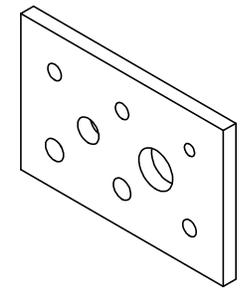
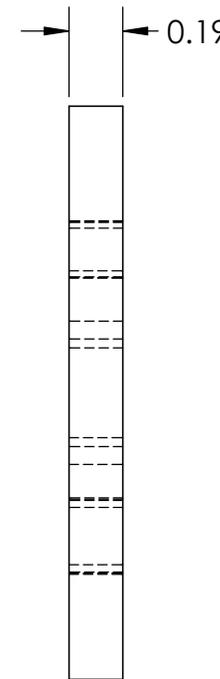
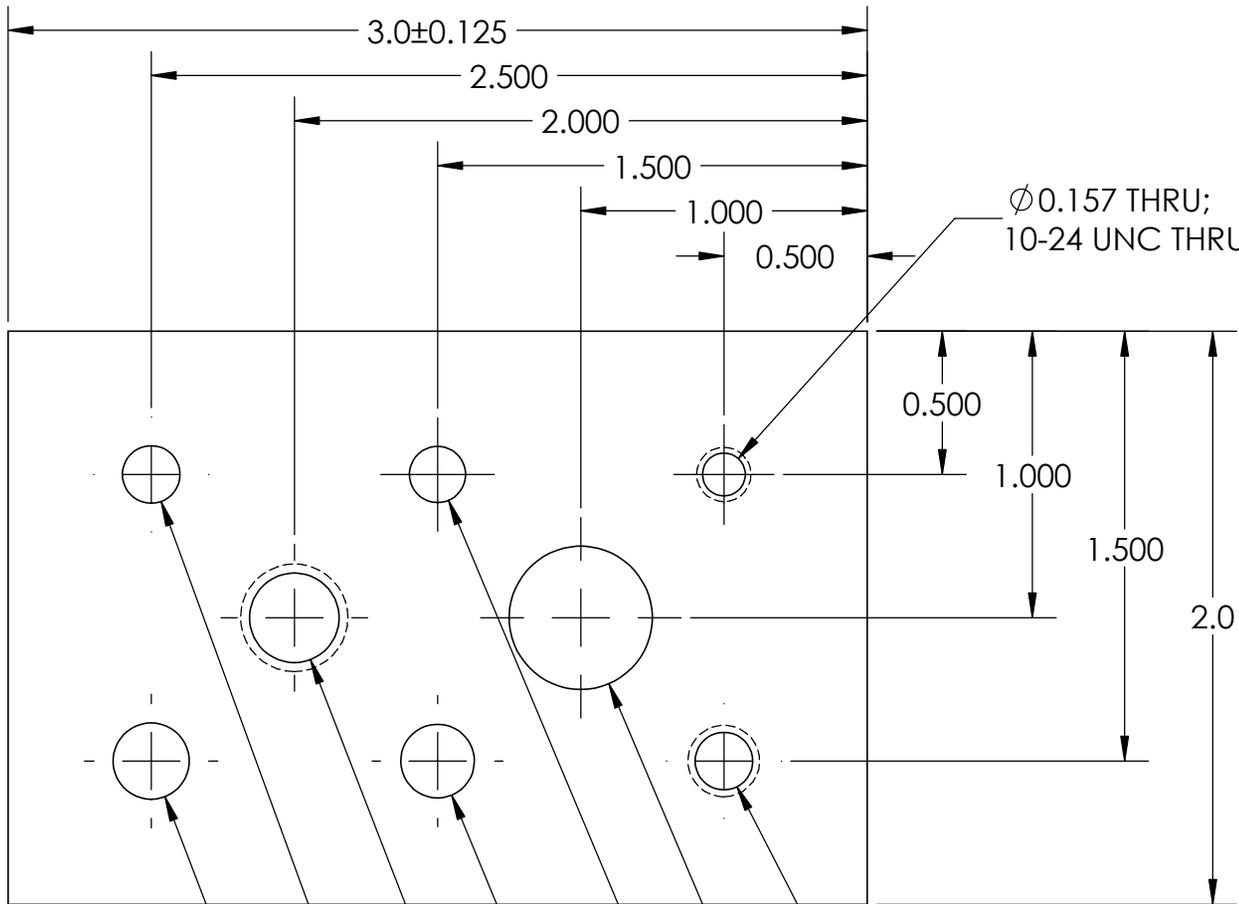


