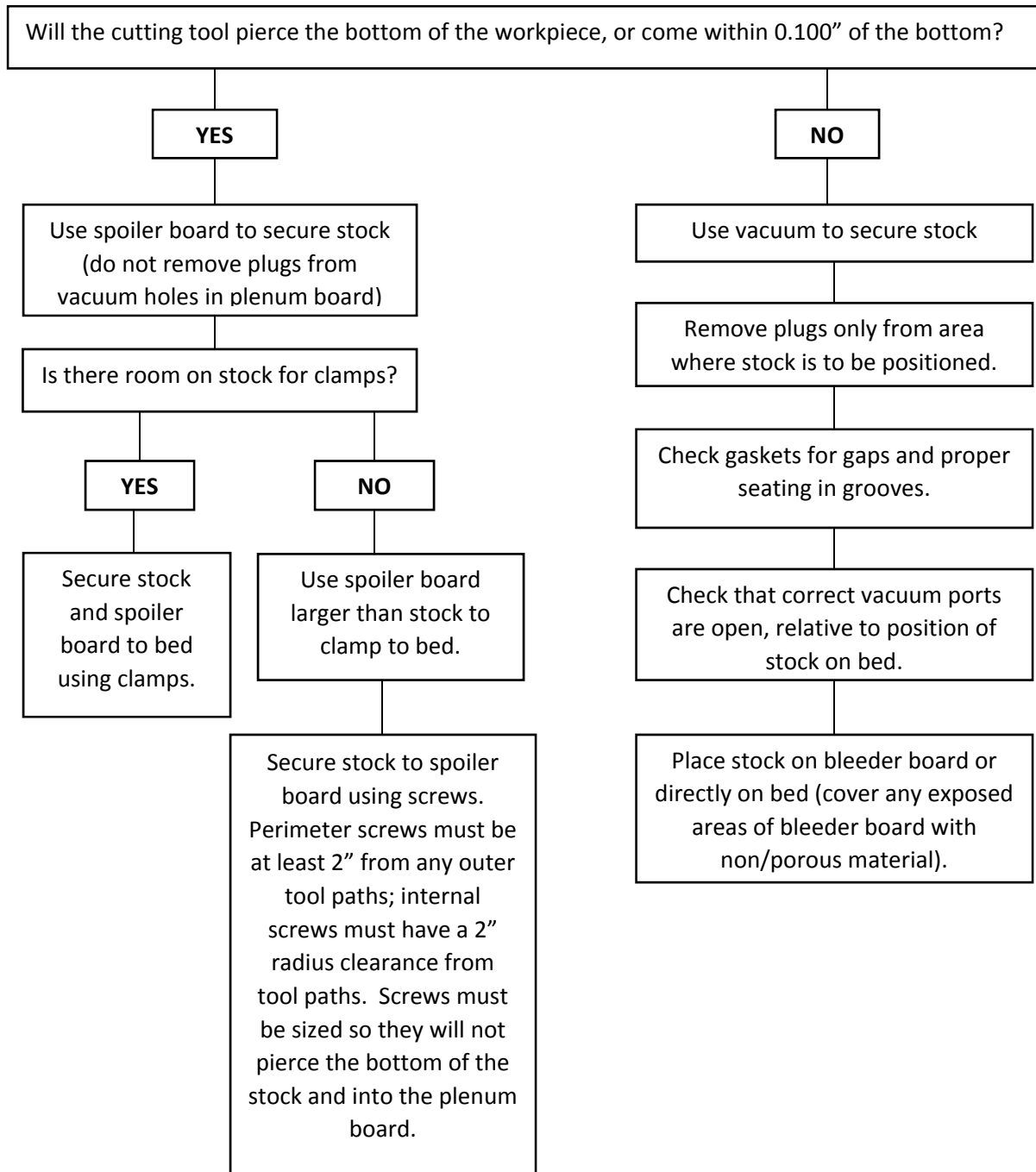
STOCK- the material that will be machined on the CNC router.

