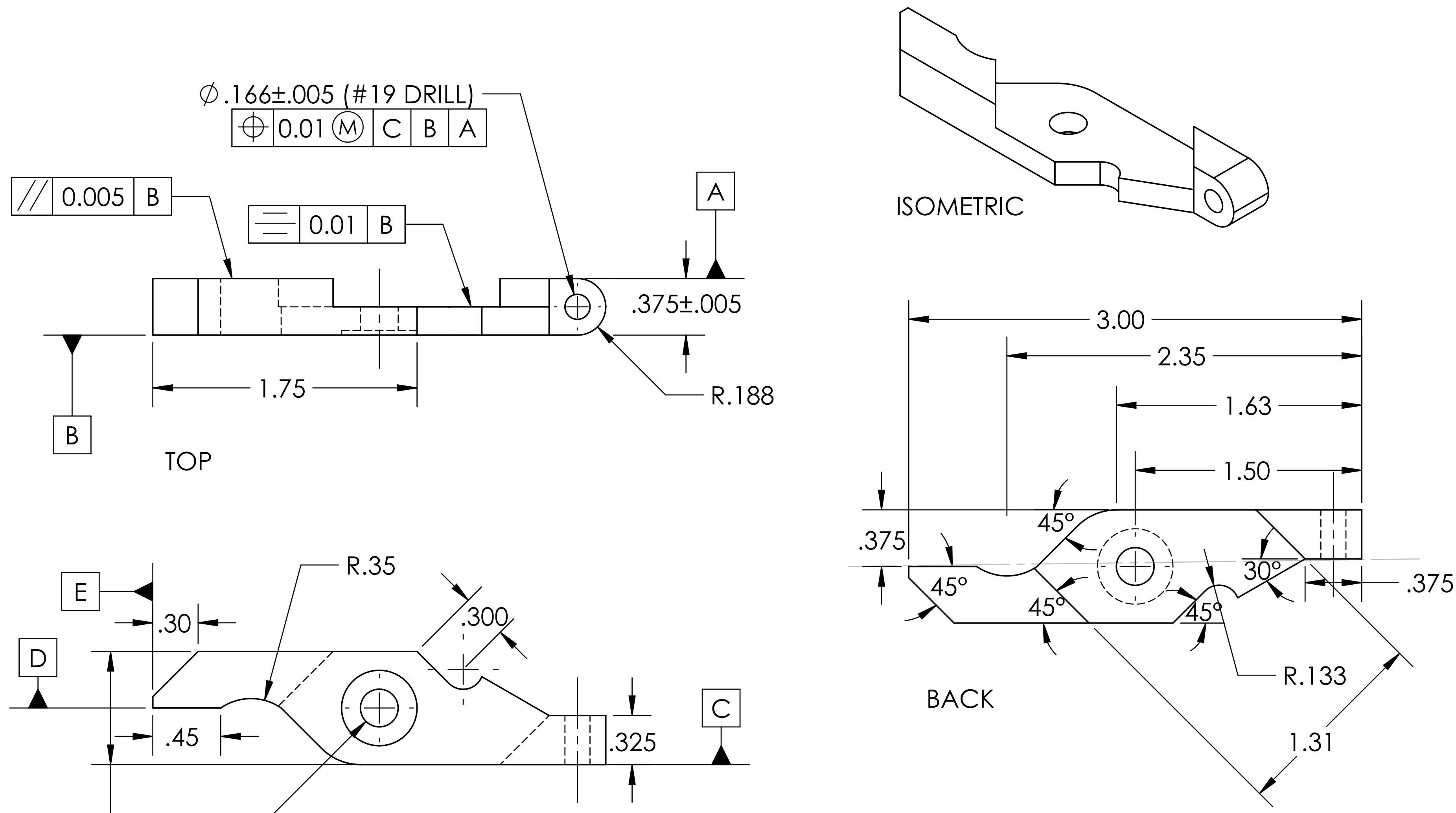
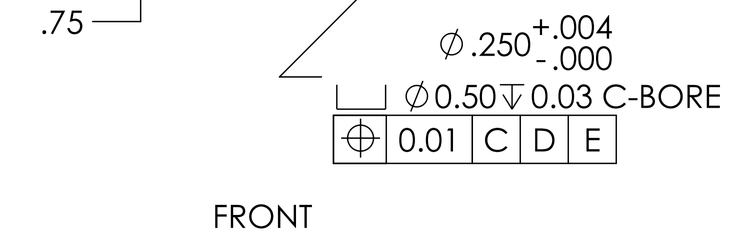




