MANUAL MILL

VERSION 3.1

MANUAL MILL

THE MILLING MACHINE MAKES PRECISION CUTS IN METALS AND PLASTICS.

MACHINE CONTROLS

P. 2

VERSION 3.1

HEAD

DIGITAL READ OUT (DRO)

CONTROL PANEL

VISE

TABLE

KNEE
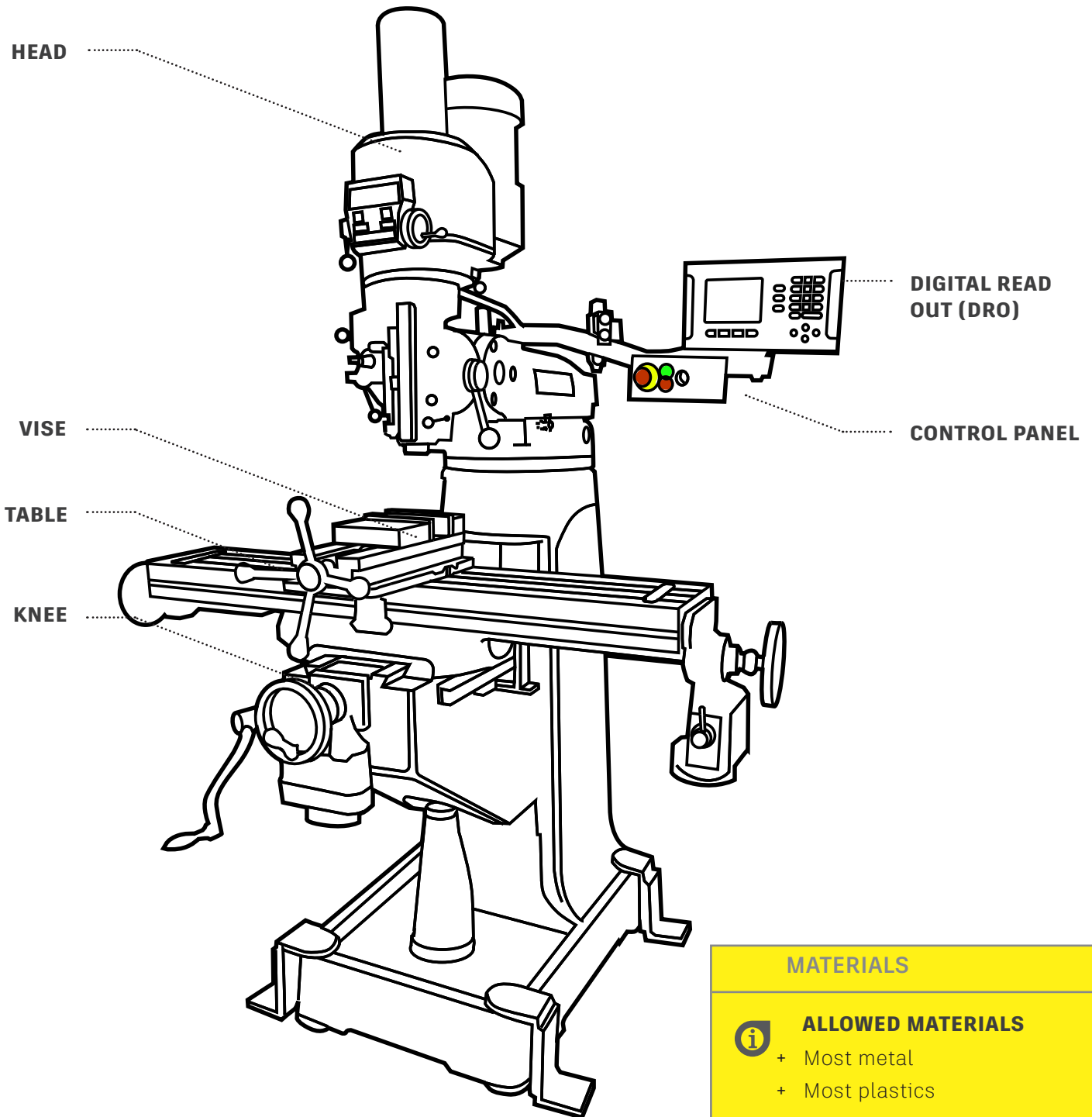
MATERIALS

ℹ ALLOWED MATERIALS
+ Most metal
+ Most plastics

⊗ BANNED MATERIALS
+ Wood
+ Carbon fiber and composites
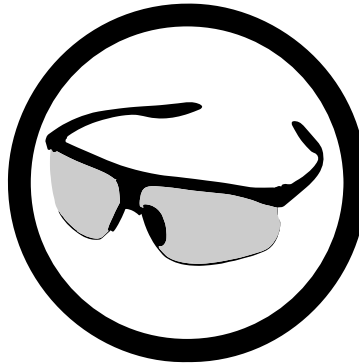
? SEE SHOP STAFF FIRST
+ All other materials

PROTECT YOUR EYES FROM FLYING CHIPS AND DUST.