SUPPORT MATERIAL: The material outside of the part you are milling. When you are milling, there must generally be some sort of support material in addition to the part being milled so as to secure the parts to the machine as they are being milled.
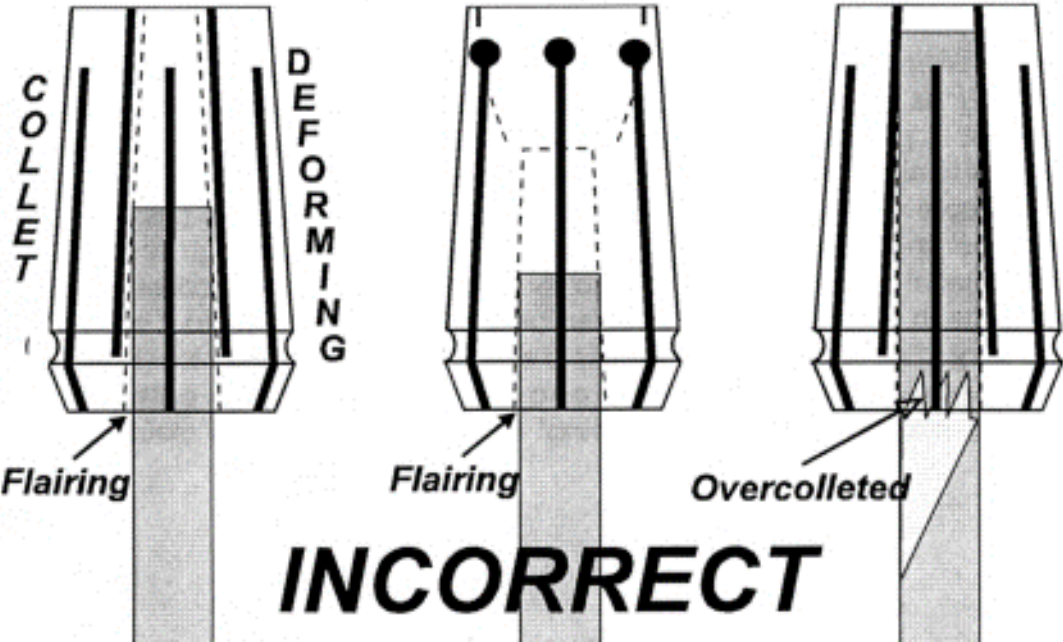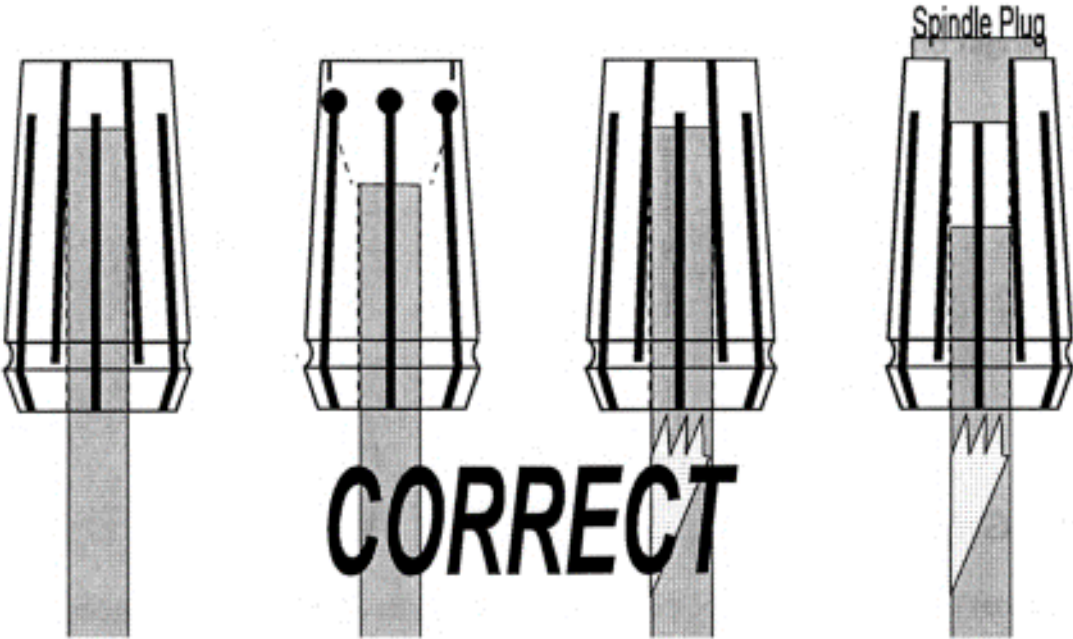
TOOL- the rotary cutter used in the CNC machine to cut the material. Tools are made from avariety of materials and in a wide range of sizes and geometry.

Securing Stock to Bed

1) Move gantry to "Home" position so bed is unobstructed for positioning of work piece.
2) Follow flow chart below to determine how to secure work piece to bed:

Will the cutting tool pierce the bottom of the workpiece, or come within 0.100" of the bottom?

YES

NO

Use spoiler board to secure stock (do not remove plugs from vacuum holes in plenum board)

Use vacuum to secure stock

Is there room on stock for clamps?

Remove plugs only from area where stock is to be positioned.

YES

NO

Check gaskets for gaps and proper seating in grooves.

Secure stock and spoiler board to bed using clamps.

Use spoiler board larger than stock to clamp to bed.

Check that correct vacuum ports are open, relative to position of stock on bed.

Secure stock to spoiler board using screws. Perimeter screws must be at least 2" from any outer tool paths; internal screws must have a 2" radius clearance from tool paths. Screws must be sized so they will not pierce the bottom of the stock and into the plenum board.

Place stock on bleeder board or directly on bed (cover any exposed areas of bleeder board with non/porous material).

Proper Tool Colleting

Spindle Plug

CORRECT

COLLET DEFORMING

Flairing

Flairing

Overcolleted

INCORRECT

Techno CNC Interface