TACOMA

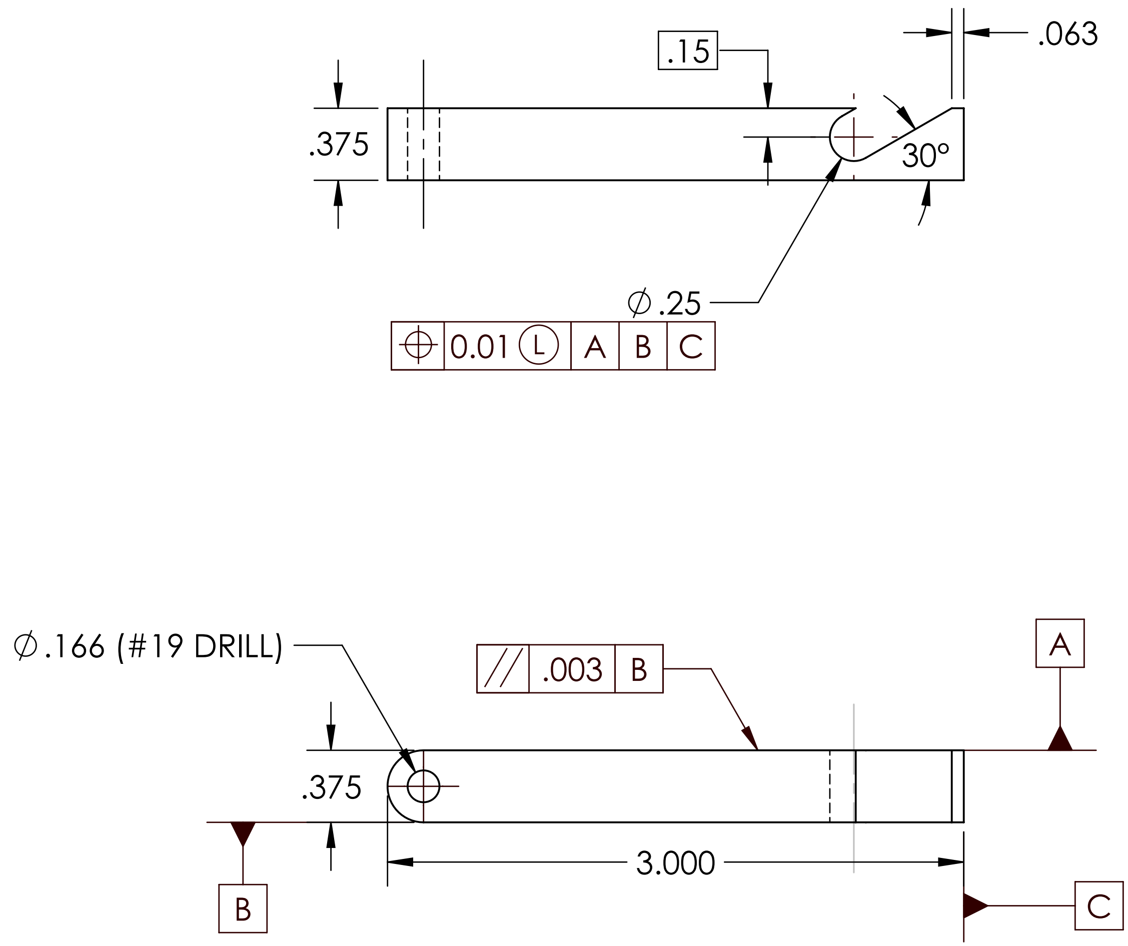
UNLESS OTHERWISE SPECIFIED:		INITS	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±1/64 ANGULAR MACH ±1 TWO PLACE DECIMAL ±.01 THREE PLACE DECIMAL ±.005	DRAWN	TJM	5/3/22
	CHECKED		
MATERIAL AISI A2 TOOL STEEL	COMMENTS: The exterior profile of the jaw must all be accurate to within .01".		
FINISH HEAT TREATED			