Always wear safety glasses.

AVOID LOOSE CLOTHING AND OTHER ITEMS THAT COULD BE CAUGHT IN ROTATING PARTS.
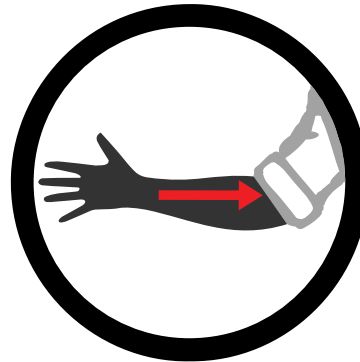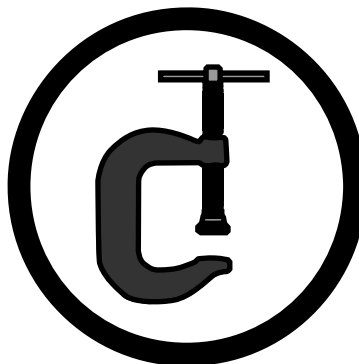
Always wear short sleeves, or rolled sleeves, pull back and tuck in long hair, remove jewelry and lanyards, etc.
Do not wear gloves.

KEEP CONTROL OF MATERIAL AT ALL TIMES.

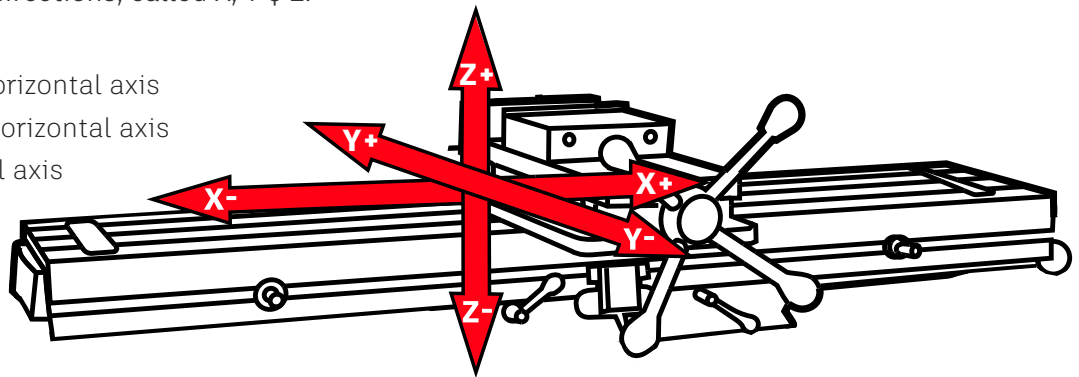Using the mill vise or strap clamps is required for all work.

MILL BASICS: MOVEMENT

When using a mill, the material is clamped into a vise or directly to the table. The table is moved so that the workpiece moves past a spinning cutter.

The table can move in 3 directions, called X, Y & Z.

+ X is the long horizontal axis
+ Y is the short horizontal axis
+ Z is the vertical axis

+ Handwheels and power feeds move the table horizontally (X & Y).
+ Z crank moves the table vertically (Z).

