SERIES: METAL TRADES A

CONTEST: AUTOMATED MANUFACTURING TECH

Online Resumé Submission

Series Director: BRUCE BOISSELLE • (978) 373-4101 • bboisselle@whittier.tec.ma.us
Series Director Assistant: MARIAH WATTERSON • mwatterson@sersd.org
Competition: Blackstone - Facilities Garage Room 180 with Event Managers: Adam Martin and Justyn Constant

REQUIREMENTS AND SCOPE OF CONTEST

Advisors will be sent log-on information for the Learning Management System, which will be open on April 10. Contestants must submit an electronic copy of their resumé to the LMS by April 26, by 5:00pm.

Clothing Requirements: avoid a clothing penalty

Blue work pants, as shown	Safety shoes	Safety glasses with side shields or goggles
SkillsUSA Massachusetts T-Shirt, provided	NO jeans	NO cell phones or SmartWatches allowed

Safety: avoid a safety violation or being removed from the contest

NO loose/long hair (must be secured) NO loose clothing NO jewelry NO sneakers

Tool Requirements: Contestants must submit online a one-page type-written resume, failure to do so will result in a 50-point penalty

Provided by the Technical Committee:

Part(s) Design	Competition Notebook	Pencils	Material for Machining	
Provided by the Contestants:				
8GB Empty Flash Drive or Larger				
CNC Machining center with:	Machinist vise	Hold-downs and clamps	Tool holders	End mills
Two Computers, a third may be utilized	One Computer loaded with CAD software for CAD program One Computer loaded with software for CAM program (Must have an open full-sized PCI slot and Windows 98 or higher operating system) (This computer will be connected to the CNC machine)			
One 6" dial or digital vernier caliper	One Calculator	One pair of 2/4" or 1" parallels		
One soft-face hammer	One 6" or 12" steel rule	Licensed versions of the above CAD and CAM software		
One dial indicator, Dial indicator must have 3/8" or 1/2" holding shank to fit into tool holder supplied by the technical committee				

Purpose: To evaluate each contestant's preparation for employment in automated manufacturing and the team approach to problem solving work environment. To recognize outstanding students for excellence and professionalism in the field of automated manufacturing technology.

State Skills:

1. Teams must be composed of three members. Teams will demonstrate their ability to perform, exhibit, and compile skills and knowledge necessary from the following list of competencies determined by the technical committee.

2. The teams will be presented with dimensioned drawing(s) of a part(s) to prototype.

3. Each team will be issued a notebook. This will be a three-ring binder. Included in the binder will be all the necessary information and forms to complete the project. These forms will not be highly specific but will coach the teams. All binders, forms and drawings must be turned in to the judges at the end of the competition.

4. The competencies required for contestants to successfully compete are as follows:
   a. Performing Mathematical and Measurement Calculations
      1. Measure work piece to the nearest .001 inch
      2. Calculate CNC speed and feeds
      3. Calculate stock utilization and setup
      4. Calculate tolerances

b. Designing, Sketching, Planning Machine Work
   1. Transfer information from drawing to CAD drawing
   2. Create CAD file for manufacturing
   3. Begin manufacturing documentation process
   4. Process Plan
   5. Plot CAD file #1
   6. Export CAD file

c. Create Tool path (CAM file), CNC Code
   1. Create process plan (Job Plan)
   2. Read-in CAD export file
   3. Create tool path
   4. Verify tool path
   5. Create CNC Code
   6. Send CNC code to machine tool

d. Perform CNC Machining Functions
   1. Verify CNC file existence
   2. Verify tool path
   3. Setup part on mill
   4. Set all offsets and tooling
   5. Adjust to speeds and feeds as needed
   6. In-process quality assurance
   7. Perform tool changes
   8. Perform multiple machining operations in one setup
   9. Verify (TQM) process and part

e. Inspection of Part TQM process
   1. Verify part to standards
   2. Document process

Group Organizational Goal:

This is a group competition, and members may interact at will. The competition should run much like industry. The CAD operator will construct the part geometry, the CAM operator will generate the tool paths, and the CNC operator will do the setup and machine the part. When a team member has spare time, he or she will help others in the group. One person should not dominate a team by doing the CAD drawing, the CAM tool path, and running the CNC machine while using the other members simply as support. The contest is designed to promote creativity in organization of production responsibility. All group members are responsible for double-checking each other's work and quality control.