Drilling & Tapping Practice Part

1. Measure raw material to ensure it is suitable for the part (2.00 ± 0.05 " and 0.19 ± 0.02 ")
2. Cut a piece of 3/16" x 2" AL rectangular bar stock roughly 3" long (± 0.125 ") in the bandsaw
3. Debur edges using file
4. Clamp workpiece in mill using parallels (workpiece surface should be within 1/8" of top of vise jaws)
 - a. **CAUTION: Remove parallels prior to drilling and never carry two in one hand**
5. Set part datums (zeros) in X and Y directions using the [cylindrical edge finder](#)
 - a. Load the [Jacob's drill chuck](#) (*refer to proper rules for changing tools: machine off; spindle positioned over plastic cover; quill raised and locked in its upper-most position*)
 - b. Load cylindrical edge finder and adjust height so SIDE of cylinder contacts part surface
 - c. Zero x-axis on side of part; offset x-axis by 0.100" (radius of cylindrical edge finder)
 - d. Zero y-axis on vise; offset y-axis by 0.100" (radius of cylindrical edge finder)
 - e. Visually confirm spindle centerline is above corner of workpiece
 - f. Zero DRO (if not already zeroed)
6. Center drill all 8 holes (~1600 rpm; **remember to change speeds with spindle running**)
 - a. Drill until about half of the SMALL cylindrical portion of the center drill is in the part. Stop drilling if the center drill's chamfer begins to cut.
7. Drill the 10-24 UNC tapped hole thru using $\text{\O}0.157$ " tap drill (size: 22)
 - a. Use oil and peck drill with pecks equal to the tool radius
8. Drill the $\text{\O}0.196$ " hole thru (size: 9) (~1400 rpm; **remember to change speeds with spindle running**)
 - a. Use oil and peck drill with pecks equal to the tool radius
 - b. NOTE: This is a close fit clearance hole for a #10 fastener
9. Drill the $\text{\O}0.201$ " hole thru (size: 7)
 - a. Use oil and peck drill with pecks equal to the tool diameter
 - b. NOTE: This is a free fit clearance hole for a size 10 fastener
 - c. NOTE: This drill bit is also used in the following step
10. Drill the 1/4-20 UNC tapped hole thru using $\text{\O}0.201$ " tap drill (size: 7)
 - a. Use oil and peck drill with pecks equal to the tool radius
11. Drill remaining 4 holes thru with $\text{\O}0.250$ " drill (size: 1/4) (~1200 rpm)
 - a. Use oil and peck drill with pecks equal to the tool radius
12. Drill the $\text{\O}0.257$ " hole thru (size: F)
 - a. Use oil and peck drill with pecks equal to the tool radius
 - b. NOTE: This is a close fit clearance hole for a 1/4" fastener

Drilling & Tapping Practice Part (cont)

