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.
Hand Tools Safety

• **Always wear safety glasses when work is being done.**

• Only used tools in good working condition
  – If tool is damaged, alert a technician and they will remove it from inventory

• Do not extend the leverage on wrenches or other tools with a cheater bar
Screwdriver Safety

• Screwdrivers should only be used for their intended purpose—driving or removing screws.

• Screwdrivers should never be used for prying, punching, chiseling, scoring or scraping

• While both slotted and cross-slotted screwdrivers will fit many fastener sizes, it is best to use screwdrivers of the proper sizes that fit snugly into the slot or recessed portion of the fastener head.

• Plastic handles should be made of fire- and heat-resistant materials. If properly designed, they give excellent grip. Rubber or vinyl is often used as a non-slip or insulating cover on plastic handles.

• Typical screwdriver handles will not insulate the user from electric current.

• It is time to discard the tool when the handle of a screwdriver becomes worn, breaks, if the tip is damaged, or if the shaft is bent.
Screwdriver Safety

• Screwdriver slippage can cause injury. Never hold the piece you’re working on in your hand while driving or loosening screws or bolts. Place it on a work surface and use a vice or a clamp to hold the material, whenever possible.

• Never use pliers for added turning leverage on the shank of a screwdriver. However, a wrench may be used on square-shank drivers.

• Never carry a screwdriver in your pocket.
Types of Screwdrivers

**Standard Slotted Tip**
- For driving and removing standard, slotted screws
- Slots generally range in size from 1/6” to 1/4”.
- Tip is flared at shoulder of blade so it is wider than the driver bar.
- Blades should not taper too sharply from the tip, because an improperly tapered tip has a tendency to rise out of the screw slot.
- Can have a square or round shank.

**Phillips Tip Screwdriver**
- Used on cross-slotted screw heads with modified U-shaped slots of uniform width.
- Sizes range from 0 to 4, with 0 being the smallest.
- Similar tip configurations include Frearson tips that have cross slots that are V-shaped slots with tapered sides, and Pizidriv® with additional, smaller slots at 45-degree angles to the main cross slots.
Types of Screwdrivers

**Star (Torx) Screwdriver**
- Designed for use with star head screws and bolts to reduce slippage.
- Tips have six lobular drive surfaces to provide additional contact surface with the screw head.
- Vertical sides transmit torque perpendicularly to the driven element so there is no slipping or cam-out.

**Square Tip (Robertson) Screwdriver**
- Have square tipped heads to help grip the screw on all four sides to provide more torque.
- Range in sizes from 0 to 3 and jumbo.
- Popular with decking projects
Types of Screwdrivers

Hex Nut Driver

• Similar to a screwdriver, but has a tip like a wrench socket.
• Used mainly on small hex nuts and in confined areas such as electronic equipment, car ignitions and plumbing jobs.
• Available in several sizes and styles, with a fixed-size or variable-size “socket” at the end to adjust to various nut sizes.
Wrench Safety

- Always wear safety glasses when work is being done.
- Applying excessive torque will strip or damage threads, so quality wrenches are designed to keep leverage and intended load in safe balance.
- Users should not put extension handles or “cheaters” on wrench handles to increase leverage. Instead, the proper size wrench should be used.
- When possible, a wrench should be pulled, not pushed. Also be sure to brace your stance in case of sudden release or slippage of the fastener.
- Never place sockets designed for a hand tool on a power tool or impact wrench.
- When breaking loose frozen fasteners, always use a box wrench with a striking face or a heavy-duty socket wrench and a sledge hammer of the appropriate size.
- Always make sure the wrench is completely seated on the nut or bolt being fastened—never tilt the wrench at an angle.
- When using an adjustable wrench, pull so that the force is on the fixed side of the jaw.
- Never use a torque wrench as a conventional wrench.
Types of Wrenches

Open-End Wrench

• An open-end wrench provides gripping power on two sides of the head with another side open so the wrench can be placed on a nut, which might not be accessible to a closed or box wrench.

• It has different size openings on each end and should fit the nut exactly to prevent mutilating the nut edges. Some models, called ratcheting wrenches, have ratcheting capabilities.