Special Note: Clarification of Rules

The scope of the contest states that the equipment supplied by the contestant will be two separate computers, one with CAD on it and one with CAM on it. SkillsUSA Massachusetts has decided that the computers that will be used do not have to remove any software to compete but will only be allowed to use one software program on each computer. IE one will be using a version of CAD and one will be using a version of CAM. At no time will contestants be allowed to use the CAD component of the CAM software. The Drafting student's ability to use his/her skills on CAD software is essential to the integrity of the contest and in the preparation of our students for the National level of competition. It is, however, important to allow the students the ability to create bounding boxes for the purpose of machinability only. This is an industry acceptable standard and will be put in place. This is the only CAD feature they will be allowed to use in their CAM software. Contestants will not be allowed to make any CAD Engineering changes to the parts in their CAM software. If you have any questions please contact the Series Director, using the contact information provided.

Observers: Observers will be allowed to view the students during the competition from the designated area only. Any infraction will result in contestant disqualification. Talking or gesturing by the observers may result in contestant disqualification. Observers will not be permitted to communicate with contestants in the holding/assembly area. Talking to judges will not be permitted. All communications are to be directed to the series director only and only at the end of the contest. Contestants are to stay until they are debriefed at the end. Any communication from observers will result in contestant disqualification. No prints or information will be allowed to leave with the student participants/school personnel. No videotaping of contests. (Still photography only)

National Standards and Competencies: See national technical standards.

Note: National technical standards are a benefit of professional membership. Advisors should log in to the national SkillsUSA site to access technical standards.

SERIES: METAL TRADES A

CONTEST: CNC 3-AXIS MILLING PROGRAMMER

(formerly CNC Milling)

Online Resumé Submission

Series Director: BRUCE BOISSELLE • (978) 373-4101 • bboisselle@whittier.tec.ma.us
Series Director Assistant: MARIAH WATTERSON • mwatterson@sersd.org
Competition: Blackstone - Machine Shop Room 130 with Event Manager: William Weir

REQUIREMENTS AND SCOPE OF CONTEST

Advisors will be sent log-on information for the Learning Management System, which will be open on April 10.
Contestants must submit an electronic copy of their resumé to the LMS by April 26, by 5:00pm.

Clothing Requirements: avoid a clothing penalty

Blue work pants, as shown	Safety shoes	Safety glasses with side shields or goggles
SkillsUSA Massachusetts T-Shirt, provided	NO jeans	NO cell phones or SmartWatches allowed

Safety: avoid a safety violation or being removed from the contest

NO loose/long hair (must be secured)	NO loose clothing	NO jewelry	NO sneakers

Tool Requirements: Contestants must submit online a one-page type-written resume, failure to do so will result in a 50-point penalty

Provided by the Technical Committee:

CNC Mill with proper holding devices	Workbench	Necessary hand tools and cutting tools
Necessary information and furnishings for judges and technical committees		

Provided by the Contestants:

6 inch caliper (digital or vernier)	0-1" micrometer	Non-programmable calculator
Machinery's Handbook (optional)	Pencils and paper	Deburring tools (files, Emory cloth, etc.)
8GB Empty Flash Drive or Larger	1- laptop computer with notepad or similar text editor program	

Purpose: To evaluate each contestant's preparation for employment in Computer Numeric Control machining. To recognize outstanding students for excellence and professionalism in the CNC machining field.

Scope of Contest:

Each contestant will receive a dimensioned drawing and material to CNC-machine a part. Participants are expected to write a CNC program, set up the machine and tool offsets and machine a part without the use of CAD/CAM software. Only the part will be evaluated, not the CNC program. Participants are given 15 minutes to study the task and ask questions before beginning. The competition may run 6-8 hours, depending on the project design.

Programs that do not run due to errors will receive no points; placement will be based on district scores.
Completed Parts will be inspected by judges and scored, any ties will be broken using district scores.

Competencies required are as follows:

1. Programming
   a. Write and verify CNC program without the use of CAM software (competitor has the opportunity to correct any program errors on the machine.)
   b. Display complete knowledge of DIN/ISO programming (G and M codes)
   c. Apply the correct use of cutter compensation (G41/G42)
   d. Adjust speeds and feeds as needed

2. Setup
   a. Setup machine and establish a zero reference point for machining the part
   b. Select and mount necessary tools from the provided set
   c. Establish tool offsets and enter them into the CNC machine control
   d. Enter any necessary tool corrections into the CNC machine control

3. Perform mathematical calculations
   a. Calculate CNC speeds and feeds
   b. Calculate programming coordinates from the drawing
   c. Calculate radius tangent points
4. Measuring
   a. Measure test part to the nearest 0.001”
5. Communication
   a. Read and interpret technical blue prints
   b. Understand all symbols on technical blue prints, such as geometric tolerances, surface-finish symbols, corner-break symbols, etc.

