Engineering Innovation Center
Fabrication Shop
Basic Mill Training
The Engineering Innovation Center Fabrication Shop was established for support of undergraduate student course work. Every effort will be made to make the shop available for these projects. Students of Engineering who desire to use this equipment for educationally-related activities are required to attend training.
Milling Machine Safety

• Safety glasses must always be worn when using the mill
• Full length pants, sleeved shirts, closed toe shoes, and safety glasses are required all times
  – Full sleeved shirts **must** be rolled up and cuffed
  – Tank tops are not permitted
• Long hair must be tied up and not dangling
  – Ponytails tucked into collar of shirt are permitted
• Watches and rings should be removed and put away
• **Dangling necklaces or lanyards must be removed and put away**
• No jackets or hoodies can be worn, even with sleeves rolled up
• Be sure that the work and cutter are mounted securely before taking a cut.
Milling Machine Safety

• When mounting or removing milling cutters, always hold them with a cloth to avoid the sharp edges.

• **Do not wear gloves while using the mill**

• When setting up work, move the table as far as possible from the cutter to avoid any injury.

• Be sure that the cutter and machine parts will clear the work before making any cut.

• Never attempt to mount, measure, or adjust work until the cutter is completely stopped. Do not attempt to stop the cutter with your hand.

• Keep hands, brushes, and rags away from a revolving milling cutter at all times.

• When using milling cutters, do not use an excessively heavy cut or feed. This can cause the cutter to break and the resulting flying pieces may cause injury.

• Always use a brush, never a rag, to remove the cuttings after the cutter has stopped revolving.

• Never reach over or near or around a revolving cutter; keep hands at least 12 inches from the revolving cutter.

• Keep the floor around the machine free of chips, oil, and cutting fluid.

• **If you are confused or uncertain ASK FOR HELP OR ADVICE.**
### Vertical Mill Description

The vertical mill is a versatile and useful machine. Learning the names of the components and tooling used on this machine will facilitate a greater understanding of your work and enable you to communicate effectively with the machinists and technicians.

- **Base**: made of ribbed cast iron, supports the machine. It may contain a coolant reservoir.
- **Column**: often cast integrally with the base. The machined face of the column provides the ways for vertical movement of the knee.
- **Turret**: attached to the column and the overarm attaches to it. Allows the overarm to rotate in the X-Y plane.
- **Knee**: moves up the face of the column (Z-axis) and supports the saddle and the table.
- **Drawbar**: fastens adapters for tooling into the spindle.

![Diagram of the vertical mill components](image)
Vertical Mill Description

- **Overarm**- Ram type, allows head to extend and retract over the table.
- **Head**- is attached to the end of the ram, provides the housing for the motor and control mechanisms for the spindle.
- **Spindle**- drives tooling to perform work.
- **Quill**- housing for the spindle and allows the tooling to slide up and down in the Z-axis.
- **DRO**- Digital Read Out, displays travel increments, feed speed, and has pattern functions.
- **Variable Speed Dial**—displays spindle speed for specified gear
- **Quill Stop Knob**—limits travel of the quill
- **Quill Feed Selector**—specifies feed rate of quill power feed
- **Quill Feed Control Lever**—engages quill power feed; pull lever to left and hold until it catches into the worm gear. Tap the lever to the right to disengage or let the quill stop knob contact the micrometer nut
- **Micrometer Adj Nut and Locknut**—stop for the quill stop knob to hit, can be set for specified quill travel
- **Quill Locks**—stops quill from traveling
Head Description

- **Speed Change Handwheel**- changes the spindle speed
  - **NOTE:** **ONLY ROTATE SPEED CHANGE HANDWHEEL WHEN MOTOR IS RUNNING**
- **Hi-Neutral-Lo Lever**- changes gearing to direct drive (Hi), neutral, or back gear (Lo)
- **Quill Power Feed Transmission Crank**- Engages worm gear to drive quill power feed
- **Quill Feed Handle**- allows manual feeding of quill
Head Description

- **High-Low Range Switch** - Powers the spindle to run clockwise or counter clockwise
- **Spindle Brake Lever** - Pushes a brake pad to slow down the spindle.
  - **ONLY APPLY SPINDLE BRAKE AFTER POWER HAS BEEN SHUT OFF**
Head Description

- **Motor**- 2 H.P. variable speed
- **Drawbar**- When tightening or loosening the drawbar, it is necessary to lock the spindle. To accomplish this, use the spindle brake which is located on the left side of the belt housing, pulling toward the operator or pushing away from the operator until it binds, then raise the quill feed handle. Additionally, putting the machine into **Back Gear (Lever Lo position)** assists in tightening/loosening the drawbar.
HEAD ROTATION

- To rotate the head:
  - Loosen the 4 bolts shown in the top photo.
  - Use a wrench to turn the bolt shown in red which will rotate the head clockwise/counter clockwise.
  - Retighten the bolts when the desired angle is reached.
Turret Rotation

- The turret pivots the entire upper assembly for special setups or to use the slotting attachment (accessory).