+ Locks keep the table from moving.
  ▸ Lock each axis that is not moving.
  ▸ Unlock an axis before moving it.
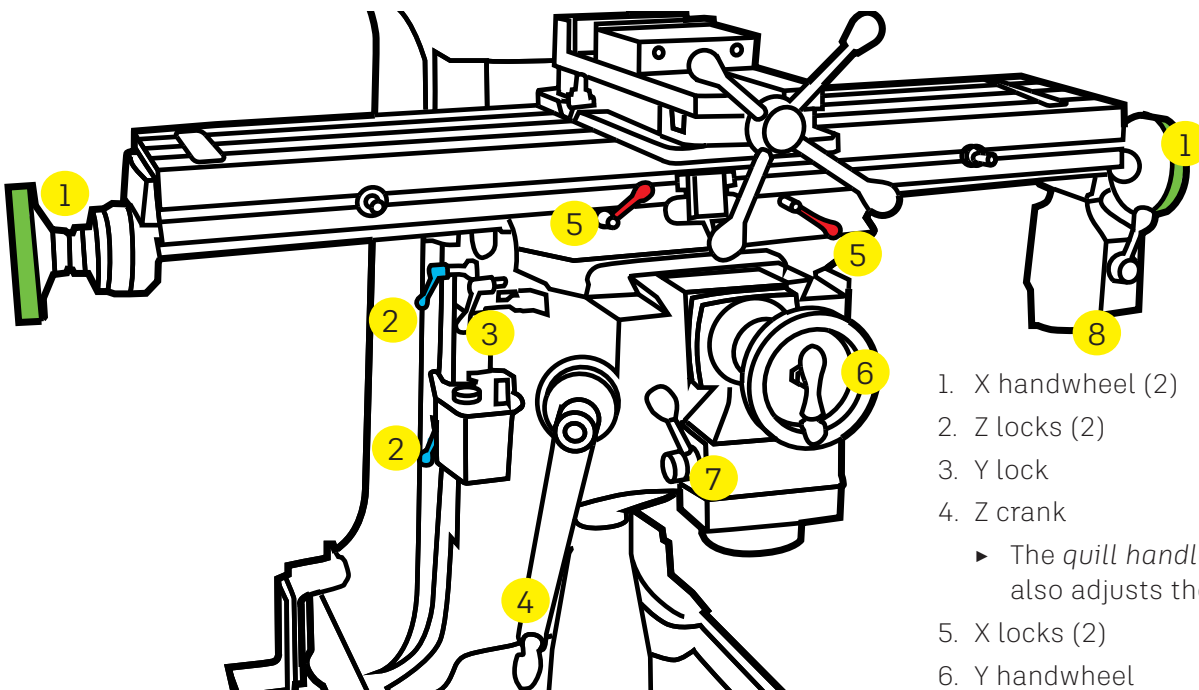
1. X handwheel (2)
2. Z locks (2)
3. Y lock
4. Z crank
   ▸ The *quill handle* (next page) also adjusts the Z height.
5. X locks (2)
6. Y handwheel
7. Y power feed
8. X power feed

The head of the mill holds the following controls:

+ Hi/low gearbox
+ Speed control and display
+ Brake
+ Quill handle
+ Quill lock

CHANGING THE GEARBOX RANGE

+ **Mill must be *off***

1. Push the lever towards the mill and rotate into high or low range.
2. Rotate the spindle by hand to fully engage the gears.
3. Move the switch on the control panel to match the gearbox switch.
   ▸ Ex. If the mill is in high range, turn the control panel switch to high.
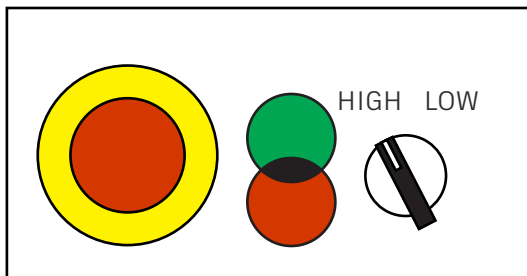
CHANGING THE RPM

+ **Mill must be *on***

4. Rotate the handwheel clockwise or counterclockwise.
5. Observe the RPM on the display.

BRAKE

6. Use the brake to stop the spindle after turning off the mill.

QUILL MOVEMENT

7. Engage the quill lock before moving the table.
8. Use the quill handle to move the quill like a drill press.
9. Set the depth stop to limit quill handle travel.

