

EML2322L – MAE Design and Manufacturing Laboratory

General Shop Safety

Introduction:

This handout is designed to acquaint new students with common shop hazards. The goal is to prevent injuries to anyone who uses this laboratory. Each student is expected to be familiar with the safety and operation instructions for each piece of equipment (s)he uses in the lab. **YOU MUST HAVE A PRINTED COPY OF THESE SAFETY SHEETS EVERY TIME YOU ARE WORKING IN THE LABORATORY.**

Consult the following safety rules frequently until they are committed to memory. Ignorance is no excuse for improper or unsafe behavior in this laboratory. Take the time to learn how to safely operate each tool you use. Once you know how to use a tool safely, scrupulously follow safe procedures and **beware that familiarity can breed haste.** Never do anything that seems unsafe, regardless of how comfortable you feel using a machine. Finally, avoid last minute shop work in favor of consistent weekly effort, as deadline-driven haste can lead to ruined projects and serious injuries.

Come to lab prepared to learn. In addition to your required safety sheets and proper safety apparel, bring something to write with and an attitude of learning. Minimize distractions to your learning while in lab by turning off your cell phones and telling chatty friends it's time to focus. Respect the TAs, as they are key to your learning and your primary defense against serious personal injury. Ask lots of questions, as that's the best way to validate your understanding of what was just explained. Finally, in regards to safety, earnestly do your best to avoid last minute shop work in favor of consistent weekly effort, as deadline-driven haste can lead to ruined projects and serious injuries. Take the project scheduling seriously and always come to lab prepared for your weekly work session so you can complete your assignments as opposed to running out of time as the end of the semester approaches.

The instructors and TAs are here to help you safely use the shop; however, we cannot be everywhere at once. Each person using the shop must take responsibility for the safe use of the facility. **When you encounter a situation you are unsure of with regard to safety, always consult an instructor *before* proceeding.** If you think someone is using the equipment unsafely, promptly discuss it with the individual and suggest a safer alternative or bring their activities to the attention of the instructors.

YOUR PERSONAL SAFETY IS OUR NUMBER ONE CONCERN.

General Safety:

The following rules apply to everyone working in the Design and Manufacturing Lab. They are intended to provide guidelines to working safely in the shop as well as familiarize you with some of the common hazards.

1. **Familiarize yourself with the layout of the laboratory. Note the location of the exits, safety glasses rack, and first aid kits.**
2. **Get checked out by a laboratory instructor the first time you use each machine or process in the shop. Never operate any machinery with which you are unfamiliar.** Every tool in the shop has safe operating procedures associated with it. Do not work on any tool in the shop until an instructor trains you on its safe operation, even on tools you have learned to operate elsewhere.
3. **Wear all necessary protective gear and clothing when in the lab.**
 - **Always wear eye protection, regardless of what you are working on.** Eye hazards always exist and you must always protect your eyes from them. If you wear corrective lenses, be sure you wear them so you can clearly see what you're doing.
 - **Always wear shoes that completely enclose your feet: no sandals, flip-flops, etc.**
 - **Always wear long pants made from substantial fabric to protect your lower body from cuts caused by sharp hazards present when working in the lab.**
 - Hearing protection is available in the form of foam ear inserts or overhead ear muffs.
 - Gloves are available for use but are **NEVER to be worn around power tools.**
4. **Remove all personal accessories and loose clothing that might get caught in moving machinery.** This includes rings, watches, bracelets, headphones, rags, ties, and open jackets. Anything that hangs loosely from your body can get caught in rotating machinery. Tuck in loose fitting shirts. Roll up or remove long sleeves (wear short sleeves whenever possible). Keep tight fitting jackets closed. Do not wear headphones while working in the shop.
5. **Securely tie up long hair.** Most power tools in the shop make use of a rotating shaft. In use the shaft is frequently sticky with oil. Long, loose hair can get caught on the rotating shaft and pull the owner's head into the danger zone.
6. **Never work alone or without an instructor present.** When working in the shop a second person must be present who is capable of assisting in the event of an accident. That second person must be able to see you while you are working, and get to you if you need help. If the second person moves to a place where they can no longer maintain visual contact with you, you must cease working.
7. **Never work when impaired or hungry.** This includes times when you are excessively tired or stressed, or otherwise inhibited from exercising appropriate caution in the shop. Do not enter the shop when under the influence of medications that might make you drowsy or alter your ability to be alert. Finally, try not to attend lab on an empty stomach, as this can result in light-headedness and impair your ability to focus.