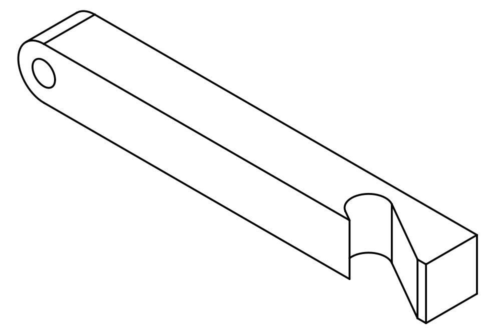
TME 345 MACHINING FUNDAMENTALS

TITLE:

Multi-tool

SIZE	DWG. NO.	REV
A	Jaw-3in	S5
SCALE: 1:1	WEIGHT: 0.10 lbs	SHEET 1 OF 3





UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ± 1/64
ANGULAR MACH ± 1
TWO PLACE DECIMAL ±0.01
THREE PLACE DECIMAL ±0.005

MATERIAL
AISI A2 TOOL STEEL

FINISH
HEAT TREATED

	INITS	DATE
DRAWN	TJM	5/3/22
CHECKED		

COMMENTS:

TME 345 MACHINING FUNDAMENTALS

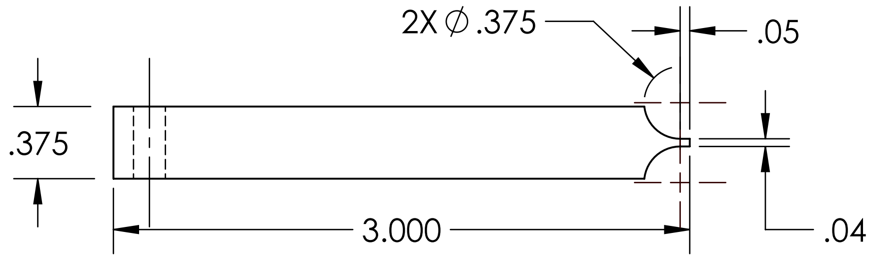
TITLE:

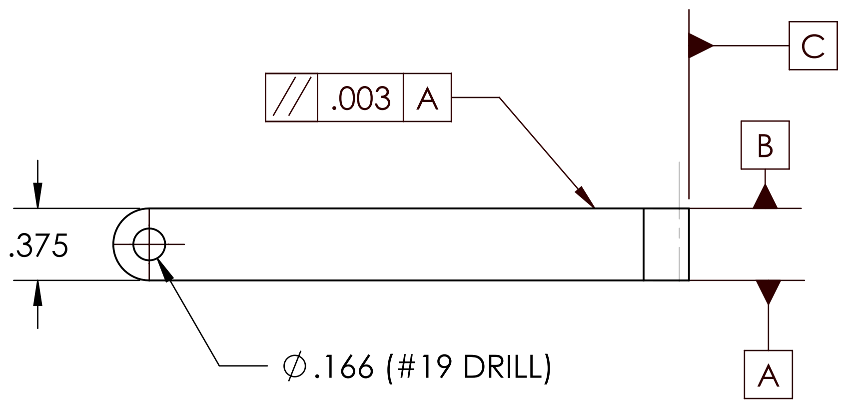
Multi-tool

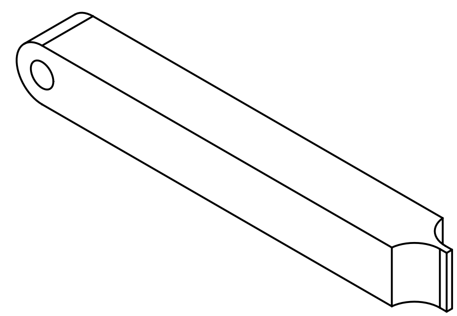
SIZE	DWG. NO.	REV
A	Bottle Opener arm	S5