• Other varieties, called flare nut wrenches, are flared to fit hex fittings and flare nuts. Generally, these are available in sets.
Types of Wrenches

**Box-End Wrench**

- A box wrench has an enclosed head and provides more leverage by completely enclosing the nut.
- Some are offset to provide knuckle room and clearance over obstructions.
- They range in size from 4 to 16 inches long and are available with either 6 or 12-point rings. Some models have ratcheting capabilities.

**Combination Wrench**

- This has a box and an open end on opposite sides of the same wrench. Both ends are usually the same size.
- A combination wrench is for working on machinery and is the most popular of all fixed-end wrench styles.
- Also available is a reversible ratcheting combination wrench that allows the user to quickly tighten nuts and bolts without lifting the wrench off and repositioning it after each rotation.
Types of Wrenches

Adjustable Wrench

• Commonly called crescent wrenches or C-wrenches, these come in two styles: locking and non-locking.
• Non-locking styles feature an adjustable end opening with little provision made for slippage.
• The locking style also has an adjustable head, but uses a locking mechanism to secure jaws in desired position, eliminating the need for constant readjustment. When properly adjusted to a nut or bolt, it will not slip.

Pipe Wrench

• Use a pipe wrench to screw pipes into elbows or other threaded devices.
• The jaws bite into the surface to hold it for turning.
• They should never be used on plated pipe installations because they will badly mar the finish.
Types of Wrenches

Socket (Hinge Handle) Wrench

• The socket wrench combines an offset handle with a male drive piece that has a spring-loaded bearing to lock on various size sockets.

• They can be used at almost any angle, since handles may be attached to the head by a jointed hinge device.

• The most common type is the detachable socket wrench, with a square drive for hand use. Common square drive sizes are 1/4-inch, 3/8-inch and 1/2-inch, and these are normally used in conjunction with a ratchet wrench. Sockets are available with 6, 8 and 12-point gripping ends, in a full range of inch and metric sizes.
Types of Wrenches

**Ratchet (Socket) Wrench**

- These are available in a variety of handle shapes and lengths and used with sockets to make turning nuts and bolts easier than with a conventional wrench.
- Available in 1/4, 3/8 and 1/2-inch drive sizes and are used with socket wrenches.
- The round or teardrop-shaped head contains a reversing mechanism to facilitate the tightening or loosening a fastener.
- Popular accessories include flex handles, speeder handles, T-handles, extensions of various lengths and universal joints to work on fasteners in hard-to-reach locations.
Types of Wrenches

Torque Wrench

- A torque wrench is designed to permit an operator to determine applied torque on bolts, nuts and other fasteners.
- The torque value (generally measured in foot pounds) is set to a micrometer scale on the handle or preset by an adjusting screw in the handle.
- Typically, they have square drives to use standard detachable 3/8 and 3/4-inch sockets.
- Available with audible signal (clicking sound) or visual display, many torque wrenches are available with dual scales for conventional and metric measurements.
Types of Wrenches

Chain Wrench
• This is another form of pipe wrench, used for tightening and loosening odd-shaped objects, such as pipes and square objects.
• It has an adjustable chain that wraps around the object, with ends that connect the teeth of the chain to engage and turn the object.
• Some models feature a locking mechanism with ratcheting action for turning in either direction.

Hex-Key Wrench
• Also called an Allen wrench, Hex-key wrenches are short, L-shaped tools designed to turn bolts or screws with hexagonal heads. They generally come in sets of different sized wrenches.
Portable Drill Safety

- Always wear safety glasses when work is being done.
- Do not wear loose clothing or jewelry when operating drill.
- Tie long hair back or secure under a cap.
- Use the correct drill bit for the type of material to be drilled and task at hand.
- Keep hands and fingers away from rotating drill chuck and bit.
- When carrying portable power drill, always lock the drill trigger with the switch lock.
Standard Drill

- Used for drilling holes, driving fasteners or removing fasteners
- Has a keyless chuck that can hold other tooling such as hole saws, paddle drill bits, and sanding drums
- Variable speed selection and clutch to drive screws to a certain torque or for drilling steel which requires high torque to penetrate
- Some models are hammer drills which make drilling holes in masonry much easier
Drill Tooling and Accessories