High/low gearbox detail

MANUAL MILL

CUTTING TOOLS AND HOLDERS
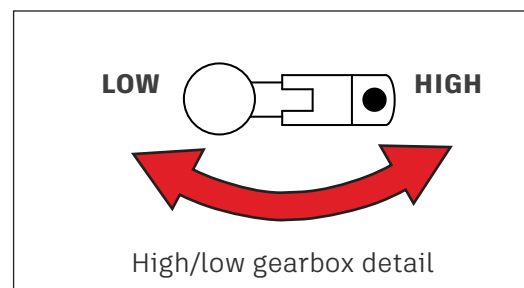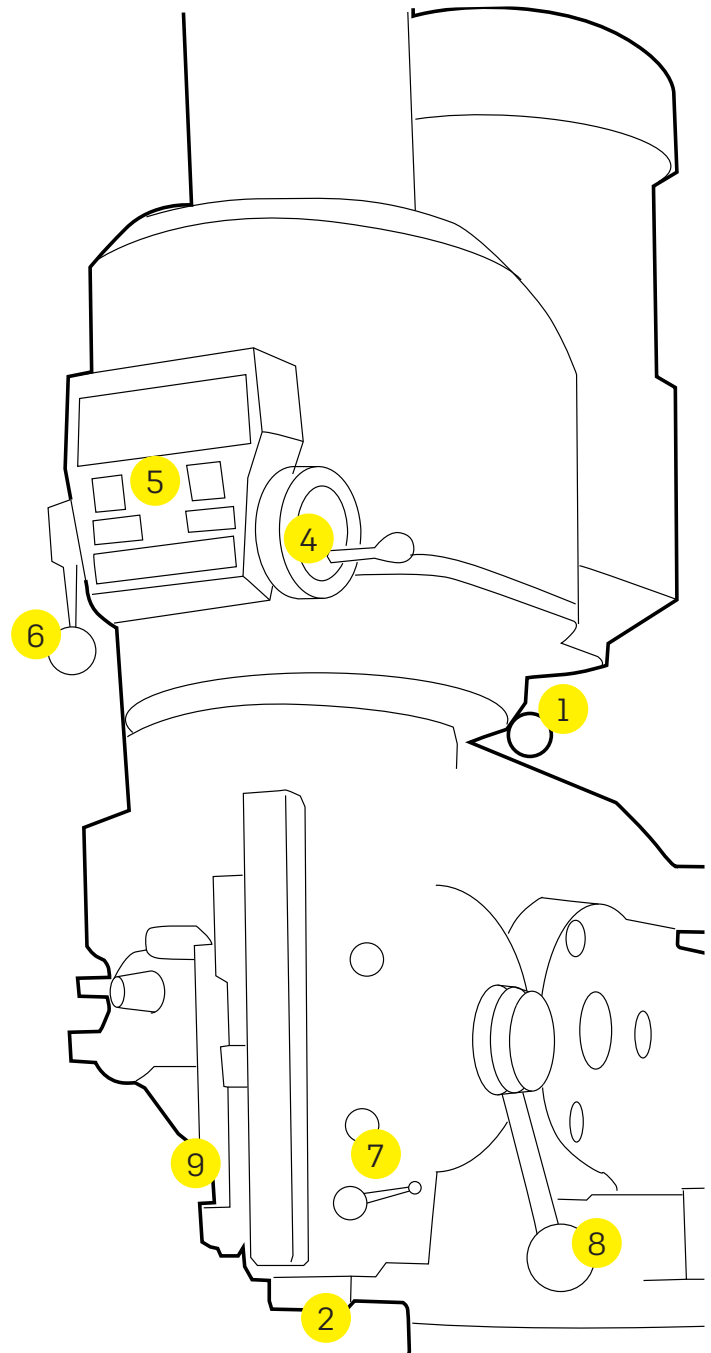
ASK SHOP STAFF FOR ASSISTANCE IN SELECTING AN APPROPRIATE CUTTING TOOL.

P. 6

VERSION 3.1

END MILLS AND COLLETS

End mills and drill bits are the most common cutting tools used in a mill.

+ End mills are designed to cut while moving sideways through the material, in X or Y.
+ Drill bits can only cut while moving in Z.

End mills come in different diameters, lengths, and shapes.

Each cutter requires a different RPM depending on the material being worked - *speed*.