SCALE: 1:1 WEIGHT: 0.10 lbs SHEET 2 OF 3

TACOMA







UNLESS OTHERWISE SPECIFIED:		INITS	DATE	TME 345 MACHINING FUNDAMENTALS
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± 1/64 ANGULAR MACH ± 1 TWO PLACE DECIMAL ± 0.01 THREE PLACE DECIMAL ± 0.005	DRAWN	TJM	5/3/22	TITLE:
	CHECKED			Multi-tool
MATERIAL AISI A2 TOOL STEEL	COMMENTS:			
FINISH HEAT TREATED				SIZE A · DWG. NO. Flat Head Arm · REV S5
				SCALE: 1:1 · WEIGHT: 0.11 lbs · SHEET 3 OF 3

TACOMA

Multi-tool and Plumb Bob Reflection **Tayber McMullen 6/7/22**
TME345 Dr. Matthew Ford UWT

Multi-tool

The manufacturing process of the multi-tool involved many types of features and processes to complete the features by subtractive methods. The multi-tool was composed of 3 parts and 3 connectors (such as a nut and screw). The bottle opener arm had to be cut squarely to 3 inches, have a 0.166" hole drilled into one end that would then would have a fillets applied to the out edge surrounding the hole. The bottle opener portion was cut out using a rounded (ball nose) drill bit at a specific diameter in the mill. For the screwdriver arm it was a little more complicated. The screwdriver arm required the same operation as the bottle opener except without the bottle opener cutout. At the opposite side of the drilled hole, the flat head of the screwdriver was made by two partial cuts on the mill using a (flat nose) bit into the side of the arm. The jaw was more unique than the arms. The outline of the jaw was made using the water jet cutter. The outline of the jaw was given to us to then add a hole for the arm and the hole to attach the jaws together. The hole where the jaws attach to each other is counter-bored so the screwhead would sit lower in the jaw body. The hole where the arms attach to the jaw were also fillets like the arms. To make the jaw teeth in-line with the other arm, both jaws where milled halfway so they slide easily to allow the jaw to close and open which I call the pocket of the jaw.

There were many challenges in creating the part; some challenges were really frustrating to deal with. The first challenge was actually the first or second hole that I drilled. I measure the edge using an edge finder. I did the math in my head (this was my first mistake). I had one number floating in my head but then lost it after subtracting 0.1", dividing by 2 and then keeping it for the x position on the mill. I gave up trying to memorize numbers and got my calculator to save the numbers for me. Looking back, I think a pencil or a sharpie would have been all that I needed to complete the feature without a calculator. The second hurdle which I endured was the milling out the pocket on the jaw. My first mill cut was too shallow (leaving extra material) and then I began on the opposite side milling it out. I milled the opposite side to its correct depth from the first milled portion. Instead of keeping the correct depth, I stepped the milling height by 4 thousands at a time to step up to try to cover up my mistake. This resulted in an uneven pocket surface which could have been corrected after completion of the pocket.

The most surprising part of the process was method by which the bottle opener slot was accomplished. From the beginning, I thought that the slot would have been achieved by the mill bit milling into arm from the side of a flat end mill cutter. I was surprise that we used and of the existence of a ball end mill bit which created the slot and the rounded edge in-line with the arm with multiple lateral passes diagonally from the top.