Test Project Scoring: The three evaluation criteria for the test part are:

1. Conformity to Print:
   a. Visual conformity and accuracy of part to drawing. (Look for shape and features of part)
   b. Edges broken
   c. Transition of surfaces
   d. Part is burr-free
   e. Damage to part (clamp marks, scratches)
2. Dimensions:
   This is an objective scoring. Scores will only be granted if dimension is in compliance with the print. The score for each dimension will either be full points or zero points.
3. Use of Material:
   Contestant will receive on piece of stock for the contest.

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National Standards and Competencies: See national technical standards.

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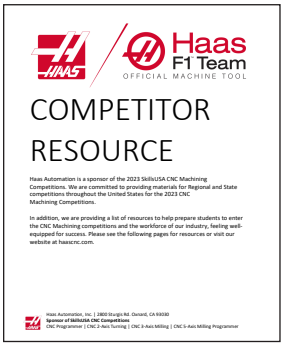
This competition evaluates each competitor’s ability to independently plan and program jobs for CNC (Computer Numerical Control) milling machines and provides instructions for operators to execute. Competitors program part features and generate NC code using CAM software, troubleshoot G-code programming errors, interpret prints (including geometric dimensioning and tolerancing or GD&T), measure/gauge parts, and demonstrate their theoretical knowledge of CNC milling machine configuration, set-up and operation.



COMPETITOR RESOURCE:

Haas Automation is a sponsor of the 2023 SkillsUSA CNC Machining Competitions. We are committed to providing materials for Regional and State competitions throughout the United States for the 2023 CNC Machining Competitions.

In addition, we are providing a list of resources to help prepare students to enter the CNC Machining competitions and the workforce of our industry, feeling well-equipped for success. Please see the following pages for resources or visit our website at haascnc.com.

About the Competition:

Regional and State-level CNC Milling Programmer, CNC 2-Axis Turning, CNN 3-Axis Milling, competitions will test two major skills areas (1) a CNC theory test and (2) CAM programming, with optional scoring for Process Control, and Oral Professional Development Assessment

CNC Theory Test: The CNC theory test is a set of multiple-choice questions closely related to the CNC subject area of focus for the competition, i.e., milling or turning.

Programming: The programming portion of the competition will provide competitors with access to a part drawing, STEP model, and Process Plan. It is the competitor's job to use the provided documents to complete a CAM program. If run, the program would produce a machined part that is in accordance with the Process Plan, collision-free, and accurate to the part drawing provided. The drawing will be complete with multiple views making it easy for competitors to visualize the part and understand its geometry. The Process Plan will provide setup instructions, a sequence of operations, and tool data. Contestant numbers must be used as the name for the CAM file. If this step is missed, the competitor will receive 0 points. Remember, save early, save often.

Competitors will be provided with project documents mentioned above on the day of their competition, but **competitors must provide the following items to compete successfully.**

- (Required) Laptop or PC with access to CAM software (Mastercam or Fusion360)
- (Required) Pen or pencil for notes or written calculations
- (Optional) Basic calculator

Recommended Competitor Preparation

Set yourself up for success by committing to continuous learning. Haas Automation, and other supporting partners, offer an array of opportunities for everyone to learn about the principles of CNC machining. Get ahead by preparing yourself as a competitor before and after competitions.

Haas Certification Program

These online courses are designed to provide the basic knowledge necessary to get started as a CNC machine operator or CNC machinist. They introduce basic CNC machine operation, proper machine safety, and fundamental machining processes. For more information and to sign-up for the free online courses, visit: https://www.learn.haascnc.com

Haas Programming Workbooks

These programming workbooks provide the basic principles to program Haas Mills and Haas Lathes. Numerous exercises throughout the workbook enable users to build their skills at their own pace. Answer Books are also available. To download, visit the Haas Learning Resources webpage: https://www.haascnc.com/myhaas/Haas_Learning_Resources.htm

Haas Video Library

The Haas Video Library gives you access to thousands of videos recorded specifically to help Haas CNC users everywhere to grow their skills and understanding of CNC machining to maximize their abilities. Access videos directly from the Haas Video Library via the Haas YouTube channel or using the Quick Picklist of the Haas Learning Resources page, which organizes a handful of entry- to advanced-level videos to help get you started. For the complete Video Library, visit: https://www.haascnc.com/video.html Or, for the shortened Quick Picklist, visit: https://www.haascnc.com/myhaas/Haas_Learning_Resources.html

CAM Programming Training and Software

Partners Mastercam and Autodesk Fusion360 provide access to software and video training programs. Please visit the links below for information on accessing software and training resources.