General Safety (con't):

8. **Never leave a chuck key in a chuck. IF THE CHUCK KEY IS IN USE YOUR HAND MUST BE ON IT.** Chuck keys can be launched across the shop if accidentally left in the chuck. The start-up power of a lathe can throw these tools with enough force to cause a fatality. It is an easy and terribly dangerous thing to do, so pay attention. The same rule applies to the chuck keys used to tighten the chucks on the drill presses.
9. **Never leave a machine running unattended (for even the shortest amount of time).** Although many of the tools in the shop can be set to cut automatically to improve part quality, you must keep your attention focused on the machining operation so you can react appropriately in the event of a problem. Due to the prototyping nature of this course, most set-ups are not tried and tested in a production sense. Therefore it is inevitable that some set-ups will fail. If you are paying attention to the operation, you may be able to avert damage to yourself, the people around you, and the equipment.
10. **Support work pieces and cutting tools as securely as possible.** A vibrating setup means the work piece is not clamped securely enough to resist the applied cutting forces. **NEVER try to make do with a flimsy set-up, or one that requires you to hold the workpiece by hand, as you, the tool and the workpiece will all be harmed. If you ever try to hold a part while cutting, you will (a) not be able to resist the large cutting forces and (b) not be able to get out of the way when (a) happens.**
11. **Keep your hands well away from the point of contact between the work piece and the cutter.**
 - **Keep all parts of yourself at least six inches from the point of contact between any work piece and cutter.**
 - **Take careful notice of the exact position and size of the workpiece and cutting tool before turning the machine on, as once in motion the true size is deceptive.** This is the leading cause of mill and lathe accidents, so be especially cautious around milling cutters and lathe chucks.
 - **NEVER remove chips with your fingers; use brushes, pliers, or compressed air.**
12. **Exercise caution using the compressed air guns.** Never aim one at another person as doing so can cause permanent sight loss. Never squeeze the trigger quickly, as doing so makes a loud noise that can startle another operator, causing an avoidable accident. **Be mindful a lot of other students are using the facility and give an audible warning by calling “EARS” before doing something that may make a lot of noise and could startle another person.**
13. **No horsing around or practical jokes will be tolerated in the laboratory.** One momentary distraction or surprise can result in a severe accident. What might be funny somewhere else could startle someone in the lab and cause them to seriously injure themselves and/or others. So please act mature any time you are working in the lab. And always walk cautiously and observantly through the lab, since you or other users may be carrying sharp objects.

Clean Up Procedures:

Systematic clean-up is part of the safe operation of the laboratory. If someone cannot find a needed tool in its regular place or has to work in another's mess, the result will be frustration. Since it is difficult to keep safety in mind when frustrated, it is important to always keep the shop clean and return everything to the correct location at the end of its use.

Do not drop your guard when cleaning up, as many of the accidents which occur in the machine shop environment occur during clean up, so please continue to be vigilant.

1. **Shut off power to the machine.** Turn off the main power switch for the machine.
2. **Unmount any cutters or tooling installed while using the machine.** Many people cut themselves trying to clean around mounted cutting tools, so remove and put them away in their proper storage locations.
3. **Put away all measuring tools, hand tools, material scraps, and drawings.** If you do not know the correct location of an item, ask a lab instructor.
4. **Clean chips and cutting oil from machines and chip pans.** Use a rag to protect your hands from sharp chips. **Most machines can be wiped down completely with a shop rag and the spray bottle of (green) cleaner located near the machine.** If you use compressed air, follow the rules for blowgun safety, and use the compressed air early in the clean-up process, or you will blow chips all over the areas you have already cleaned. ***The machine should always be left cleaner than when you began working on it.***
5. **Sweep the floor around the area of the machine(s) you use.** Be careful not to strike your body on any parts of the machine as you clean around it.
6. **Return all machine tables to the centers of their travel.** This includes raising the milling machine tables back to their normal work height (about 6" from the spindle to the work vice).
7. **Report missing or broken tools to the laboratory staff.** Almost everything in the lab can be repaired or replaced, but we need to know about problems to correct them in a timely fashion that does not inconvenience users. **Unless the cause was willful disrespect, you will never be reprimanded for breaking any tooling, so please do not hesitate to inform the laboratory staff so we can replace or repair the tooling in a timely manner.**
8. **Clean your personal / group work area.** Put all tools away in their proper locations, wipe off the top of your workbenches, and sweep the floor surrounding your work area.

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Emergency Response Procedures

As stated previously, this handout is intended to acquaint new students with common shop hazards. However, **despite our best intentions, the occasional accident is going to happen** since we are working in a modern manufacturing facility. The purpose of this section is to outline common emergency response procedures in the event of an accident.