The most difficult tolerances to hold was the bottle opening slot, there was not easy way to quickly check to see if the hole slot hole was 0.15" from the face. The slot was drilled diagonally, I had not considered how deep to go using the dial indicator on the mill which makes it difficult to know how deep to mill into the part. I had not done the necessary measurements to first conclude how accurate the jig used was, what angle the jig was clamped into place was, and how deep to go knowing these specifications of the made drawings and setup.

If I were to manufacture this tool again, I would like a better way of creating the slot for the bottle opener arm. The ball nose drill bit which which was used in for the slot created an inconsistent face due to the vibration of the piece and the vibration of the bit. I would contend that the part should be drilled with a flat nose drill bit from the side to limit the vibration and have more consistent chip size. In theory and from my knowledge of machining, using this described method would result in a cleaner face within the bottle opener.

Taking this discussion to a larger scale, there would be many changes to how this part would be made. The use of water jet cutter with the assistance of CNC machines would result in highly accurate parts with consistency. The jaws would be water cut and then finished by a CNC machine. The arms would be cut from a steal bar accurately to and squarely to +3 inches and then the CNC machine will complete the arms with 1 or 0 flips depending on the CNC setup and abilities.

To be able to mass produce this multi-tool, I would like to explore how to determine the feed and speed which a CNC machine would use to complete operations. The resultant chip size, chip color and sound help the machinist to know what speed and feed that a CNC machine needs to operate. I believe that it may take many years or decades to find the right variables to perfectly machine a part while taking into account heat, drill bit life, surface finish quality, and machining speed.

Plumb Bob

The length of the plumb bob was not accurately done on the plumb bob because I did not utilize a dial gauge to find the proper amount of material to lose. I had extra material at the final build of the plumb bob. Another separate issue was rust that was building on the outside of the plumb bob. The rust developed because it was left in the humid trunk of my car. I would like to take some Scotch Bright to remove the rust when the plumb bob is eventually assembled. We were not able to fully assemble the plumb bob because we did not have the components to finish the plumb bob.

Tolerance Reflection | TME345 Dr. Matthew Ford UWT | Tayber McMullen 6/7/22

Multi-tool Unsatisfied Tolerances

Slot end Y location – Bottle Opener Arm

Use a more stationary jig and to be more careful in measurement. It is possible that the drill bit is not perfectly straight down. Making sure that the drill bit is properly secured in the chuck so that it makes a perfect square cut into the part.

Width Y – Jaw

The water jet cutter created these features. It could mean that the water cutter tip needs to be replaced, the water jet to be calibrated or that it was programmed incorrectly. If you would like to create a more accurate part, a CNC machine could accurately create the outer profile of the part with extreme precision that the water jet may not have. On the other hand, creating the part using a CNC machine could be more costly than using a CNC machine.

Plumb Bob Unsatisfied Tolerances

Total Length

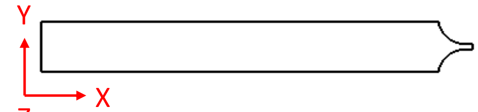
This could be satisfied more easily if the lathe had stops and jigs so that the part does not have to be repeatedly measured until it has satisfied the wanted cut distance. Secondly, a dial indicator could have been used when measuring the distance cut. When cutting the plumb bob to length, a dial indicator was not used and thus created a plumb bob which was out of tolerance.

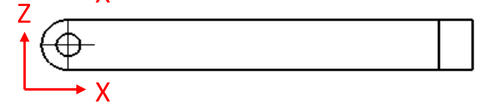
Length to taper

This distance is affected by the total length. If the total length was in tolerance, this would still most likely be out of tolerance by a few thousands of an inch. To make it closer to tolerance, we would have to measure the max cross-section size (approx 1.136”) and determine if that is the wanted size will create an accurate length to taper distance.