Mastercam Learning Content: https://university.mastercam.com/

Mastercam Software Access for SkillsUSA: https://www.mastercam.com/skillsusa/

Contact Email: education@mastercam.com

Autodesk Fusion360 Training Courses: https://help.autodesk.com/view/fusion360/ENU/courses/#manufacturing-milling-turning-and-inspection

Autodesk Fusion360 Software Access: https://damassets.autodesk.net/content/dam/autodesk/www/fusion-360/Fusion%20Single%20Install%20Instructions.pdf

Autodesk Fusion360 Webinars:

One-Hour Webinar

Educators will get a high-level walkthrough of Autodesk, specifically focusing on our integrated, cloud-based Fusion 360 CAD/CAM software. Topics include: how to download Fusion 360 for free, how to assign students licenses, and how to build a class.

Two-Hour Hands-On Webinar

Educators will learn the basics of Fusion 360 by walking through an introductory, real-world, classroom-ready project. Topics include 2D sketching, 3D extrusions, creating assemblies, and exporting 3D models for manufacturing.

Visit https://www.autodesk.com/campaigns/education/webinar-series to register for one of our free Fusion 360 webinars.

Autodesk Fusion360 Contact Email: amy.shapiro@autodesk.com

Decimal Equivalent Chart .0059 – .0980

Decimal Equiv.	Drill Size	mm	Tap Sizes	Decimal Equiv.	Drill Size	mm	Tap Sizes
.0059	97	0.150		.0320	67	0.813	
.0063	96	0.160		.0330	66	0.838	
.0067	95	0.170		.0350	65	0.889	
.0071	94	0.180		.0360	64	0.914	
.0075	93	0.191		.0370	63	0.940	
.0079	92	0.201		.0380	62	0.965	
.0083	91	0.211		.0390	61	0.991	
.0087	90	0.221		.0400	60	1.016	
.0091	89	0.231		.0410	59	1.041	
.0095	88	0.241		.0420	58	1.067	
.0100	87	0.254		.0430	57	1.092	
.0105	86	0.267		.0465	56	1.181	
.0110	85	0.279		.0469	3/64	1.191	#0-80
.0115	84	0.292		.0520	55	1.321	
.0120	83	0.305		.0550	54	1.397	
.0125	82	0.318		.0595	53	1.511	#1-64 · #1-72
.0130	81	0.330		.0625	1/16	1.588	
.0135	80	0.343		.0635	52	1.613	
.0145	79	0.368		.0670	51	1.702	
.0156	1/64	0.397		.0700	50	1.778	#2-56 · #2-64
.0160	78	0.406		.0730	49	1.854	
.0180	77	0.457		.0760	48	1.930	
.0200	76	0.508		.0781	5/64	1.984	
.0210	75	0.533		.0785	47	1.994	#3-48
.0225	74	0.572		.0810	46	2.057	
.0240	73	0.610		.0820	45	2.083	#3-56
.0250	72	0.635		.0860	44	2.184	
.0260	71	0.660		.0890	43	2.261	#4-40
.0280	70	0.711		.0935	42	2.375	#4-48
.0292	69	0.742		.0938	3/32	2.381	
.0310	68	0.787		.0960	41	2.438	
.0313	1/32	0.794		.0980	40	2.489	

Tap drill sizes above based on approximately 75% full thread
Tap # Sizes #0 = .060 #1 = .073 #2 = .086 #3 = .099 #4 = .112
Tap # x .013 + .060 = Thread # OD