The *flutes* are the cutting edges. In general, use *2 flute* end mills for plastic and aluminum, and *4 flute* end mills for steel.
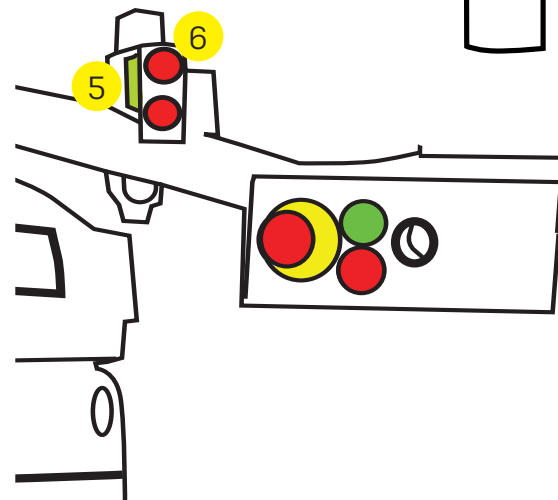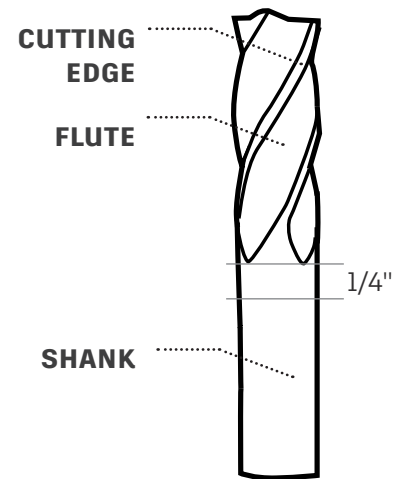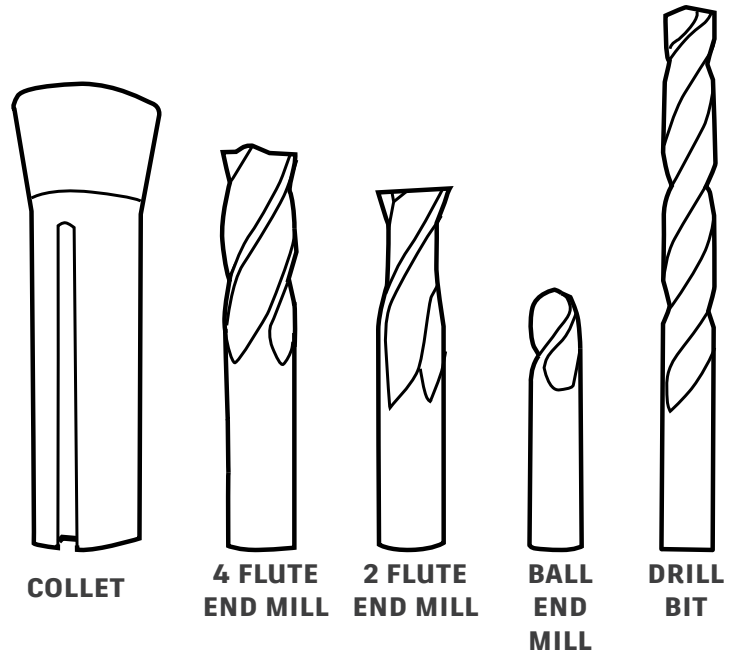
Ask Shop Staff for assistance selecting an appropriate end mill for your project.

End mills must be held in a *collet*.

+ Never hold an end mill in a drill chuck.
+ The collet must be the same size as the shank of the end mill.
+ Only grip the shank; not the flutes.
+ Leave no more than 1/4" of shank out of the collet.
+ Hold drill bits in a chuck that installs in the mill.

INSTALLING A BIT AND COLLET

1. Slide the shank of the cutting tool into the large end of the collet.
2. Place the small end of the collet into the bottom of the spindle.
3. Push up on the collet, and slowly rotate it until the key in the spindle slides into the keyway in the collet.
   ▸ Hold the collet in place for the next steps.
4. Push the quill handle to the top of the stroke.
5. Press and hold the gold bar on the power drawbar controller.
6. Press the IN button on the controller.
   ▸ Hold the button until the pitch changes - about 3-4 seconds.

COLLET **4 FLUTE END MILL** **2 FLUTE END MILL** **BALL END MILL** **DRILL BIT**

**CUTTING EDGE** **FLUTE** **SHANK** 1/4"

USING THE VISE & PARALLELS

Parallels are used to elevate your workpiece in the vice, and allow working on the top of your material, or to drill through it, without hitting the table or vise.

Only items with two parallel sides and a flat bottom may be held in the vise.

+ For holding complex shapes, see Shop Staff.
+ To install or remove the vise, see Shop Staff.

1. Clean the vise & parallels with a chip brush or shop towel.
2. Set two equal height parallels against the vise faces.
3. Set your workpiece on top of the parallels.
4. Have a minimum of 1/4" of material in the vise.
5. Tighten the vise.
   ▶ The parallels will probably loosen a bit.
6. Strike the workpiece straight down with a *deadblow* hammer.
   ▶ Never use a metal hammer.
   ▶ Do not re-tighten the vise.
7. See if the parallels will move in the vise.
   ▶ If so, remove the parts, and start over.