- To swivel turret:
  - Use wrench and loosen the 4 bolts
    - DO NOT REMOVE BOLTS
  - Rotate turret by push against the ram
  - Retighten bolts when desired angle is reached
Ram Movement

- Use wrench and loosen left and right bolt
  - NOTE: DO NOT REMOVE BOLTS
- Use wrench on center bolt to slide the ram into desired position
  - NOTE: The Lagun mill has a handle instead of a center bolt to slide the ram to the desired position.
- Re-tighten left and right bolts, starting with right bolt

NOTE
- It is recommended that on heavy milling work, the head should be kept as close to column as possible, where maximum rigidity is obtained.
Range and Gear Selection

HI-LOW RANGE SWITCH

• This is the motor reversing switch. When the attachment is in **Direct Drive (High Speed)** the motor and spindle are turning in a clockwise direction as viewed from the top of machine. When the attachment is in **Back Gear (Low Speed)**, the spindle would run backwards (counter clockwise) unless the motor direction is reversed by moving switch to low.

HI-NEUTRAL-LO LEVER

• This lever is used to put the attachment into either **Back Gear** or **Direct Drive**. Rotate the spindle by hand to facilitate meshing of clutch or gears
• Neutral is provided to permit free spindle rotation for indicating and setup work
• **DO NOT SHIFT HI-NEUTRAL-LO LEVER WHILE MOTOR IS RUNNING**

**NOTE:**
For the Lagun mill, 2 corresponds to high speed (direct drive), 1 corresponds to low speed (back gear), and 0 is motor off. Additionally, Red is “Hi”, blue is “Lo”, and in between is neutral for the Hi-Neutral-Lo lever.
Spindle Speed Adjustments

VARIABLE SPEED DIAL

• Visibly indicates RPM in windows, the speed range machine is operating in.
• **Low Range** - 60 to 500 rpm
• **High Range** - 500 to 4200
• **ONLY ADJUST THE SPINDLE SPEED WHEN THE MOTOR IS RUNNING**

SPINDLE BRAKE

Brake lever can be moved in either direction to stop spindle; however, when locking spindle, lever should be moved pulling toward operator or pushing away from operator and then raised. When brake is worn out it has to be replaced. There are no adjustments to be made.

**NOTE:** Brake shown is from Lagun mill, and functions differently, simply push the lever away from operator.
QUILL FEED HANDLE

• Place the handle on the quill feed shaft
• Select the most suitable position
• Push home until the locating pin engages
Quill – Power Feed

• **Quill Feed Selector**- This crank is used for selecting the three feeds; .0015”, .003’, and .006” per revolution. It is shifted by pulling knob out and turning from one position to the other. Feeds are stamped on cover below indentation hole. Feed is more readily engaged when spindle is running.

• **Quill Stop Knob**- Is used to disengage automatic feed in either direction as well as the stop point setting working depths

• **Micrometer Nut**- This nut is used for setting depths. Each graduation on nut indicates .001” of depth, it reads directly to scale mounted along side of it. Depths may be obtained by setting micrometer nut in conjunction with quill stop.

• **Quill Feed Control Lever**- Engages quill power feed, pull lever to left and hold until the it catches into the worm gear. Tap the lever to the right to disengage or let the quill stop knob contact the micrometer nut
Saddle and Table Clamping

SADDLE CLAMPING

• When milling with longitudinal table feed only, it is advisable to clamp the knee to the column and the saddle to the knee to add rigidity to these members and provide heavier cuts with minimum of vibration. The saddle locking lever is located on the left hand side of the saddle.

• Excessive pressure can cause slight table bind. Use moderate clamping pressure (hand tight) as this will hold the saddle sufficiently.

TABLE CLAMPING

• The table clamp levers are located on the front of the saddle and should be clamped when longitudinal movement is not required.
MANUAL FEEDS

• **For X-axis and Y-axis:**
  Grip handle and turn to either left or right until spring loaded plunger engages in position.
  
  – NOTE- Only the Bridgeport Vertical Mill has the quick release safety handle. The Lagun Vertical mill and Clausing mini mill do not have this feature.