Decimal Equivalent Chart .0995 – .2969

Decimal Equiv.	Drill Size	mm	Tap Sizes	Decimal Equiv.	Drill Size	mm	Tap Sizes
.0995	39	2.527		.1875	3/16	4.763	#12-32
.1015	38	2.578	#5-40	.1890	12	4.801	
.1040	37	2.642	#5-44	.1910	11	4.851	
.1065	36	2.705	#6-32	.1935	10	4.915	
.1094	7/64	2.778		.1960	9	4.978	
.1100	35	2.794		.1990	8	5.055	
.1110	34	2.819		.2010	7	5.105	1/4-20
.1130	33	2.870	#6-40	.2031	13/64	5.159	
.1160	32	2.946		.2040	6	5.182	
.1200	31	3.048		.2055	5	5.220	
.1250	1/8	3.175		.2090	4	5.309	
.1285	30	3.264		.2130	3	5.410	1/4-28
.1360	29	3.454	#8-32 · #8-36	.2188	7/32	5.556	1/4-32
.1405	28	3.569		.2210	2	5.613	
.1406	9/64	3.572		.2280	1	5.791	
.1440	27	3.658		.2340	A	5.944	
.1470	26	3.734		.2344	15/64	5.953	
.1495	25	3.797	#10-24	.2380	B	6.045	
.1520	24	3.861		.2420	C	6.147	
.1540	23	3.912		.2460	D	6.248	
.1563	5/32	3.969		.2500	1/4&E	6.350	
.1570	22	3.988		.2570	F	6.528	5/16-18
.1590	21	4.039	#10-32	.2610	G	6.629	
.1610	20	4.089		.2656	17/64	6.747	
.1660	19	4.216		.2660	H	6.756	
.1695	18	4.305		.2720	I	6.909	5/16-24
.1719	11/64	4.366		.2770	J	7.036	
.1730	17	4.394		.2810	K	7.137	
.1770	16	4.496	#12-24	.2813	9/32	7.144	5/16-32
.1800	15	4.572		.2900	L	7.366	
.1820	14	4.623	#12-28	.2950	M	7.493	
.1850	13	4.699		.2969	19/64	7.541	

Tap drill sizes above based on approximately 75% full thread
Tap # Sizes #5 = .125 #6 = .138 #8 = .164 #10 = .190 #12 = .216
Tap # x .013 + .060 = Thread # OD

Decimal Equivalent Chart .3020 – 1.000

Decimal Equiv.	Drill Size	mm	Tap Sizes	Decimal Equiv.	Drill Size	mm	Tap Sizes
.3020	N	7.671		.5625	9/16	14.288	5/8-18
.3125	5/16	7.938	3/8-16	.5781	37/64	14.684	5/8-24
.3160	O	8.026		.5938	19/32	15.081	
.3230	P	8.204		.6094	39/64	15.478	11/16-12
.3281	21/64	8.334		.6250	5/8	15.875	
.3320	Q	8.433	3/8-24	.6406	41/64	16.272	11/16-20 · 11/16-24
.3390	R	8.611		.6563	21/32	16.669	3/4-10
.3438	11/32	8.731	3/8-32	.6719	43/64	17.066	
.3480	S	8.839		.6875	11/16	17.462	3/4-16
.3580	T	9.093		.7031	45/64	17.859	3/4-20
.3594	23/64	9.128		.7188	23/32	18.256	
.3680	U	9.347	7/16-14	.7344	47/64	18.653	13/16-12
.3750	3/8	9.525		.7500	3/4	19.050	13/16-16
.3770	V	9.576		.7656	49/64	19.447	13/16-20 · 7/8-9
.3860	W	9.804		.7813	25/32	19.844	
.3906	25/64	9.922	7/16-20	.7969	51/64	20.241	7/8-14
.3970	X	10.084		.8125	13/16	20.637	
.4040	Y	10.262	7/16-28	.8281	53/64	21.034	7/8-20
.4063	13/32	10.319		.8438	27/32	21.431	
.4130	Z	10.490		.8594	55/64	21.828	15/16-12
.4219	27/64	10.716	1/2-13	.8750	7/8	22.225	15/16-16 · 1.0-8
.4375	7/16	11.113		.8906	57/64	22.622	15/16-20
.4531	29/64	11.509	1/2-20	.9063	29/32	23.019	
.4688	15/32	11.906	1/2-28	.9219	59/64	23.416	1.0-12
.4844	31/64	12.303	9/16-12	.9375	15/16	23.813	
.5000	1/2	12.700	9/16-18	.9531	61/64	24.209	1.0-20
.5156	33/64	13.097	9/16-24	.9688	31/32	24.606	
.5313	17/32	13.494	5/8-11	.9844	63/64	25.003	
.5469	35/64	13.891		1.000	1	25.400	

Tap drill sizes above based on approximately 75% full thread
A decimal equivalent chart can be displayed on a Haas control by pressing the HELP/CALC button, and then selecting the Drill Table tab. Use the Jog handle or cursor keys to scroll through the chart.