WORKPIECE

PARALLELS

**VISE FACE**   **VISE FACE**
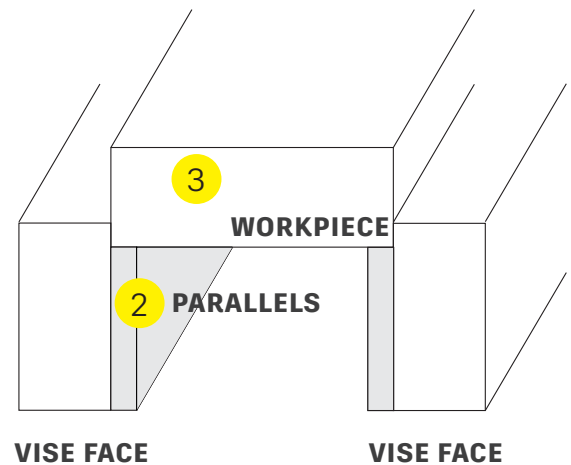
USING STRAP CLAMPS

Strap clamps are used to hold a part that can't fit in the vise.

Use a minimum of 2 strap clamps; more is better.

1. Screw a *threaded stud* into a *t-nut*.
2. Slide the t-nut into a *slot* on the table.
3. Place the stepped end of a *strap clamp* onto the *step block*.
4. Place the nose of the strap clamp onto the workpiece.
   ▶ **The nose must be slightly lower than the stepped end.**
5. Tighten the nut on the top of the strap clamp.
6. Check that the part is secure.
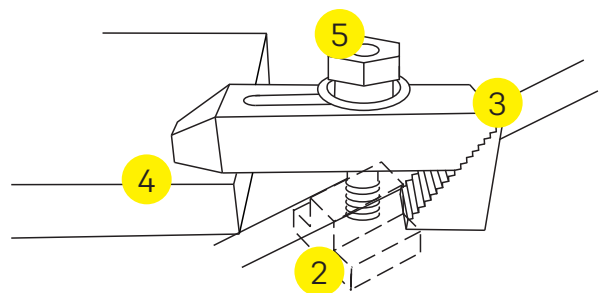
CONVENTIONAL CUTTING VS. CLIMB CUTTING

Conventional cutting is when the workpiece moves against the direction of the cutting bit.

+ All manual mill work should be done with conventional cuts.

Climb cutting is when the workpiece moves in the same direction as the bit.

+ This is not advised on the manual mill.

+ Climb cutting should be reserved for CNC milling.

WORKPIECE

FEED DIRECTION

CONVENTIONAL CUTTING

FEED DIRECTION

WORKPIECE
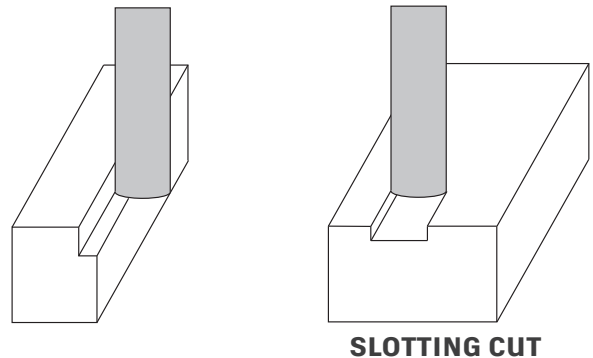
**CLIMB CUTTING
NOT RECOMMENDED**
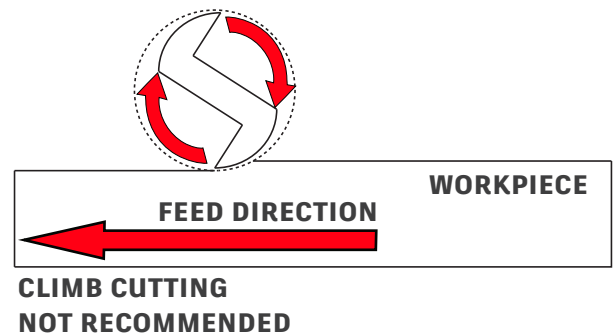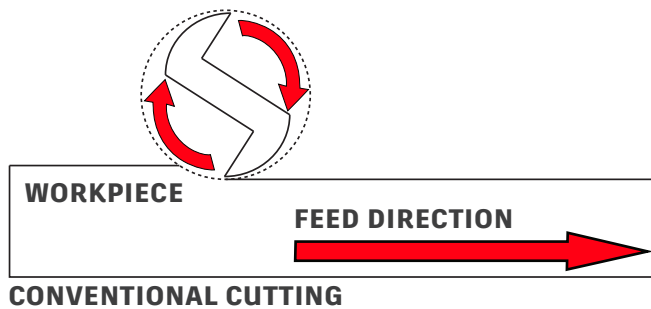
CUTTING WIDTH AND DEPTH

An end mill can only remove a certain amount of material at once.