Accident Response Levels:

1. **TA ASSISTANCE:** for **minor cuts** (not requiring stitches), **abrasions or burns**
2. **INFIRMARY:** for **more serious, yet non-severe injuries** (like cuts requiring stitches)
3. **EMERGENCY ROOM:** for **serious injuries** (like deep lacerations that won't clot)

Infirmiry Information:

Hours of Operation: FALL/SPRING: M-F 8-5 pm; Sunday 12-4 pm
SUMMER: M-F 8-4:30 pm; Sunday 12-4 pm

Phone Number: (352) 392-1161

Accident Response Protocols:

1. In the event of an injury:
 - a. Try to remain calm.
 - b. Alert TAs in the area so they can offer assistance after asking your permission and putting on gloves.
 - c. If the injury does not prevent you from walking, move to the bathroom with assistance. Never walk alone, as it is possible to become dizzy and faint, which can cause an even worse injury.
 - d. If you can't walk, sit in a chair and let the laboratory staff help you.
 - e. If the injury is minor to moderate, allow a TA to stabilize the wound and if necessary escort you to the infirmary.
 - f. If the injury is severe, call for emergency medical assistance (i.e. paramedics and an ambulance by dialing 911) or allow a TA to drive you to the SHANDS E.R.
2. First aid kits are located in the bathroom and on the wall between the machine shop and work table areas (by the welding shop). Use any items necessary from the kits, but please let the lab manager know if one of the first aid kits runs low on consumables. The first aid kits contain the following items for dealing with accidental injuries:
 - a. nitrile gloves
 - b. band aids
 - c. antiseptic
 - d. gauze pads
 - e. medical tape
 - f. burn gel
 - g. tourniquet
 - h. scissors

Accident Response Protocols (cont):

3. Cuts and Abrasions:

- a. Always wear gloves when offering medical assistance to another person.
- b. Control the bleeding by firmly covering the area of the wound with a sterile bandage or gauze (or even a paper towel) to assist in clotting
- c. If possible rinse the wound with soap and water and gently blot the area
- d. Apply antiseptic (ointment or spray) on a sterile bandage or gauze (or paper towel).
- e. Cover small cuts with appropriately sized band-aids or butterfly bandages.
- f. Cover larger cuts with gauze and medical tape. If possible, apply blood clotting spray to the gauze before covering the wound and securing with the medical tape.
- g. Seek professional medical attention if you notice signs of infection, like increased pain, redness, swelling, fever or oozing.

4. Burns:

- a. For minor (1st degree) burns (skin is not burned all the way through the outer layer; appears red and sore; covers a small area):
 - i. Apply cool water to the area of the burn for 10-15 minutes or cool the burn with cold compresses (never put ice on the burn).
 - ii. Gently blot the area to dry it.
 - iii. Gently apply burn gel, but don't cover the wound so it can remain cool.
- b. For moderate (2nd degree) burns approximately 3" in size or smaller (first layer of skin is burned through and second layer is also burned; appears blistered and painful):
 - i. Apply cool water to the area of the burn for 10-15 minutes or cool the burn with cold compresses (never put ice on the burn).
 - ii. Cover the burn with a sterile gauze bandage. Don't use fluffy cotton, or other material that may get lint in the wound. Wrap the gauze loosely to avoid putting pressure on burned skin. Bandaging keeps air off the burn, reduces pain and protects blistered skin.
 - iii. Take an over-the-counter pain reliever like aspirin, ibuprofen (Advil, Motrin, others), naproxen (Aleve) or acetaminophen (Tylenol, others).
- c. For major (3rd degree) burns larger than 3" or on hands, feet, face, groin, buttocks or major joints (burns involving all layers of skin; usually no pain and causes skin to be white or charred):
 - i. Call 911 for emergency medical help.
 - ii. Don't remove burned clothing or immerse large severe burns in cold water.
 - iii. Elevate the burned body part(s).
 - iv. Cover the area of the burn using a moist sterile bandage or moist cloth towels.
- d. For minor or moderate burns, seek professional medical attention if you notice signs of infection, like increased pain, redness, swelling, fever or oozing.

Accident Response Protocols (cont):

5. Foreign Debris in Eye(s):
 - a. Eyewash bottles are located in the bathroom and on the wall by the lab rotisserie.
 - b. If you need to use a bottle, flush your eyes with the entire contents of the bottle for at least 15 minutes to ensure the foreign substance is removed from your eye.
 - c. When rinsing, forcibly hold eye open to ensure effective rinsing behind eyelids. Move eye side-to-side and up-down during rinsing to allow the water to carry the foreign debris out of the eye. Remove contact lenses as well.
 - d. When done, blot the area around your eye lightly with a paper towel, but never rub your eye to dry it (in case there's still anything still inside).

BANDSAW SAFETY

(DoALL) Vertical Bandsaw:

1. **Always wear safety glasses** when operating the bandsaw.
2. **NEVER wear gloves** as they can catch on the moving blade and pull your hand(s) into the cutting zone, causing severe injury.
3. **Set the upper blade guide within ¼" of the workpiece.** Adjust guard with machine off.
4. **NEVER place your hand in the plane of the blade; use a push block for small work** so if your hand slips it will not collide with the blade.
5. Do not push the workpiece into the blade with enough force to cause the machine to chatter; slow down and/or find a more rigid manner in which to support/clamp the work in the saw.
6. **Never cut materials that might be hardened, such as tool steel, files or stainless steel.** Any material than cannot be cut easily with a standard hand file should never be cut in a bandsaw; use an abrasive cutoff saw instead or ask an instructor.
7. If the blade breaks, shut off the power, stand clear until the machine stops and inform the laboratory staff so a replacement blade can be promptly installed.