Mill and Lathe Formulas

Cutting Speed (surface feet/min.)
SFM = 0.262 x DIA x RPM

Revolutions Per Minute
RPM = 3.82 x SFM ÷ DIA

Feed Rate (in/min.)
IPM = FPT x T x RPM

Feed Per Revolution
FPR = IPM ÷ RPM

Feed Per Tooth (in)
FPT = IPM ÷ (RPM x T)

Metal Removal Rate
MRR = W x d x F

Converting IPR to IPM
IPM = IPR x RPM

Converting IPM to IPR
IPR = IPM ÷ RPM

Converting SFM to SMPM
SMPM = SFM x .3048

Converting IPR to MMPR
MMPR = IPR x 25.40

Distance over Time (in minutes)
L = IPM x TCm

Time Cutting over Distance (Mill) (minutes)
TCm = L ÷ IPM

Time Cutting over Distance (Mill) (seconds)
TCs = L ÷ IPM x 60

INCH METRIC CONVERSION

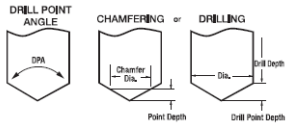
mm x 0.03937 = in.	in. x 25.4 = mm
m x 39.37 = in.	in. x 0.0254 = m
m x 3.2808 = ft	ft x 0.3048 = m
m x 1.0936 = yd	yd x 0.9144 = m
km x 0.621 = mi	mi x 1.6093 = km
Celsius to Fahrenheit (°C x 1.8) + 32 = °F	Fahrenheit to Celsius (°F - 32) ÷ 1.8 = °C

Drill Point Depth & Countersink Diameter Formulas

To calculate drill tip depth for a chamfer diameter, or drill point depth for a required drilling depth:

Drill Point Angle (DPA)	Factor
60°	0.866 x Dia. = Point Depth
82°	0.575 x Dia. = Point Depth
90°	0.500 x Dia. = Point Depth
118°	0.300 x Dia. = Point Depth
120°	0.288 x Dia. = Point Depth
135°	0.207 x Dia. = Point Depth

Example: To calculate for a 118-degree drill tip depth, multiply the dia. by 0.3
i.e., 0.250 drill diameter x .3 = 0.075 drill tip depth



SERIES: METAL TRADES A

CONTEST: CNC PROGRAMMER (formerly CNC Technician)

Online Resumé Submission

Series Director: BRUCE BOISSELLE • (978) 373-4101 • bboisselle@whittier.tec.ma.us
Series Director Assistant: MARIAH WATTERSON • mwatterson@sersd.org
Competition: Blackstone - Machine Shop Room 130 with Event Manager: Michael Pasciuto

REQUIREMENTS AND SCOPE OF CONTEST

Advisors will be sent log-on information for the Learning Management System, which will be open on April 10. Contestants must submit an electronic copy of their resumé to the LMS by April 26, by 5:00pm.

Clothing Requirements: avoid a clothing penalty

Blue work pants, as shown	Leather work boots	Safety glasses with side shields or goggles
SkillsUSA Massachusetts T-Shirt, provided	NO jeans	NO cell phones or SmartWatches allowed

Safety: avoid a safety violation or being removed from the contest

NO loose/long hair (must be secured) | NO loose clothing | NO jewelry | NO sneakers

Tool Requirements: Contestants must submit online a one-page type-written resume, failure to do so will result in a 50-point penalty

Supplied by the Technical Committee:

Haas Programmable Controller	CNC Lathe & CNC Mill
Inspection equipment. (Inspection Station)	All tooling for program execution on CNC Lathe and Mill
Deburring and finishing tools (Finishing station)	

Supplied by the Contestant:

Two Sharpened Pencils	Scratch paper	Machinist Handbook
Trigonometry Book	Calculator	8GB Empty Flash Drive or Larger

State Skills:

The purpose of this contest is to evaluate each contestant's preparation for employment in Computer Numeric Control Turning and Milling. In addition, recognize outstanding students for excellence and professionalism. This contest will assess the ability to write and execute CNC turning and milling programs, interpret prints (including GDT), and measure/gage parts. Participants will also demonstrate theoretical knowledge of CNC machine configuration, setup and operations.

