EML2322L – MAE Design and Manufacturing Laboratory

Important TA Equipment Knowledge

The following list contains important knowledge the TAs should possess when working in the lab. Reviewing this list each semester and adding to it should facilitate TA knowledge transfer.

A. **Lathe:**
1. Ensure lathe is fully engaged in HI/LO range each time by gently rocking the chuck while switching the gear selection handle with your left (partial engagement grinds gears)
2. Do not overtighten toolpost clamping nut (~20lbf)
3. Know how to set the z-axis carriage stop to avoid chuck jaw collisions
4. Know how to adjust the automatic feed rates (0.007″/rev for alum, 0.004″/rev for steel)
5. Understand e-stop button function on South Bends (it's typically not used on the older two, but can get activated during cleanup, so check it if the machines won't turn on; however, it should be used at the end of each day to prevent the pump from running all night on the newest South Bend (the one on the west end of the lab))
6. Understand foot brake function and use (for emergency use only, but you can't activate it while standing at the back of the machines, so don't stand there while training)
7. Instruct students to not retract the tailstock quill past the 1" mark, as doing so ejects the tool
8. Make sure students are gentle with the chip pan during cleanup
9. Know how to oil guideways (in case a student wipes them off while cleaning)
10. Understand and be comfortable with the Ajax controls and additional safety protocols (speed range selection, power switch, power feed directions)
11. Understand how to properly release tools from Ajax tailstock using knockout bar
12. Chuck jaws may be reversed to allow clamping of larger parts; change the jaws back to original configuration at the end of the work session
13. Larger HSS drills are located in the gray cabinets by the lathes (use ½″ increments)
14. Don't run lathes slower than 250 rpm when creating the Entstort wheel hub counterbore or the endmill can shatter when the flutes break through the set screw holes
15. Understand zeroing for drilling blind holes on the lathe (tip zero vs. full diameter zero)
16. Understand how to setup and use the part-off/grooving tool (check tool height, ensure part-off blade is parallel to X-axis, keep it short, feed by hand to feel chip packing, oil liberally)
17. Understand how to setup and use boring bars (check tool height, ensure bars are parallel to Z-axis, clamp bars short (like endmills), check clearance between the chuck jaws and the outside corner of the compound rest, make sure you don't run the bars into the chuck bore)
18. Advanced: understand how to change lathe chucks (support chucks on wood, replacement chuck and spindle nose must be SPOTLESS, tighten cam-locks in diagonal pattern, check all cam-locks are TIGHT before turning on lathe)
19. Advanced: understand how to knurl on a lathe
20. Advanced: understand how to cut threads on a lathe

B. **Milling Machine:**
1. Know how to change speed range by rocking the spindle while rotating the handle (HI/LO)
2. Always lock the spindle friction lock to ensure uniform cutting
3. Never load endmills in drill chucks because radial forces will cause the chuck to open
4. Never rigid tap using keyless chucks (use keyed chucks or tap collets instead)

5. Always clamp drills larger than 1/2" in collets, not in drill chucks (unless the shanks have been flatted); be careful to never clamp on the small fillet between the shank and drill body
6. Drills < ½" should use ¼" increments; drills > ½" can use ½" increments
7. Understand how to use annular cutters (no pilot hole, no step-up, the speed calculated for drilling the same size hole, remove intermediate slugs when drilling thru multiple parts)
8. When clamping parts that don't have machined (parallel) edges, clamp the part on top of 1/16" parallels and leave them in the vise, or use the thick paint paddles in the mill table drawer to increase the surface contact and clamp the part securely
9. Know how to fix the drawbar after a student fails to lock the spindle in the upper-most position and tries to release the tool (rotate spindle by hand while lifting up on the quill handle and if that doesn't work, activate the IN controls in 2s bursts while applying ~15lb of force to the quill handle to raise the spindle)
10. Know how to fix mill if students change speed while off (rotate spindle forward by hand while cranking the speed dial back to the original position)
11. Understand how to adjust the quill feed handles for comfortable operator feel
12. Understand how the table friction locks work and that when used in lab we must remind the students so they don't forget to disengage them
13. Know the location of the power feed rapid traverse button and that students never use it
14. Understand how to use V-blocks properly (i.e. only one is necessary to hold wheel hub)
15. When possible clamp parts together to create identical parts simultaneously (miniature clamps for this purpose can be found in the mill table drawer)
16. Be familiar with tool locations for additional center drills, jobber drills, edge finders, tap guides, taps, reduced shank drills, annular cutters, hole saws, calipers, etcetera)
17. Know how to use depth gage to properly zero Z-axis for drilling blind holes
18. Know how to oil guideways (in case a student wipes them off while cleaning)
19. Always make contact with the SIDE of the conical edge finder, never the tip
20. To save milling machine time, use the hand tapping station and wheel hub jig located by the drill press to tap the holes in the face or side of the second wheel hub (or other parts)
21. Understand how to align vise to X-axis and mill head to XY-plane
22. If the spring loaded tap guide sticks, tap it firmly on its side against something rigid
23. If the DRO goes into "power saver mode", rotate one of the DRO axes to wake it up
24. The DROs have an inch and mm mode, which is convenient for some part features
25. Use minimum quantity lubrication for milling lab parts and more oil for drilling and tapping
26. Be familiar with additional vise jaws for use with taller / longer / less-common part shapes
27. Be familiar with adjustable jackstands for use under less rigid workpieces
28. Be familiar with 5C collet blocks which are useful for cutting flats or hexes in round stock
29. If multiple parts are cut use work stops to reduce setup time
30. Never place any hard tools directly on the precision milling machine tables (sans covers)