13. Drill the Ø0.266" hole thru (size: H)
 - a. Use oil and peck drill with pecks equal to the tool radius
 - b. NOTE: This is a free fit clearance hole for a ¼" fastener
14. Drill the 3/8-16 UNC tapped hole thru using Ø0.313" tap drill (size: 5/16) (~1000 rpm)
 - a. Use oil and peck drill with pecks equal to the tool radius
15. Drill the Ø0.5" hole thru (size: ½) (~700 rpm)
 - a. Use oil and peck drill with pecks equal to the tool radius
16. Remove the Jacob's drill chuck
 - a. *Refer to proper rules for changing tools: machine off; spindle positioned over plastic cover; quill raised and locked in its upper-most position*
 - b. *CAUTION: the Jacob's chuck is heavier than the other tools, so don't drop it*
17. Tap the 10-24 UNC hole thru
 - a. Load tap guide into spindle using a ½" collet
 - b. Load 10-24 tap into tap handle
 - c. Use oil while tapping and reverse direction every full turn to break chips
 - d. *CAUTION: if tap handle becomes difficult to rotate, fully back tap out of hole, blow away the chips, re-oil tap, and resume tapping the thread*
18. Tap the ¼-20 UNC hole thru
 - a. Use tap guide which should already be loaded in a collet in the spindle
 - b. Load ¼-20 tap into tap handle
 - c. Use oil while tapping and reverse direction every full turn to break chips
19. Tap the 3/8-16 UNC hole thru
 - a. Use tap guide which should already be loaded in a collet in the spindle
 - b. Load 3/8-16 tap into tap handle
 - c. Use oil while tapping and reverse direction every full turn to break chips
20. Remove the tap guide from the spindle
 - a. *Refer to proper rules for changing tools: machine off; spindle positioned over plastic cover; quill raised and locked in its upper-most position*
21. Remove part from mill vise
22. Deburr holes using hand-held countersink tool
23. Clean up milling machine
 - a. Always have a TA or instructor inspect your machine for cleanliness before leaving
 - b. *CAUTION: DO NOT wipe metal surfaces! Only wipe painted and plastic surfaces (the oil on the metal surfaces is essential for proper machine function)*



- NOTES:
 1. DIMS IN INCHES
 2. QUANTITY: 1
 3. MAT'L: ALUMINUM
 4. BREAK ALL EDGES
 5. FINISH NOTED SURFACES

Ø0.266 THRU

Ø0.196 THRU

Ø0.257 THRU

Ø0.313 THRU;
3/8-16 UNC THRU

Ø0.201 THRU

Ø0.201 THRU;
1/4-20 UNC THRU

Ø0.157 THRU;
10-24 UNC THRU

TOLERANCE UNLESS NOTED				TITLE:		
OPERATION	PLACES IN DIMENSION			Drilling & Tapping Practice Part		
	0.0	0.00	0.000	DRAWN J. DERSCH		
MACHINING	±0.050	±0.020	±0.005	DESIGNED J. DERSCH		
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE	DWG. NO.	REV
WELDING	±0.1	±0.060		A	EML2322L-PRAC-M	A
ANGULAR DIMS	±5	±2	±0.5	SCALE: 3:2		SHEET 1 OF 1

EML2322L – MAE Design and Manufacturing Laboratory

Lathe Practice Part

1. Measure raw material diameter to ensure it is suitable for the part ($\text{Ø}1.00 \pm 0.020$ ")
2. Cut a piece of 1" diameter round bar stock roughly 3-1/2" long (± 0.125 ") in the bandsaw
3. Debur edges using file
4. Clamp workpiece in lathe chuck with 3" of material protruding from chuck jaws
 - a. **CAUTION: NEVER leave the chuck key in the chuck**
5. Install turning/facing tool onto tool post
 - a. Use the tool with a silver colored insert (not gold)
 - b. Ensure the tool is aligned vertically with the part centerline using the ruler or lathe gage
 - c. Check for proper relief angles ($\sim 5^\circ$) and adjust as necessary
6. Set zeros in X and Z directions
 - a. **CAUTION: any time you interact with anything on the left side of the machine (like the DRO), use your left hand; NEVER reach over the spindle**
7. Face end of workpiece and re-zero Z axis
 - a. Remove 0.020" of material using the automatic feed
 - b. After removing the material and before moving the cutting tool away from the part, re-zero the DRO using your left hand; although not specified as requiring a finished surface, precise measurements must be made from this surface, so it should be finished
8. Turn shoulder on part (~ 600 rpm)
 - a. Perform 0.100" radial depth cuts using the autofeed until 0.1" remains along the Z-axis
 - b. Finish the last 0.1" along the Z-axis by feeding the tool manually
 - c. Try to leave ~ 0.020 " on the diameter for the finish pass
 - d. Use a drop of cutting oil for each pass
9. Cut chamfer (~ 600 rpm)
 - a. Use the tool with a silver colored insert (not black or gold)
 - b. Gently touch off on corner to be chamfered and zero the Z-axis
 - c. Move 0.030" along Z-axis
10. Debur remaining edge with file
 - a. **CAUTION: Use proper safety procedure (lowest speed, rubber handled file, left-handed, weight on your feet not into workpiece)**
11. Remove workpiece from lathe chuck
12. Cut part 1/8" over final length on the bandsaw