- **Drill Bits** – Standard drill bits, used to make holes in wood, plastic, aluminum, and mild steel (with cutting fluid)
- **Masonry Bits** – for drilling holes into brick or concrete, must use hammer drill
- **Spade Bits** – for larger holes into wood, rough finish
- **Hole saws** – for cutting holes in wood, plastic, metal medium finish
- **Forstner Bits** – for cutting holes in wood, good finish, leaves flat bottom
- **Drive Guide** – Extends driver length and has sleeve to guide screws
Impact Driver

- Delivers strong, sudden rotational and downward force
- Used to loosen large bolts and nuts that are frozen or over-torqued
- Also used to tighten screws with greater torque than a screwdriver can provide
- Instead of an adjustable drill chuck, has a hex collet, only one size.
Pliers Safety

- Always wear safety glasses when work is being done.
- Pliers should not be used for cutting hardened wire unless specifically manufactured for this purpose.
- Never expose pliers to excessive heat. This may draw the temper and ruin the tool.
- When using cutting pliers, always cut at right angles. Never rock from side to side or bend the wire back and forth against the cutting edges.
- Don’t bend stiff wire with light pliers. Needle-nose pliers can be damaged by using the tips to bend too large a wire. Use a sturdier tool.
- Never extend the length of handles to secure greater leverage. Use a larger pair of pliers or a bolt cutter.
- Discard any plier that is cracked, broken, sprung or has nicked cutting edges.
- Pliers should not be used on nuts or bolts. A wrench will do the job better and with less risk of damage to the fastener.
- Oil pliers occasionally. A drop of oil at the hinge will lengthen tool life and assure easy operation.
- Unless specified as insulated handles, the cushion grips on pliers are not intended to give any degree protection against electric shock and should not be used on live electric circuits.
Box-Joint and Crimping Pliers

Box-joint pliers
• General utility tool with up to eight adjustments, allowing for jaw openings up to 4-1/2".
• Either multiple hole or tongue-and-groove designs available.
• Straight and curved jaws are available.
• Most common type of box-joint (multiple slip-joint) is 10“ water pump pliers.

Crimping Pliers
• Multi-purpose electrician's pliers to crimp solderless connectors, strip most common gauge wire, cut and hold or bend wire.
• They also have sheaving holes that cut common sizes of screws without deforming threads.
Cutting Pliers

Cutting Pliers

• Can be side, end or diagonal types.

• Side cutters have a cutting blade on one side only and are available in long-, curved- and short-nose types.

• End cutting nippers have cutting blades on the end and are used to make sharp, clean cuts close to the surface on wires, bolts and rivets.

• Diagonal cutters have two cutting blades set diagonally to the handle. They offer leverage when pulling cotter pins and are used by mechanics and electricians for general cutting.
Fence and Lineman’s Pliers

Fence Pliers

• Used to pull and cut staples in fencing and other work involving wire.
• Only tool needed for work on wood or metal posts.
• Feature flat, heavy head for hammering, staple-pulling hook, wire cutters on each side and pliers jaws to pull wire.

Lineman’s Pliers

• Also called electrician’s pliers, used for cutting, holding, shaping and twisting wire.
• Heavy-duty, side-cutting pliers designed for all regular wire-cutting needs.
• Have gripping jaws in addition to cutting edges.
• High-leverage lineman’s pliers have rivet placed closer to the cutting edges to provide more leverage.
• Two head patterns are available: standard (bevel nose) and round nose, which is more streamlined.
Locking Pliers

- Adjustable, vise-type locking pliers that can be locked on to a work piece and operate like a clamp.
- Features an adjustment screw that changes the jaw size to apply the correct clamping pressure.
- Available in various sizes and shapes: curved jaw puts pressure on any style nut or bolt head; curved jaw with wire cutter also allows user to cut wire; straight jaw provides maximum contact on flat, square or hex work; long nose provides easy access in hard-to-reach places; large jaw is used by plumbers, welders and mechanics working with large objects; and bent nose is for work in tight places.
- Some use a mechanism that allows one-handed release; others require two hands to disengage.
Needle-Nose and Midget Pliers

Needle-Nose Pliers

• Also called long-nose pliers, they have a pointed nose for doing work in tight places.
• Used frequently for electrical and electronics work.
• Most have side cutters for cutting wire.
• The jaws and cutting blades meet evenly