The maximum depth and width of cut is 1/2 of the end mill diameter.

+ For example, a 1/2" end mill can cut no more than 1/4" deep and 1/4" wide in a single pass.

+ A *slotting cut* is an exception to the width of cut rule.

SLOTTING CUT

USING THE POWER FEED

The power feed moves the table at a constant rate, which can help improve finish quality.

1. Turn the speed dial to 0.
2. Move the lever in the direction you want the table to move.
   ▶ In the illustration, the table will be moving to the right.
3. Adjust the feed rate by turning the speed dial.
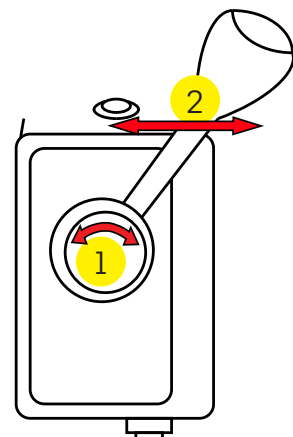
For accurate work, each axis needs to have a known zero point (origin).

There are two ways to determine zero; create it or find it.

CREATING A ZERO

X or Y axis

1. Take a light cutting pass to make the edge flat and square.
2. Turn off the mill.
3. On the DRO (see next page) zero the axis.
   ▸ In this example, zero the X axis.
4. Move the end mill 1/2 its diameter towards the center of the workpiece.
   ▸ This will center the spindle over the edge of the material.
5. Zero the axis on the DRO again.
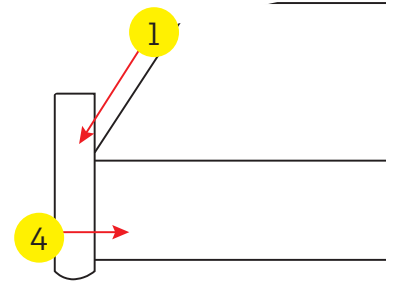
Z axis

1. Take a light cutting pass across the top of the part.
2. Set the Z axis to zero.
   ▸ The zero will need to be reset if the quill moves, or you change the end mill.

FINDING A ZERO

X or Y axis

1. Install an *edge finder*.
2. Push the bottom of the edge finder over 1/8".
3. Start the mill and adjust to 800 RPM.
4. Very **slowly** move the edge finder into the edge of the material until the bottom pops over to one side.
5. Zero the axis on the DRO.
6. Repeat step 4 to double check.
7. Move the edge finder 1/2 its diameter towards the center of the workpiece.
   ▸ This will center the spindle over the edge of the material.
8. Zero the axis on the DRO again.