Lathe Practice Part (cont)

13. Clamp small diameter of workpiece in lathe
 - a. **CAUTION: NEVER leave the chuck key in the chuck**
14. Set zero in Z direction
 - a. **CAUTION: any time you interact with anything on the left side of the machine (like the DRO), use your left hand; NEVER reach over the spindle**
15. Face end of workpiece to final dimension (~ 600 rpm)
 - a. Begin by removing 0.020" of material using the autofeed
 - b. Re-zero the DRO using your left hand
 - c. Finish facing part using 0.100" maximum depth of cut
16. Remove turning/facing tool
 - a. Turn machine off
 - b. Clean and inspect tool prior to putting it away
17. Debur edge with file
 - a. **CAUTION: Use proper safety procedure (lowest speed, rubber handled file, left-handed, weight on your feet not into workpiece)**
18. Center drill hole using tailstock (~ 600 rpm)
 - a. Drill until about half of the SMALL cylindrical portion of the center drill is in the part. Stop drilling if the center drill's chamfer begins to cut.
19. Drill hole thru with 1/4" drill to a depth of 0.8"
 - a. Use oil and peck drill with pecks equal to the tool radius
 - b. Zero the tailstock when the drill begins to cut at its full diameter
20. Drill hole thru with 9mm drill to a depth of 0.8"
 - a. Use oil and peck drill with pecks equal to the tool radius
 - b. Zero the tailstock when the drill begins to cut at its full diameter
21. Remove workpiece from lathe chuck (**remember to be careful with the chuck key**)
22. Debur holes using hand-held countersink tool
23. Clean up lathe
 - a. Always have a TA or instructor inspect your machine for cleanliness before leaving
 - b. **CAUTION: DO NOT wipe metal surfaces! Only wipe painted and plastic surfaces (the oil on the metal surfaces is essential for proper machine function)**
24. Clamp workpiece in milling machine (center hole should be visible)

Lathe Practice Part (cont)

25. Set zero in X direction using the conical edge finder
 - a. Load the [Jacob's drill chuck](#) (*refer to proper rules for changing tools: machine off; spindle positioned over plastic cover; quill raised and locked in its upper-most position*)
 - b. Load conical edge finder and adjust height so SIDE (NOT TIP) of cone contacts part surface
 - a. Zero on one side of part; move to opposite side and use the ½ or CL function to take one half of the cord length, setting the zero to part centerline
26. Set zero in Y directions using the cylindrical edge finder
 - a. Zero y-axis on part
 - b. Offset y-axis zero by 0.100" (radius of cylindrical edge finder)
 - c. Visually confirm spindle centerline is above edge
 - a. Re-zero DRO
27. Center drill hole (~ 1600 rpm; *remember to change speeds with spindle running*)
 - a. Drill until about half of the SMALL cylindrical portion of the center drill is in the part. Stop drilling if the center drill's chamfer begins to cut.
28. Drill the 10-24 UNC tapped hole thru using 0.157" tap drill (size 22)
 - a. Use oil and peck drill with pecks equal to the tool radius
29. Tap the 10-24 UNC hole thru
 - a. Load tap guide into spindle using a collet
 - b. Load 10-24 tap into tap handle
 - c. Use oil while tapping and reverse direction often to break chips
 - a. *CAUTION: if tap handle becomes difficult to rotate, fully back tap out of hole, blow away the chips, re-oil tap, and resume tapping the thread*
30. Remove the Jacob's drill chuck
 - a. *Refer to proper rules for changing tools: machine off; spindle positioned over plastic cover; quill raised and locked in its upper-most position*
 - b. *CAUTION: the Jacob's chuck is heavier than the other tools, so don't drop it*
31. Remove part from mill vise (be careful not to drop it into the vise)
32. Deburr holes using hand-held countersink tool
33. Clean up mill
 - a. Always have a TA or instructor inspect your machine for cleanliness before leaving
 - b. *CAUTION: DO NOT wipe metal surfaces! Only wipe painted and plastic surfaces (the oil on the metal surfaces is essential for proper machine function)*