(Marvel) Vertical Power Feed Bandsaw:

1. **Always wear safety glasses** when operating the bandsaw.
2. **Never wear gloves** as they could get caught on the moving teeth and pull your hands into the moving blade, causing a severe injury.
3. **The upper blade guide should be set to within ¼ inch of the workpiece.** Adjust the guard with the machine turned off and never loosen the adjustment handle more than ¼ turn.
4. Do not push the blade into the workpiece hard enough to cause the machine to chatter; slow down and/or find a more rigid manner in which to clamp the work in the saw.
5. **Always adjust the speed of the bandsaw while the machine is running. Never adjust the speed with the machine turned off.** Do not run the band saw at a higher speed than recommended for the material being cut. There is a table on the saw with recommended saw speeds for various materials.
6. **Make sure the workpiece is clamped securely before turning on the saw. Failure to do so will result in the workpiece dislodging from the vise and breaking the saw blade.**
7. **Always bring the blade into contact with the material before engaging the automatic power feed.** The proper procedure is as follows: (1) firmly clamp the workpiece in the vise; (2) turn on the saw so the blade is rotating; (3) adjust the coolant if necessary; (4) gently bring the moveable saw blade into *light* contact with the workpiece by rotating the manual feed wheel; (5) engage the automatic feed lever; (6) disengage the automatic feed after the workpiece is cut but before the blade passes the remaining stock in the vise; (7) slowly retract the blade to its original (starting) position; (8) turn off the saw.
8. **Never cut materials that might be hardened, such as tool steel, files, hardened guideways, stainless steel, etc.** Any material than cannot be cut easily with a standard hand file should never be cut in a bandsaw; use an abrasive cutoff saw instead or ask an instructor.
9. If the band breaks, immediately shut off the power and stand clear until the machine has stopped. Promptly inform the laboratory staff so a replacement blade can be installed.
10. Never leave the machine unattended when the saw is running.

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CALIPER USE AND SAFETY

1. **Treat calipers gently, as they are very fragile.** If you drop a pair of calipers, inform an instructor so they can be taken out of service before reporting false measurements.
2. **Leave calipers in the plastic storage boxes when not in use.** Close the lid to the box so chips do not damage the delicate gears inside the calipers.
3. **Open and close the calipers slowly** with one hand to prevent damaging the precision rack & pinion gears inside the caliper body; **rapidly adjusting the calipers will destroy the gears.**
4. **Wipe debris off the part to be measured and the caliper jaws** before bringing the calipers into contact with the part.
5. **Ensure the calipers are zeroed** before making a measurement.
6. **Measure the part twice** to ensure repeatability (i.e. precision) of the measurement.
7. **NEVER measure a part on a machine while the spindle is running.**
8. **Calipers are only to be used as precision measuring devices;** they are never to be used as scribes, wrenches, clamps, wire strippers, etcetera.

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CHEMICAL AND SOLVENT SAFETY

1. **Avoid skin contact.** Wear latex gloves which are available in the safety storage cabinet.
2. **Never use or store volatile solvents around hot surfaces, sparks or flames** (as in the welding shop).
3. **Do not use chemicals or solvents in confined, unventilated areas.** Open the large door on the west end of the laboratory or use the exhaust fan in the wood shop.
4. **Always use solvents over a suitable pan to contain accidental spills.**
5. **Clean up spills immediately using rags (for small quantities) or absorbent pads (for larger quantities).** Dispose of the solvent soaked rags or absorbent pads in the proper labeled canister in the satellite waste storage area.
6. Develop and maintain good personal hygiene habits. **Remove protective equipment and wash thoroughly with warm soapy water immediately after contact with solvents.**
7. **Always return chemicals and solvents to the proper location immediately after use.**
8. **Never bring unauthorized chemicals into the laboratory.** Each solvent must be accompanied by an MSDS with clear and safe rules for use and storage.