C. **Marvel Bandsaw:**
1. Know how to properly clamp parts in the vise (use both vise halves and pump the vise lock twice each time) and check that it's properly clamped each time before cutting
2. Know how to feed the blade manually in cases where more sensitivity is required (feed it with just enough force so it cuts and doesn't just rub the material); **start all round cuts this way to make sure the part is clamped securely in the vise**
3. Verify coolant level is at the top of the inlet screen and know how to top it off using a bucket and the hose by the garage door

D. **Drill Press:**
   1. Always use the safety vise or rest the vise against the vertical support column
   2. Always show students how to clamp workpieces (don't just give them a clamp and leave)
   3. Always warn students about drilling through table or vise
   4. Never drill holes larger than ½" on the drill press (move to mill instead)
   5. Always ensure the Jacobs chuck key is fully tightened with the key when loading tools into the drill press which still uses a key operated drill chuck
   6. Use accessory V-blocks in drill press vises to hold round parts

E. **Sheetmetal Equipment:**
   1. Know how to use sheetmetal roller
   2. Understand use of yellow hand shear to cut large circles
   3. Know how to rotate turret when punches are at the wrong heights
   4. Know how to use small sheetmetal hole cutters which mount in hand drill or drill press
   5. *Unibits* work well for drilling various size holes in sheetmetal, but they can be very aggressive in novice hands, so instruct the student(s) accordingly
   6. When shearing sheetmetal try to optimize drop size(s) for future use
   7. Understand how to cut a notch (square slot) on the Do-All by first making two diagonal cuts and then removing the resulting triangles
   8. Understand capability of knife brake
   9. Understand how to install rivets using a rivet gun and how Clecos spring clamps work
   10. Keep the sheetmetal rack organized by material type and thickness, and pull sheets smaller than 2x4' out about 1" away from the other pieces so they can be used first
   11. Understand how to safely use angle grinders and die grinders

F. **Welders / Plasma Cutter:**
   1. Know how to set up and use the MIG welder and what settings to use for what material (turn on shielding gas each time; 2 and 20 for sheetmetal and 3 and 30 for 1/8" mat'l)
   2. The voltage control for the Hobart MIG welder MUST be ON a number (like 2 or 3) and not in between two numbers or the party will not start
   3. Tell the students to clearly communicate when they START and STOP welding so no one gets flashed with the arc; "eyes" and "raise helmets" work well
   4. Know how to free MIG wire when filler metal cools in weld while attached to stinger
   5. Know how to set up and use the spot welder (green light; timer set to 1-2 seconds)
   6. Remember to turn the air on and off before and after using the plasma cutter
   7. If the plasma doesn't seem to be cutting the ground clamp probably isn't connected
   8. Know how to use the new plasma cutter's drag tip and pierce 1/16″ to 1/8″ from the work
   9. Be sure welding table is clear of the workpiece so the plasma doesn't pierce the table
   10. Use the straight edge and circle templates to dramatically improve your plasma cut quality
   11. Become familiar with right angle grinders and die grinders for use deburring workpieces and make sure you know how to use them; students generally do not have the knowledge or experience to use them safely, so only TAs should use these tools
   12. Secure part in vise or to table using c-clamps (not vise grips) before using angle grinder

G. **VF2 / TM2 CNC Milling Machines:**
   1. Ask Mike or another TA to review the CNC tapping demo with you until you are comfortable running it alone (including turning the machine ON)
   2. ALWAYS run the probe at 5% RAPID when within 6" of part/vise
   3. Know how to reattach CNC coolant hoses on VF2 if they come off while adjusting

H. **Additional Shop Tools:**
   1. There is a Dremel in the Power Tools cabinet by the garage door which can used as a small sander, grinder or cutoff tool; ask for a demo if you haven't used one before
   2. …