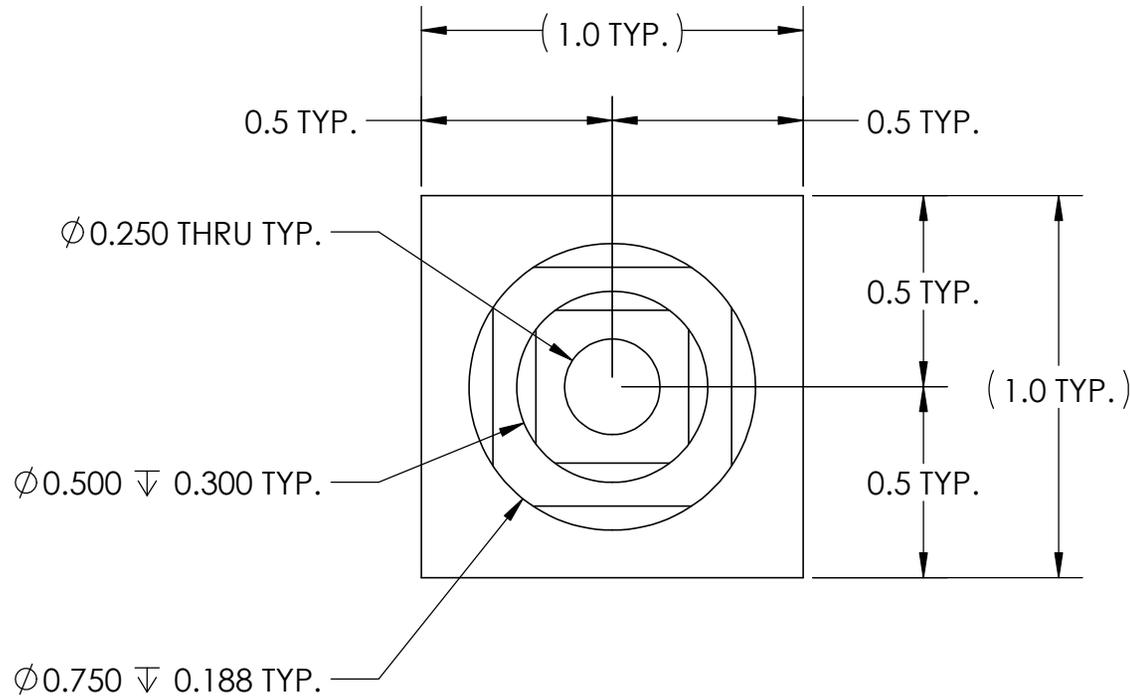
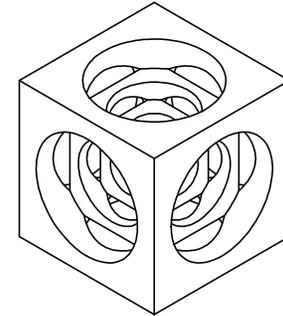
Turner's Cube Practice Part