DISC AND BELT SANDER SAFETY

1. **Always wear safety glasses** when operating sanders.
2. **Never wear gloves** as they could get caught between the disc/belt and the table and pull your hand(s) into the machine, resulting in severe abrasion injury.
3. **Never operate sanders without the guards in place.** Be cautious to **keep your fingers away from the motor belt, pulleys and rollers**, as these are common pinch points.
4. On the disc sander always use the downward motion side of the disc to sand. **Never use the upward motion side of the disc, as this will throw the workpiece upwards (towards the operator's face) with TREMENDOUS force.**
5. **Always place workpieces against the table on the sanders.** Never try to freely support the workpiece and bring it into contact with the rotating disc, even “for a second”!
6. **On the horizontal belt sander, always sand so the belt motion is away from you** in case you lose control of the workpiece.
7. **When using the belt sander, gently move the workpiece back and forth sideways over the full width of the belt to evenly distribute heat and wear.**
8. **Never operate machines with torn belts or disks.**
9. **Do not sand material that produces hazardous dust.** Such materials as galvanized metals, carbon fiber, copper beryllium alloys, asbestos, etc. must not be sanded or filed without proper respirators. When sanding aluminum for more than 30 seconds (or sanding pieces repeatedly), wear a respirator which is available in the safety storage cabinet.
10. **Never sand parts that are extremely hot**, as doing so will destroy the sanding belt or disc. Frequently cool the work using the nearby water container.
11. **Do not use sanders for bulk (more than 1/8”) material removal.** Rather, (re)cut the workpiece in the bandsaw or milling machine and *then* sand if necessary.

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DRILL PRESS AND HAND DRILL SAFETY

General:

1. **Always wear safety glasses** when operating the drill press.
2. There are three types of drill bit identifications: (1) numbered, (2) lettered and (3) fractional
3. **Never place a drill bit in the wrong location in the drill index**, as doing so can result in someone else grabbing the wrong size drill bit and ruining a part (s)he invested considerable time in. If unsure of the drill bit size, measure it with a pair of calipers and consult the drill index charts located in the main laboratory, or ask a TA for assistance.

Clamping the Workpiece:

4. Always clamp the workpiece in a vise or directly to the drill table. **Never rely on your hands to hold the part to be drilled, as the drill bit can snatch a handheld workpiece and cause severe injury.** Attach smaller sheetmetal workpieces to a larger plate or board which can be properly clamped in the vise or to the drill press table directly.
5. **Support the workpiece on parallels or a backing board when drilling thru material to prevent drilling into the machine table or vise.** If using parallels, be certain not to drill into them, as this will destroy both the drill bit and the parallels.
6. When drilling holes in sheetmetal, use the punch press when possible (i.e. when the material to be drilled is less than 0.065" thick).

Drilling:

7. **Never touch the drill bit or chuck when the machine is in motion.**
8. **Run drills at an appropriate speed for the diameter of drill bit and material used.** Use the graphical speed chart posted on the clipboard by each machine. A high pitch squealing noise indicates the speed needs to be lowered immediately.
9. **Use cutting fluid when drilling holes**, as it greatly extends the usable life of the drill bits by providing lubrication and reducing the temperature in the cutting zone. One or two drops of cutting fluid is sufficient for shallow holes.

Drilling (con't):

10. **Don't use excessive force when drilling;** let the drill bit do the work. If unsure about what excessive is for a particular material/drill bit combination, ask an instructor. If excessive force is required the drill bit may be damaged or incorrect for the intended use.
11. **Reduce drilling pressure as the drill bit breaks through the bottom of the material.**
12. **NEVER remove chips with your hands, as they can cause severe lacerations (even when the drill press is turned off) and can pull your hand into the rotating drill bit.** Remove chips with a chip-brush or a rag after the spindle has ceased rotating.
13. When releasing the drill bit from the chuck, make sure the power is off and hold the drill bit with a rag while loosening the chuck to ensure it does not drop on the table.
14. **If the drill binds in a hole, stop the machine and turn the spindle backwards by hand to release the bit. Consult a laboratory instructor before proceeding.**
15. **When drilling holes, withdraw the drill bit frequently to properly evacuate chips.** This is called peck drilling and prolongs tool life.

GRINDER SAFETY

1. **Always wear safety glasses**, goggles or face shields when operating grinders. Wire wheel brushes are especially hazardous as they throw steel wire strands at high velocities, so always wear a face-shield when using powered wire wheels.
2. **Never wear gloves** when operating power equipment like grinders and sanders.
3. **Never operate abrasive wheel machinery** (i.e. bench grinders, angle grinders, abrasive chop saws, pneumatic cutoff saws, die grinders, etc.) **without guards in place**.
4. **Toolrests on pedestal grinders must be set within 1/16” of the wheels at all times.**
5. **Never use a wheel that has been dropped or received a heavy blow**, even though there may be no apparent damage. Such wheels may fly apart on startup as are not worth the risk.
6. **Report cracked, broken or vibrating wheels to the laboratory instructor.**
7. **Stand to one side of the wheel(s) when starting grinders in case of wheel damage.**
8. **Always grind on the outermost face of the grinding wheel; NEVER grind on the side of the grinding wheel.**
9. **Always hold work securely while grinding and use the toolrest for support; never try to freely support the workpiece and bring it into contact with the grinding wheel.**
10. **NEVER grind aluminum or other soft, nonferrous metals on a standard grinding wheel**, as doing so can close the pores of the wheel, causing it to overheat and explode. **Only grind ferrous metals.** Sanders can be used for nonferrous materials.
11. **NEVER touch any part of the grinding wheel. If the grinder is running, your hand can get pulled between the grinding wheel and the steady rest. Furthermore, it is often impossible to discern if a grinder is running, so even if it appears to be off, NEVER touch any part of the wheel.** Anytime the wheel(s) must be handled for maintenance the proper procedure is to always unplug the grinder and touch the wheel with a piece of metal to ensure the wheel is not rotating.
12. **Always use locking pliers to hold small pieces.**
13. **Be especially cautious of your fingers and knuckles around grinders and wire brushes.**
14. **NEVER use excessive force while grinding**, as one slip can result in your hand contacting the wheel and being rapidly abraded.