Midget Pliers

• Include straight, chain, round, end-cutting, diagonal-cutting and flat-nose pliers in extra-small sizes.
• Used by professionals such as electronic technicians who work with small objects in confined areas.
Hand Saw Safety

- **Always wear safety glasses when work is being done.**
- Understand the purpose of the saw you are using, the material and type of cut matters
- Inspect saw before use, damaged saws should be reported and loose saw blades should be adjusted
- Check the material for knots or nails, these can cause the blade to buckle and cause injury
- Never test sharpness with hands, use a piece of scrap wood
- Fix work piece with a vise or with clamps
  - **DO NOT HOLD WORK PIECE WITH HAND AND CUT WITH SAW**
- Start cuts slowly with long even strokes
Rip Saw

- Has large, chisel-shaped teeth, usually 5-1/2 teeth per inch, and is made to cut with the wood grain.
- Blade lengths measure from 24" to 28".
- Teeth are cross-filed to ensure that the chisel point is set square to the direction of cutting for best performance.
- This saw is best held at a 60º angle to the surface of the board being cut. The ripping action of the saw produces a coarse, ragged cut that makes the saw unsatisfactory for finish work.
Crosscut Saw

- Designed for cutting across wood grain and produces a smoother cut than rip saws.
- Has teeth shaped like knife points to crumble out wood between cuts.
- The most commonly used crosscut saws are 10- to 12-point for fine work and 7- or 8-point for faster cutting. 10 teeth per inch is considered general purpose.
- Blade lengths range from 20" to 28", with 26" the most popular.
- Can also be used to cut plywood.
- Best cutting angle for this saw is about 45°
Hack Saw

- Is a fine-toothed saw designed to cut metal or plastic. Hacksaws consist of a blade held in a steel frame with relatively high tension to hold the blade rigidly straight.

- Blades come in coarse-, medium (18 tpi), fine (24 teeth per inch) and very fine-toothed (32 tpi). Regular or standard blades are used for general-purpose cutting; high-speed or bi-metal blades for cutting hard, extra-tough steel.

- Most models can be adjusted to hold various blade lengths.

- A close-quarter (or utility) hacksaw holds and positions a hacksaw blade so it can be used effectively in narrow spaces and slots.

- Replacement blades include rod saw blades capable of cutting through most hard materials—spring and stainless steel, chain, brick, glass and tile.
Compass and Keyhole Saw

- Cuts curved or straight-sided holes.
- Saw blades are narrow, tapered nearly to a point to fit into most spaces.
- Blades come in three or four styles that can be changed to fit the job.
- Some models have induction-hardened teeth for longer life without sharpening.
- Keyhole saws are small compass saws with finer teeth that can cut metal.
- Turret head keyhole blades can be rotated and locked in several positions for easier cutting in tight, awkward spots.
Coping and Back Saw

Coping Saw

• Used for cutting irregular shapes, curves and intricate decorative patterns.
• Name comes from saw’s usefulness in coping back the joints of molding when fitting two pieces together.
• Saw consists of a thin blade and a C-shaped steel tension frame.
• The removable blade is typically 6-1/2" long.

Back Saw

• It is a thick-bladed saw with a stiff, reinforced back that provides the rigidity necessary in a precision cut.
• It varies in length from 10" to 30" and is found in tooth counts from seven to 14 teeth per inch.
• Used with miter boxes to cut miters.
Bow and Dovetail Saw

Bow Saw

- Consists of a tubular steel frame and a saw blade for fast cutting of all woods.
- The bow saw's frame is important, since the thin blade, usually 3/4" wide, must be held under high tension for fast cutting.
- Advantages of this general-purpose saw are its all-around utility and light weight.
- Some bow saws are designed to hold hacksaw blades as well as standard bow saw blades. These multi-purpose saws can be used to cut wood, metal or plastic.

Dovetail Saw

- Similar to a backsaw, with stiff reinforced back, only smaller with finer teeth.
- Used for fine finish cuts, such as cutting dovetail joints in woodworking.
- Common saw for trimming molding and furniture repair.
- Can also be used to cut plastics and laminates
Tool Box Saw

- Also called a Panel Saw or Short Cut Saw
- Good for ripping, crosscutting and general cutting of lumber, plywood, particle board and plastic materials.