Screwdriver arm - Tayber McMullen

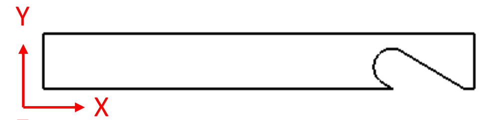
Screv	Description	Dimension	Tolerance	Tools used	Measured	In tolerance?	Notes
S1	Total length X	3.00	0.05	caliper	2.9945	TRUE	
S2	Width Y	0.375	0.005	digimetric micrometer	0.3750	TRUE	
S3	Width Z	0.375	0.005	digimetric micrometer	0.37545	TRUE	
S4	Hole diameter	0.166	0.005	gage pins	0.167	TRUE	
S5	Hole Z location	0.1875	0.005	height gage	0.1874	TRUE	
S6	Datum face flatness	0.000	0.002	Dial Indicator	0	TRUE	Datum varies less from end-to-end <0.001
S7	Parallelism	0.000	0.003	Dial Indicator	0.0005	TRUE	
S8	Blade width	0.040	0.005	digimetric micrometer	0.04120	TRUE	

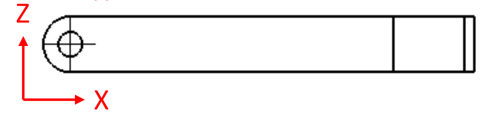




Bottle opener arm

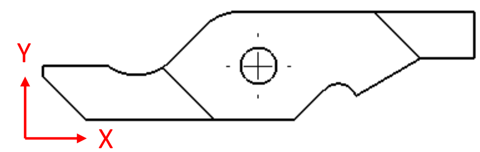
	Description	Dimension	Tolerance	Tools used			Notes
C1	Total length X	3.00	0.05	caliper	2.993	TRUE	
C2	Width Y	0.375	0.005	digimetric micrometer	0.3753	TRUE	
C3	Width Z	0.375	0.005	digimetric micrometer	0.3752	TRUE	
C4	Hole diameter	0.166	0.005	gage pin	0.166	TRUE	
C5	Hole Z location	0.188	0.005	height gage	0.1856	TRUE	averaged two measurements with from
							either face
C6	Datum face flatness	0.000	0.002	Dial Indicator	0	TRUE	Datum varies less from end-to-end <0.001
C7	Parallelism	0.000	0.003	Dial Indicator	0.001	TRUE	
C8	Slot end Y location	0.100	0.005	caliper	0.118	FALSE	

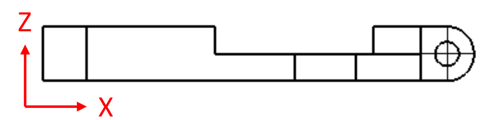




Jaw

	Description	Dimension	Tolerance	Tools used			Notes
J1	Total length X	3.00	0.05	caliper	2.9885	TRUE	
J2	Width Z	0.375	0.005	digimetric micrometer	0.38795	TRUE	
J3	Width Y	0.750	0.005	digimetric micrometer	0.74870	FALSE	
J4	.25 Hole diameter	0.250	0.05	gage pin	0.253	TRUE	Used two gage pins to measure hole \
J5	.25 Hole Y location	0.208	0.005	height gage	0.2035	TRUE	I wiggled .250 gage pin and averged it and
							then subtracted the radius of the gage pin
J6	.25 Hole X location	1.500	0.005	caliper	1.498	TRUE	measured like above
J7	Cutaway face symmetry	0.194	0.01	digimetric micrometer	0.1920	TRUE	





Plumb Bob - Tayber McMullen

	Description	Dimension	Tolerance	Tools used	Measured	In tolerance?	Notes
P1	Totel length	4.00	0.01	Caliper	4.020	FALSE	
P2	Length to taper	3.00	0.01	Caliper	3.031	FALSE	Accounted for cosine error by rough estimation
P3	Shoulder length	0.50	0.01	Caliper	0.492	TRUE	
P4	Shoulder diameter	0.89	0.01	Mircometer	0.8850	TRUE	
P5	Taper angle	30.00	0.05	Various	29.870	TRUE	I calculated using arctan function to find the angle of the tip
P6	Taper runout						Tooling not adequate to perform measurement
	Largest cross-section measurement	N/A	N/A	Caliper	1.136		