LATHE SAFETY

1. **Always wear safety glasses** when operating the lathe.
2. **Remove chuck key from chuck immediately after use.** Breaking this rule can cause severe personal injury or equipment damage; to prevent the risk, *never remove your hand from the chuck key when in use.*
3. **Verify cutting tool is not chipped and has the proper clearance angle.**
4. **Tighten tool-post properly** by applying ~20 lb of force to the end of the tool-post wrench.
5. **Set cutting tool on the vertical centerline of the workpiece.** Check tool height by gently clamping a plastic ruler between the workpiece and cutting tool or by using a lathe gage.
6. **Rotate the chuck through one revolution by hand to ensure adequate tool clearance. Be careful not to run the tool into the chuck.** When in motion the location of the chuck jaws is dangerously deceptive, so always note their location before turning the lathe on.
7. **Ensure the spindle is rotating in the proper direction** (CCW looking from the tailstock towards the spindle) **before cutting material.** Failure to do so damages tooling.
8. **Run the machine at the proper cutting speed.** Use the graphical speed chart posted on the clipboard by each machine.
9. **Allow the spindle to completely stop turning before reversing the direction of rotation by switching between *forward* and *reverse* on the spindle power switch.**
10. **NEVER bring anything (fingers, measuring tools, rags, air guns, etc.) within 6" of the cutting zone.** Stated another way: *ensure the lathe is fully stopped before making measurements or checking surface finish.*
11. **Be careful reaching across the lathe,** as doing so can bring your hand / wrist into the cutting zone (e.g. be cautious setting the DRO which is mounted on the headstock).
12. **Ramp SLOWLY and GENTLY into contact with the workpiece every time.**
13. **Keep hand on power feed handle ANY TIME the power feed is enabled.**
14. **Do not remove more than 0.100" off the radius or end of a workpiece in a single pass.** If a cutting tool vibrates, reduce the depth-of-cut, feedrate, and/or spindle speed.
15. **Always ask if spindle speed and feedrate are to be changed while the lathe is running or once it has stopped.** Each machine is different and failure to adjust the machine in the proper manner will result in extensive mechanical damage.
16. **When loading drills, look closely to ensure the axis of the drill and spindle are coincident before tightening the drill chuck.**
17. **Never remove chips with your hands,** as doing so can cause severe lacerations (even when the lathe is off) **and can pull your hand into the rotating work and/or the tool.**
18. **File left handed to prevent contacting the rotating chuck jaws. Never use a file without a handle** and always reduce the spindle speed to its lowest setting when filing.
19. **Never polish or sand workpieces when the lathe is running,** as the abrasive cloth used can easily catch and pull your fingers around the rotating workpiece. The abrasive will also be deposited onto the machine's guideways, greatly accelerating wear.
20. **Before cleaning the lathe remove tools from the tool post and tailstock.**

21. Be gentle when sliding the tailstock; once it begins moving, it is easy to slam the **drill** into the workpiece or the tailstock into the stop pin which keeps it from falling off the ways.

MILLING MACHINE SAFETY

General:

1. **Always wear safety glasses** when operating the milling machine.
2. **Always clamp work securely in the vise** or directly to the table; **never hold by hand.**
3. Always **transport parallels individually** (one in each hand) **and lower them gently into the vise** (never drop them in place), as doing so will damage the precision vise and parallels.
4. **Check speed range before turning on the spindle;** HI range is used for most operations; speed range must only be changed by a trained course instructor/TA.
5. **Before turning on the spindle, make sure the cutter is clear of the workpiece and vise.** Never bring cutting tools into contact with the vise. Check all clearances before machining and if interference appears possible, re-clamp the workpiece and/or tool.
6. **ALWAYS ensure cutter is rotating the proper direction before cutting material** (CW as viewed from the top of the spindle looking down towards the workpiece).
7. **Always adjust the spindle speed while the machine is running. NEVER ADJUST THE SPEED WITH THE SPINDLE TURNED OFF.**
8. **Run the machine at the proper cutting speed.** Use the graphical speed chart posted on the clipboard by each machine.
9. **NEVER bring anything (fingers, measuring tools, rags, air guns, etc.) within 6" of the cutting zone.** Stated another way: *ensure the mill is fully stopped before making measurements or checking surface finish.*
10. **Ramp SLOWLY and GENTLY into contact with the workpiece every time.** While doing so, keep your other hand on the plastic table covers to sense for increased vibration.
11. **Never remove more than 0.100" from the workpiece in a single pass.** If the cutting tool vibrates, reduce the depth of cut and/or feedrate.
12. **When using the power feed, keep your hand on the directional joystick to ensure your fingers aren't pinched between the rotating handle and power feed housing.**
13. **When using the power feed, wait five seconds for the gear-drive to stop rotating before switching directions using the directional joystick.**
14. **When loading drills, look closely to ensure the axis of the drill and spindle are coincident** before tightening the drill chuck.
15. **Never remove chips with your hands, as doing so can cause severe lacerations (even when the mill is turned off) and can pull your hand into the rotating tool.**
16. **Before cleaning the mill remove the sharp cutting tool from the spindle** using a rag to protect your hand.
17. **Do not use milling machine tables for storing tools, as they can easily be damaged by rolling off the tables onto the floor;** use the wooden work tables instead.

Installing Tools:

18. The proper technique for installing a tool is as follows:
 - a. Make sure the power is off and the spindle has stopped rotating.
 - b. **Always position one of the plastic table covers below the spindle before changing tools** to ensure the vise is out of the way of tools which are accidentally dropped.
 - c. Release the 1.5" long quill clamp on the right side of the quill housing by rotating the lever *counter-clockwise* using the palm or your right hand.
 - d. Raise the spindle to the uppermost position using the quill handle on the right side.
 - e. **Raise the silver spindle lock to the highest position by pressing the round button, raising it to the top of its travel and releasing the button. Ensure the spindle lock is all the way up by threading it finger-tight against the black quill stop.**
 - f. Select the appropriate collet to fit the shank of the tool to be installed; *there should only be enough clearance for a piece of paper to fit between the shank and the collet.*
 - g. Inspect the collet to make sure there are no chips on or inside it.
 - h. Insert the collet inside the spindle bore. Collets are keyed and can only be installed in one angular orientation, so slowly rotate the collet while lifting it into the spindle. Once the proper orientation is found the collet will rise ~3" into the spindle bore.
 - i. Use your right hand to hold the tool being installed with a rag to protect your fingers against the sharp cutting edges of the tool.
 - j. Insert the tool into the collet and hold both in the correct position with your right hand; *make sure the collet is clamping on the full diameter of the tool shank.*
 - k. When the tool is located at the correct height in the collet, press the GREEN safety button and the RED 'IN' button to the left side of the machine spindle. Press these buttons for 1-2 seconds until you hear a distinct change in tone signaling the tool and collet are clamped securely; *release immediately upon hearing this sound.*
 - l. Finally, make sure the tool is securely clamped in the collet using a rag to protect your hand; if it is not, consult a laboratory instructor for assistance.

Removing Tools:

19. The proper technique for removing a tool is as follows:
 - a. Make sure the power is off and the spindle has stopped rotating.
 - b. **Always position one of the plastic table covers below the spindle before changing tools** to ensure the vise is out of the way of tools which are accidentally dropped.
 - c. Release the 1.5" long quill clamp on the right side of the quill housing by rotating the lever *counter-clockwise* using the palm or your right hand.
 - d. Raise the spindle to the uppermost position using the quill handle on the right side.
 - e. **Raise the silver spindle lock to the highest position by pressing the round button, raising it to the top of its travel and releasing the button. Ensure the spindle lock is all the way up by threading it finger-tight against the black quill stop.**
 - f. Hold the tool being removed with a rag to ensure it does not fall onto the table. The rag will protect your hand against the sharp flutes of the cutter. Do not try to pull the tool out with your hand; simply allow it to be released from the spindle under gravity.
 - g. Press the GREEN safety button and the RED 'OUT' button to the left side of the machine spindle. Hold these buttons engaged for 1-2 seconds until the tool **and collet** are gently released from the machine spindle.
 - h. Carefully wipe the tool and collet off with a rag and return them to their proper storage locations. Do not mix collets between machines.

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SHEETMETAL EQUIPMENT SAFETY

1. **Always wear safety glasses.** Do not let your guard down around this type of equipment because is it manually operated; **material drops can be ejected at high velocity.**
2. **Exercise caution when working with sheetmetal, as the edges will be extremely sharp and can result in SEVERE lacerations.** Always use gloves when handling sheetmetal, and inspect gloves for holes prior to use.
3. **NEVER operate the equipment in tandem with a second person,** as the slightest miscommunication can result in severe injury or loss of fingers.
4. **Always abide by the maximum material thickness the equipment is designed to operate on (typically 0.065”).** Maximum capacity is noted on the machine; if the label is not clearly visible, ask an instructor before proceeding.
5. **NEVER** cut or bend round material or wire on the sheetmetal shears or brakes, as this equipment is only for thin sheet metal. This rule also applies to hand shears (large scissors).
6. **Always apply rubber edge trim to any sheetmetal edges which may come into contact with someone’s hand or body** (this trim does not need to be included in your BOM and is available by asking any of the TAs).