1. Measure raw material to ensure it is suitable for the part (1.000 ± 0.010)
2. Cut a piece of 1" x 1" AL rectangular bar stock roughly 1-1/8" long (± 0.062 ") in the bandsaw
3. *Gently* debur edges using file
4. Clamp workpiece in milling machine using parallels (workpiece surface should extend roughly 1/4" above top of vise jaws)
 - a. **NOTE: Parallels should normally be removed prior to cutting the workpiece, however, due to the precision required, leave the parallels in the vise**
5. Set part datum (zero) in Z direction using an [1-1/4" end mill](#)
 - a. Load the 1-1/4" endmill in a collet (**refer to proper rules for changing tools: machine off; spindle positioned over plastic cover; quill raised and locked in its upper-most position**)
 - b. Carefully zero z-axis (~ 800 rpm; **remember to adjust speed with spindle running**)
6. Face workpiece (~ 800 rpm) by removing as little material as possible (typ. 0.003 – 0.005")
7. Zero and face remaining 5 sides
 - a. Make each edge the same length (to within ± 0.003 " if possible)
 - b. **CAUTION: When using calipers, ensure machine is off and spindle has ceased rotating**
8. Install vise-stop on rear vise jaw with machine off and use it when clamping part henceforth
9. Set part datums (zeros) in X and Y directions using the [cylindrical edge finder](#)
 - a. Load the [drill chuck](#) (**refer to proper rules for changing tools: machine off; spindle positioned over plastic cover; quill raised and locked in its upper-most position**)
 - b. Load cylindrical edge finder and adjust to proper spindle speed (~ 1000 rpm)
 - c. Zero to centerline of part along x-axis and y-axis
10. Center drill part (~ 1600 rpm; **remember to adjust speed with spindle running**)
 - a. Drill until about half of the SMALL cylindrical portion of the center drill is in the part. Stop drilling if the center drill's chamfer begins to cut.
11. Drill the $\varnothing 0.250$ " hole thru (~ 800 rpm; **remember to adjust speed with spindle running**)
 - a. Apply oil and peck drill with pecks approximately equal to the drill radius
12. Center drill and drill the $\varnothing 0.250$ " hole thru (size: 1/4) on remaining two sides

Turner's Cube Practice Part (cont)

13. Counterbore $\frac{3}{4}$ " holes on all 6 faces
 - a. Load the $\frac{3}{4}$ " cbore in a collet (*refer to proper rules for changing tools: machine off; spindle positioned over plastic cover; quill raised and locked in its upper-most position*)
 - b. Lower the depth stop (spring loaded spindle lock) to $\sim \frac{3}{4}$ " without touching part
 - c. *Carefully* zero z-axis with spindle locked against the depth stop (~ 250 rpm; *ask a TA to place the mill in LOW RANGE and remember to rotate the power switch to LOW RANGE and adjust speed with spindle running*)
 - d. Raise spindle fully
 - e. Raise Z-axis the depth of the $\frac{3}{4}$ " cbore (0.188")
 - f. Cbore hole using quill handle, cutting oil, and GENTLE cutting force
 - g. Lightly debur and rotate part to new face and repeat cbore for remaining faces
14. Counterbore $\frac{1}{2}$ " holes on all 6 faces
 - a. Load the $\frac{1}{2}$ " cbore in a collet (*refer to proper rules for changing tools: machine off; spindle positioned over plastic cover; quill raised and locked in its upper-most position*)
 - b. Lower the depth stop (spring loaded spindle lock) to $\sim \frac{3}{4}$ " without touching part
 - c. *Carefully* zero z-axis with spindle locked against the depth stop (~ 500 rpm; *ask a TA to place the mill back in HI RANGE and adjust speed with spindle running*)
 - d. Raise spindle fully
 - e. Raise Z-axis the depth of the $\frac{1}{2}$ " cbore ($0.300 - 0.188 = 0.112$ ")
 - f. Cbore hole using quill handle, cutting oil, and GENTLE cutting force
 - g. Lightly debur and rotate part to new face and repeat cbore for remaining faces
15. Remove the counterbore from the spindle (*refer to proper rules for changing tools: machine off; spindle positioned over plastic cover; quill raised and locked in its upper-most position*)
16. Remove part from mill vise
17. Lightly debur holes using hand-held countersink tool
18. Clean up milling machine
 - a. Always have a TA or instructor inspect your machine for cleanliness before leaving
 - b. **CAUTION: PLEASE DO NOT wipe off machine guideways (the oil on these surfaces is essential for proper machine function)**
 - c. **Check the machine has been returned to HI RANGE, and if not, ask a TA to please do so for the next student who uses it**