Use the tip of the small end.
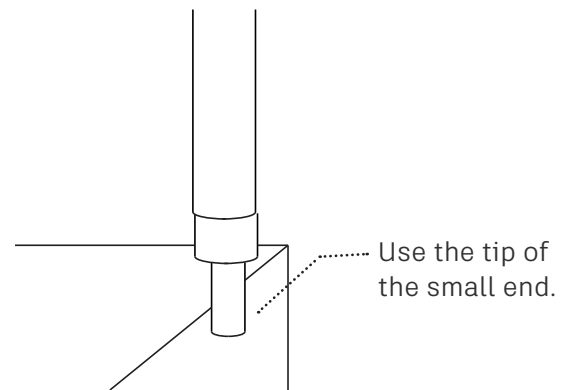
Z axis

1. Install the end mill.
2. Lower the quill (or raise the table with the quill locked) until the end mill gently touches the table.
3. Lock the quill.
4. Set the Z axis to zero.
   ▸ The zero will need to be reset if the quill moves, or you change the end mill.
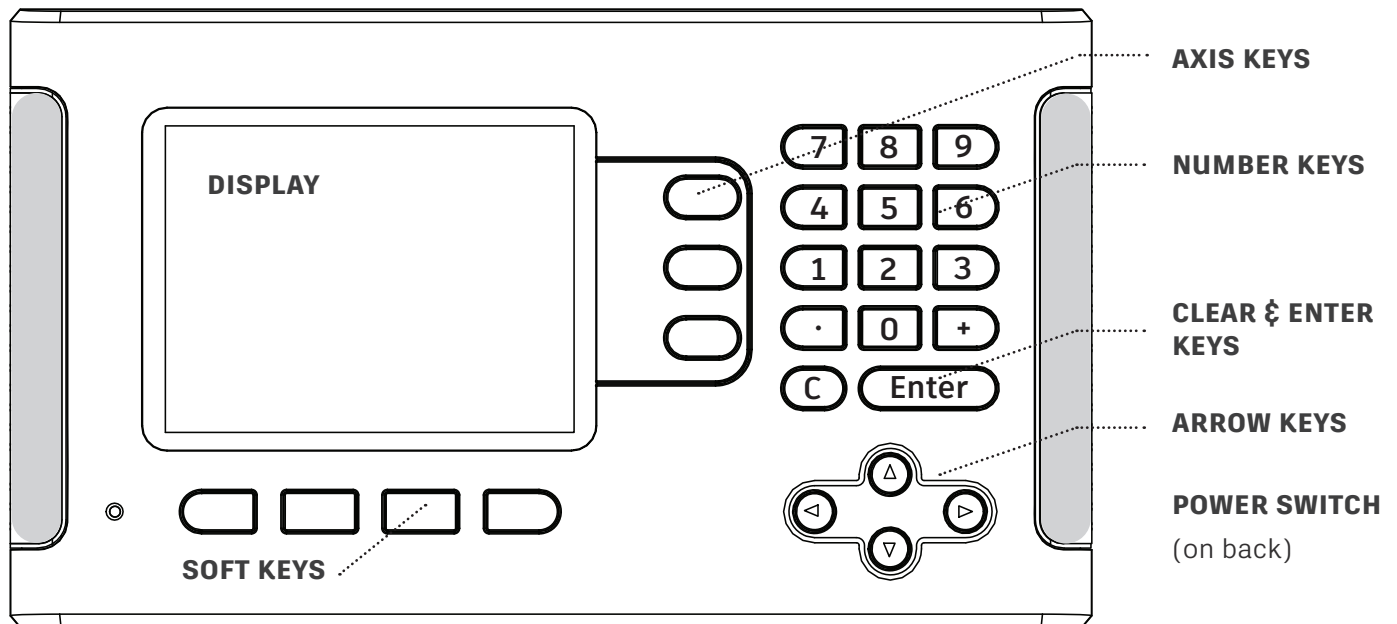
UNITS OF MEASUREMENT

Most of the cutting tools are measured in decimal inches by 0.001" (1/1000"). For example, 1/4" is 250 one-thousandths of an inch, and written as 0.250".

The *digital readout* (DRO), as well as the digital calipers, display in decimal inches or millimeters.

DIGITAL READ OUT (DRO)

The DRO displays the position of the X and Y axis in increments of 0.0002" or 0.005mm

The *Soft Keys* change using the left/right arrows. Look at the label above the key to see its current function.

+ Press **NO REF** when the DRO first starts up.
+ Press **INCH/MM** to switch to metric.

Press the **ZERO/SET** soft key to switch between zero or set mode (displayed in the upper right).

+ ZERO mode: press the axis key to set that axis to zero.
  ▶ Ex. Press the X axis key in **ZERO** mode and the X axis will be set to 0.
+ SET mode: enter a number and press the axis key to set that axis to the number entered.
  ▶ Ex. Enter 1.25 and press the X axis key in **SET** mode and the X axis will be set to 1.25.

The DRO has built-in advanced features, such as circular or linear patterns. Explore the interface or talk to Shop Staff.

AREA AND MACHINE PREPARATION

1. Clean and clear the table.
2. Secure the workpiece.
   - ▶ See Shop Staff if you need assistance.
3. Select a cutting bit & collet.
4. Install the bit & collet.
5. Lookup the RPM (speed) for your cutter and material.
6. Change the hi/low gearbox if needed.
7. Lock the quill (unless drilling).
8. Lock any axis not being moved.
9. Determine which way the table will need to move to avoid climb cutting.
10. Place the shield in front of the work area.

ALL WORK MUST BE CLAMPED AT ALL TIMES.

MAKING THE CUT

1. Start the mill.
2. Change the RPM.
3. Engage the end mill into the material.
   - ▶ Take no more than 1/2 the diameter of the cutter in depth or width of cut.
   - ▶ Avoid climb cutting.
4. Unlock an axis before moving it.
   - ▶ Lock the axis after movement.
5. Use the power feed for a better surface finish.

DO NOT CLIMB CUT.

CLEANUP

1. Clean the mill and the area nearby.
   - ▶ Use brushes and a vacuum.
   - ▶ Never use compressed air.
2. Clean up any coolant spills.
3. Put away end mills, drill bits and tools.
4. Recycle scraps and put reusable pieces in the storage bin in the metal shop.

NEVER CLEAN OFF THE TABLE WHILE THE END MILL IS SPINNING.