WELDING SAFETY

General:

1. **All persons in the welding area must wear proper welding shields/helmets.**
2. **Wear protective clothing.** Never weld with any part of the body uncovered, as the arc light is ultraviolet and will cause extreme sunburn. Natural fiber clothes are required because they will not melt onto you in the presence of extreme heat.
3. **Do not wear contact lenses around the welding equipment for extended periods.** The intense light from the arc welding can cause contact lenses to damage your eyes.
4. **Wear proper footwear** to protect your feet from sparks and molten metal.
5. **Close the welding curtain around the welding area** to protect others from optical injury.
6. **Treat the welding gun like a real gun and do not touch the trigger until you are ready to weld,** as doing so can cause a large arc flash that will temporarily blind others in the area.
7. **Clearly communicate when you START and STOP welding so no one gets flashed with the arc by calling “EYES” before starting and “RAISE HELMETS” when finished.**
8. **Always assume EVERY PART on the welding table may be HOT and touch cautiously.**
9. **Never weld on painted, galvanized, greasy or oily metals,** as the fumes can be toxic and the welds will be contaminated and will fail in use.
10. **Allow for proper ventilation when brazing or soldering, as some fluxes are toxic.**

Explosion / Fire Prevention:

11. **Keep fire extinguishing equipment nearby** and know how to operate it.
12. **Ensure welding/hot-work area is clear of chemicals and flammable materials. Never weld in the same location where cleaning operations are performed since most of those chemicals are volatile and the vapors can be lethal.**
13. **Never cut or weld any container that has held flammable materials,** regardless of how well it's been rinsed; **MANY PEOPLE HAVE LOST LIMBS OR BEEN KILLED THINKING A CONTAINER WAS CLEAN ENOUGH TO WELD.**

Gas Cylinder Handling:

14. **Always strap gas tanks to the welder,** welding cart or a fixed object (like a wall). **Never allow gas cylinders to free stand.** Replace the safety cap on cylinders when not in use.
15. **Avoid handling gas bottles with greasy hands, gloves or rags.** Fatal explosions have resulted because of accidental tank tipping.
16. **When changing regulator ensure your hands are not contaminated with oil – oxygen and oil can result in explosion with the metal regulator is tightened down.**
17. **Never leave the compressed gas cylinder tank valves fully open to minimize the chance of it becoming stuck.**

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WELDING / HOT WORK SAFETY CHECKLIST

WORK AREA

- YES NO 1. Is the work area clear of ALL flammable chemicals and oil deposits?
- YES NO 2. Is the work area clear of ALL combustibile materials, including paper products, dust and trash cans?
- YES NO 3. Is the entire welding area suitable for hot sparks (i.e. walls, floor, etc.)?
- YES NO 4. Is the welding area closed off from view via welding curtains?
- YES NO 5. Does the welding area provide adequate ventilation for the users?
- YES NO 6. Is a fire extinguisher within 10 feet of the welding area and do you know how to use it?
- YES NO 7. Are you prepared to treat EVERY workpiece on the welding table as if it may be EXTREMELY HOT and exercise the respective caution?

PERSONAL SAFETY EQUIPMENT (PPE)

- YES NO 8. Are all persons welding wearing heat resistant footwear?
- YES NO 9. Are all persons welding wearing long natural fiber pants?
- YES NO 10. Are all persons welding wearing natural fiber welding jackets?
- YES NO 11. Are all persons welding wearing welding gloves?
- YES NO 12. Are all persons welding wearing welding helmets and safety glasses?

WORKPIECES

- YES NO 14. Are all workpieces clean and free of oil, rust, paint, or other coatings? For example, never weld galvanized coated materials because the fumes produced by the intense heat are toxic.
- YES NO 15. Was alcohol or acetone used to properly clean the parts to be welded? NEVER use cleaners containing chlorine (i.e. aerosols like brake cleaner) to clean parts for welding, because the chlorine gas will be converted into Phosgene, which is LETHAL IN THE SMALLEST DOSES.
- YES NO 16. Is the workpiece a container that has held combustibile materials or flammable solvents like gasoline, acetone, etc.? *If so, STOP and DO NOT WELD ON IT, regardless of how well you think or have been told it's been rinsed. MANY PEOPLE HAVE LOST LIMBS OR LIVES AFTER MISTAKENLY BELIEVING A CONTAINER WAS CLEAN ENOUGH TO WELD. Containers MUST be welded by a professional, WITHOUT EXCEPTION.*