OPPOSITE FACES SHOULD BE PARALLEL WITHIN 0.002
 EDGES SHOULD BE WITHIN +/- 0.003" OF ALL OTHER EDGES



NOTES:

1. DIMS IN INCHES
2. MAT'L: 6061-T6 ALUMINUM
3. FINISH ALL SURFACES TO 1000 R_a
4. BREAK ALL EDGES
5. QUANTITY: 1

TOLERANCE UNLESS NOTED				TITLE: Turners Cube		
OPERATION	PLACES IN DIMENSION			DRAWN	DESIGNED	REV
	0.0	0.00	0.000			
MACHINING	±0.020	±0.010	±0.002	J. DERSCH	J. DERSCH	
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060		SIZE A	DWG. NO. EML2322L-TCUBE	REV A
WELDING	±0.1	±0.060				
ANGULAR DIMS	±5	±2	±0.5	SCALE: 2:1		SHEET 1 OF 1

Turner's Cube Base Practice Part

1. Measure raw material diameter to ensure it is suitable for the part ($\text{Ø}0.75 \pm 0.020$ ")
2. Cut a piece of $\frac{3}{4}$ " diameter AL round bar stock in the bandsaw with a TA's help (if there isn't a piece < 30" already on the material rack (1))
3. Debur edges using file
4. Clamp workpiece in lathe chuck with 2" of material protruding from chuck jaws
 - a. **CAUTION: NEVER leave the chuck key in the chuck**
5. Install turning/facing tool onto tool post
 - a. Use the tool with a silver colored insert (not gold)
 - b. Ensure the tool is aligned vertically with the part centerline using the ruler or lathe gage
 - c. Check for proper relief angles ($\sim 5^\circ$) and adjust as necessary
6. Touch off and set zeros in X and Z directions
 - a. **CAUTION: any time you interact with anything on the left side of the machine (like the DRO), use your left hand; NEVER reach over the spindle**
7. Face end of workpiece and re-zero Z axis (~ 600 rpm)
 - a. Remove 0.020" of material using the automatic feed
 - b. After removing the material and before moving the cutting tool away from the part, re-zero the DRO using your left hand; although not specified as requiring a finished surface, precise measurements must be made from this surface, so it should be finished
8. Finish turn part OD
9. Cut chamfer (~ 600 rpm)
 - a. Use the tool with a silver colored insert (not black or gold)
 - b. Gently touch off on corner to be chamfered and zero the Z-axis
 - c. Move 0.030" along Z-axis
10. Remove chamfer tool
 - a. Turn machine off
 - b. Clean and inspect tool prior to putting it away
11. Center drill hole using tailstock (~ 600 rpm)
 - a. Drill until about half of the SMALL cylindrical portion of the center drill is in the part. Stop drilling if the center drill's chamfer begins to cut.
12. Drill hole thru with $\frac{1}{4}$ " drill to a depth between 0.568" and 0.630" (~ 600 rpm)
 - a. Use oil and peck drill with pecks equal to the tool radius
 - b. Zero the tailstock when the drill begins to cut at its full diameter