I. **Contact Metrology:**
   1. In the accurate words of Israelle Widjaja, "properly measuring things is hard ☺."
   2. Rule of Ten: the gage or measuring instrument should be 10 times as accurate as the characteristic (i.e. smallest tolerance) to be measured.
   3. A measuring instrument is useless if not calibrated regularly against a calibrated gage.
   4. A measuring instrument which offers no constant torque method of measurement is junk; also, those that do only work if the clutch is rotated at consistent and constant velocity.
   5. Whenever possible conduct measurements as close to NTP (normal temp and pressure) as possible (68°F & 1atm (14.696 psia)).
   6. Whenever possible measure in an environment that will not damage the part or measuring instrument if either is dropped.
   7. Clean the contact jaws or tips with alcohol and a piece of tissue paper before use.
   8. Always remember to double check the zero of the measurement instrument before use.
   9. Understand metals have a typical coefficient of linear expansion of 0.000010 in / (in-°F); therefore holding on to a measuring instrument and/or a part long enough will cause a 2″ nominal part to change length 0.0006″ due to temperature change alone.
   10. Always take at least three measurements to be "carelessly certain" of the ballpark value.
   11. Become proficient with gage blocks and gage pins, as these are typically manufactured to ±0.000100″ or ±0.000050″, and are good for moderate precision calibrations.
   12. Research parallax error and Abbé error to understand why calipers are not regarded very highly in metrology circles ☺.

J. **Miscellaneous:**
   1. If you notice the lab is running low on commonly used materials (80/20, steel rod, aluminum flatbar, etc.), PLEASE TELL MIKE so he can reorder
   2. Understand preferred cutting methods for various sheet metal processing. For example, long straight cuts should use the shear; enclosed and small radius contours should use plasma cutter; and tight corners on exterior perimeter should use Do-All or hand shear.
   3. Use the Cutting Speed Charts to prevent drills from screaming and overheating
   4. If drills are missing/damaged, search the local area / machines and then retrieve a replacement from the large drill index in the mill cabinets
   5. If a DRO stops measuring/displaying properly, make sure the power and encoder cables are fully seated into their sockets, turn DRO off and back on, then ask Mike
   6. Understand ABS and INC DRO settings
   7. Understand proper removal of Entstort hub from motor shaft (use 3/4" punch and small steel hammer to knock the shaft out without damaging the threads)
   8. Understand the difference between taper, plug, bottom, pulley, spiral, and spiral point taps
   9. Proper filing method (use full length of file, only cut moving the file away from your body, maximize motion perpendicular to workpiece edge, not parallel to it)
   10. Sharpies will regularly become clogged with the light coating of grease placed on the steel sheetmetal so it doesn't rust during transport/inventory; if a Sharpie stops writing, try cleaning the tip on a sheet of paper before discarding it
   11. We have digital protractors and longer (8" and 12") calipers in the metrology cabinet when additional accuracy and precision are needed

K. **Robot Testing Tips:**

1. Turn off control boxes when making wiring changes
2. Do not allow students to turn robots sideways to change wheels, as doing so dramatically increased the likelihood of breaking a wheel
3. Do not perform mechanical work (like wheel changes) on the robots on the floor, as doing so scratches the floor and creates trip hazards
4. Use sheetmetal edge trim to protect students and TAs from sharp sheetmetal edges
5. Know how to tighten the Denso wheel hubs properly using the extended reach T-handled allen wrenches which have been added to each toolbox

L. **Tool Materials & Coatings:**

1. HSS tools can be ground sharper than (sintered) carbide tools, so HSS is often used for finish passes where surface finish is of utmost importance
2. All materials have a minimum chip thickness below which they will smear rather than cut, making it difficult to achieve tight tolerances. Harder materials generally have a smaller minimum chip thickness.
3. Using an air blast (as opposed to oil) for a finish pass generally gives a better surface finish in materials that don't have a tendency to gall to the cutting tool material (oil forms a variable boundary layer between the workpiece and tool, causing inconsistent cutting action and chip thickness when taking small (i.e. < 0.005") depth cuts)
4. Ultra-thin coatings are applied to all types of cutting tools to act as thermal barriers and reduce the tendency for galling (i.e. improve crater wear, reduce built-up edge, reduce shear strain, etc.). Common tool coatings include TiN, TiCN, ZrN and DLC.
5. TiN (titanium nitride) is a dull 14K gold color and is the oldest heat barrier coating for general purpose ferrous machining; it is applied via CVD (chemical vapor deposition) or more modernly via PVD (physical VD) and is the cheapest coating among the list.
6. AlTiN (aluminum titanium nitride) is a dark gray / black coating and offers excellent high temperature resistance and hardness for ferrous machining. Commonly used to cut alloy and stainless steels, and aerospace alloys like titanium, inconel and nickel.
7. TiCN (titanium carbonitride) is also a dark gray / violet colored coating that offers excellent high temperature resistance and hardness; however it is effective for both ferrous and non-ferrous machining (it's almost 80% harder than TiN).
8. ZrN (zirconium nitride) is a light gold (champagne) colored coating that offers high hardness and abrasion resistance for non-ferrous machining.
9. DLC (diamond-like coating) offers excellent wear resistance in abrasive non-ferrous materials, but is unsuitable for ferrous applications.

M. Final Thoughts:

1. You only get better through experience, so work on additional tasks using the lab equipment. There are always laboratory tasks which need to be completed that will help you gain more experience with the equipment. When working on them, let Mike or an older TA assist and teach you the different capabilities of the equipment.
2. …