• **For Z-axis - Knee**
  Engage handle teeth into the knee teeth and rotate clockwise to move knee up
  
  – NOTE: The Lagun does not have a removable knee handle while the Bridgeport and Clausing mills have removable knee handles

• **For Z-axis – Quill**
  Release the quill lock and rotate the quill feed handle to bring spindle to desired depth
Table and Knee - Power Feeds

POWER FEEDS – ALL AXES

- To engage the lever, move the Feed Engage Lever to the desired direction of table movement.
- Feed Rate can be adjusted by turning the Feed Rate dial on the respective power feed unit.
  - Refer to the DRO (Digital Read Out) to determine the feed rate.
- To engage rapid feed, turn the handle to the desired direction and press the Rapid Feed Button adjacent to the feed rate dial.
  - DO NOT USE RAPID FEEDS TO MAKE A CUT ON A WORK PIECE
- NOTE: Only the Bridgeport and Lagun have power feed accessories.
- NOTE: The Lagun manual feed handles will rotate when power feed is on, make sure you are clear of the handle and the air hose does not get wrapped around the handle.
Fixtures and Attachments

FIXTURES
A fixture is a work holding device fastened to the table of a machine or to a machine accessory, such as a rotary table. It is designed to hold work pieces that cannot readily be held in a vise or in production work when large quantities are to be machined. The fixture is generally custom designed so that the identical parts will be positioned exactly and held securely.

ATTACHMENTS
Attachments may be divided into three classes:

1. Those designed to hold special attachments; these are attached to the spindle and column of the machine.
2. Arbors, collets, and adapters which are designed to hold standard cutters. These are mounted in the spindle.
3. Those designed to hold the work piece, such as a vise, rotary table, and indexing or dividing head.
Vices

PLAIN VISE
- Bolted to the table and is positioned quickly and accurately by keys on the bottom which fit into T-slots on the table. Clamps the work piece between the live (moving) jaw and dead (stationary) jaws.

SWIVEL BASE VISE
- Similar to the plain vise, except that it has a swivel base that enables the vise to be swiveled through 360° in the X-Y plane.

UNIVERSAL VISE
- Can be swiveled through 360° in a horizontal plane and may be tilted from 0 to 90° in a vertical plane. It is used primarily by toolmakers, moldmakers, and diemakers, since it permits the setting of compound angles for milling.
Superspacers

SUPERSPACER

• Has a chuck with 3 jaws, similar to lathe chuck.
• Used to hold cylindrical parts.
• Work piece can be rotated and indexed to cut geometry at precise angular locations.
• Attaches to mill table to machine flat surfaces onto cylindrical parts
ENDMILLS

Endmills have cutting teeth on the end as well as on the periphery and are fitted to the spindle by a suitable adapter. Endmills can plunge into a work piece and machine across the face of the work piece as well. They are of two types of endmills

• **Solid end mill** - The shank and cutter are one piece. Generally smaller than shell end mills and may have either straight or helical flutes

• **Shell end mill** - uses a separate shank.

They are available with straight and tapered shanks and with two or more flutes.

• When a slot is cut with a two-flute end mill, the depth of cut should not exceed one-half the diameter of the cutter.

• When the four-flute end mill is used for slot cutting, it is started at the edge of the metal.
Tooling – T-Slot and Dovetail

T-SLOT CUTTER
The T-slot cutter is used to cut the wide horizontal groove at the bottom of a T-slot after the narrow vertical groove has been machined with an end mill. It consists of a small side milling cutter with teeth on both sides and a shank for mounting.

DOVETAIL CUTTER
The dovetail cutter is similar to a single-angle milling cutter with an integral shank. Dovetail cutters are available with an internal thread to be mounted on a special shank. They are used to form the sides of a dovetail after the tongue or groove has been machined with a side milling cutter. Dovetail cutters are available with 45, 50, 55, or 60° angles.
WOODRUFF KEYSEAT CUTTER
The Woodruff keyseat cutter is similar to a plain and side milling cutter. Smaller sizes are made with a solid shank and straight teeth; larger sizes are mounted on an arbor and have staggered teeth. They are used for milling semi-cylindrical keyseat in shafts.

FLYCUTTER
The flycutter is a single-pointed cutting tool with the cutting end ground to the desired shape. It is mounted in a special adapter or arbor. Since all the cutting is done with one tool, a fine feed must be used. They are used in experimental work where the high cost of a special cutter would not be warranted.
Unsafe practice or obvious abuse of equipment constitutes a danger to people and damages equipment. Therefore the Fabrication Shop Manager or any person observing an unsafe act should stop unsafe practices in the Fabrication Shop. Students violating any of these rules will have their Fabrication Shop privileges revoked for a period of at least two weeks. Longer periods may be assessed, depending upon the judgment of the Fabrication Shop Manager and the Engineering Innovation Center Facility Manager.