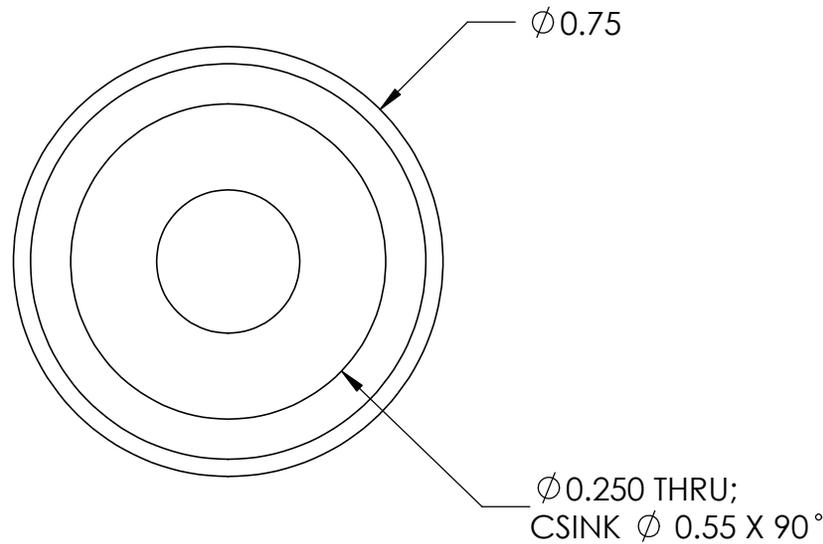
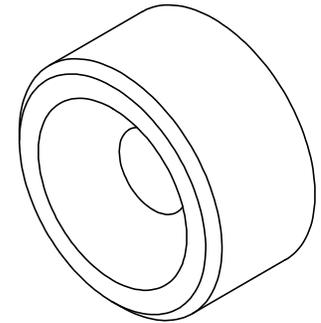
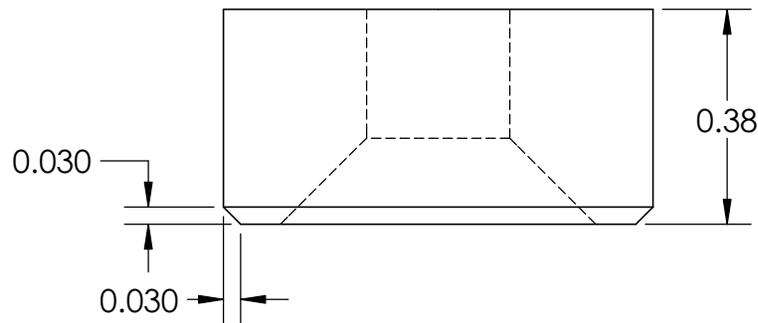
Turner's Cube Base Practice Part (cont)

13. Countersink to a diameter of 0.55" using the special 110° csink tool with the purple stripe (~200 rpm)
 - a. Use oil and peck
 - b. **CAUTION: turn the machine off prior to measuring part**
14. Ask TA to part-off workpiece (2)
15. Remove material from lathe chuck (*remember to be careful with the chuck key*)
16. Deburr holes using hand-held countersink tool
17. Clean up lathe
 - a. Always have a TA or instructor inspect your machine for cleanliness before leaving
 - b. **CAUTION: DO NOT wipe metal surfaces! Only wipe painted and plastic surfaces (the oil on the metal surfaces is essential for proper machine function)**

TA NOTES:

1 Material Selection: Use 3/4" AL rod from the material rack. Look for the piece which has been cut to roughly 30" for making the Turner's Cube Bases to minimize waste.

2 Parting Off: Since a flat base is required and the part is too small to effectively clamp in the lathe chuck jaws, the part should be parted-off on the lathe by a TA or Mike. If you have not been trained to part-off, ask Mike or another trained TA to perform the part-off for you. Begin the part-off, stop and file the back-side chamfer, and complete the part-off.



- NOTES:
 1. DIMS IN INCHES
 2. MAT'L: 6061-T6 ALUMINUM
 3. FINISH ALL SURFACES
 4. BREAK ALL EDGES
 5. QUANTITY: 1

TOLERANCE UNLESS NOTED				TITLE: Turners Cube Base		
OPERATION	PLACES IN DIMENSION			DRAWN	J. DERSCH	
	0.0	0.00	0.000			
MACHINING	± 0.060	± 0.030	± 0.005	DESIGNED	J. DERSCH	
CUT OFF (SAW, BURN, SHEAR)	± 0.1	± 0.060		SIZE	DWG. NO.	REV
WELDING	± 0.1	± 0.060		A	EML2322L-TCUBEB	A
ANGULAR DIMS	± 5	± 2	± 0.5	SCALE: 3:1		SHEET 1 OF 1