Contestants will be judged on the following areas:

MILLING: Programing using HAAS Simulators, Program execution on HAAS CNC Mill. (Parts are judged as a finished Product)
TURNING: Programming and program execution on HAAS CNC Lathe (Parts are judged as a finished Product)
CNC Theory
G & M Codes
Blueprint Reading
Communications

Use of calculators, Machinery Handbook, Trig books are allowed at worksite. All miscellaneous worksheets, note cards, etc. that are not otherwise obtainable by all contestants are not allowed. Contest site will provide all equipment and tooling for tasks required. Contestants will need to maintain a safe and professional working environment. Care and usage of tooling, inspection equipment, and overall workplace etiquette expected of a professional will be considered in final score.

CNC Technician Skills:

Work Station 1A: CNC Machining - This station will allow competitors to program a HAAS CNC Turning center from prints, load and set tools and execute their program.

Work Station 1B: CNC Machining - This station will allow competitors to program a HAAS CNC Milling Center from prints using a HAAS Simulator. Programs will then be loaded in to a HAAS CNC Milling Center to execute their program.

Work Station 2: CNC Machining - Setup procedures- This station will allow a competitor to review a print/ program and pre-machined part. Competitor will properly mount the finished piece into the (HAAS) CNC Milling Center and locate a given datum point. No actual machining operations will take place at this station.

Workstation 3: Measuring and Gauging - This session is performance based; competitors will physically measure and record actual parts through instructions and print specifications.

Workstation 4: Print Reading and GDT - This station will allow competitors to interpret provided drawings and dimensioning/toleranceing.

These are subject to change slightly without losing main scope or ideas. There will be additional more timed workstations which will encompass simple tooling identification, program reading (identification of line by line code), and interviewing & employability assessments.

Observers: Observers will be allowed to view the students during the competition from the designated area only. Any infraction will result in contestant disqualification. Talking or gesturing by the observers may result in contestant disqualification. Observers will not be permitted to communicate with contestants in the holding/assembly area. Talking to judges will not be permitted. All communications are to be directed to the series director only and only at the end of the contest. Contestants are to stay until they are debriefed at the end. Any communication from observers will result in contestant disqualification. No prints or information will be allowed to leave with the student participants/school personnel. No videotaping of contests. (Still photography only)

National Standards and Competencies: See national technical standards.

Note: National technical standards are a benefit of professional membership. Advisors should log in to the national SkillsUSA site to access technical standards.

This competition evaluates each competitor's ability to independently plan and program jobs for 2-Axis CNC (Computer Numerical Control) turning centers and 3-Axis CNC milling machines and provides instructions for operators to execute. Competitors program part features and generate NC code using CAM software, troubleshoot G-code programming errors, interpret prints (including geometric dimensioning and tolerancing or GD&T), measure/gauge parts, and demonstrate their theoretical knowledge of CNC turning center and milling machine configuration, set-up and operation.

COMPETITOR RESOURCE:

Haas Automation is a sponsor of the 2023 SkillsUSA CNC Machining Competitions. We are committed to providing materials for Regional and State competitions throughout the United States for the 2023 CNC Machining Competitions.

In addition, we are providing a list of resources to help prepare students to enter the CNC Machining competitions and the workforce of our industry, feeling well-equipped for success. Please see the following pages for resources or visit our website at haascnc.com.

About the Competition:

Regional and State-level CNC Milling Programmer, CNC 2-Axis Turning, CNN 3-Axis Milling, competitions will test two major skills areas (1) a CNC theory test and (2) CAM programming, with optional scoring for Process Control, and Oral Professional Development Assessment

CNC Theory Test: The CNC theory test is a set of multiple-choice questions closely related to the CNC subject area of focus for the competition, i.e., milling or turning.

Programming: The programming portion of the competition will provide competitors with access to a part drawing, STEP model, and Process Plan. It is the competitor's job to use the provided documents to complete a CAM program. If run, the program would produce a machined part that is in accordance with the Process Plan, collision-free, and accurate to the part drawing provided. The drawing will be complete with multiple views making it easy for competitors to visualize the part and understand its geometry. The Process Plan will provide setup instructions, a sequence of operations, and tool data. Contestant numbers must be used as the name for the CAM file. If this step is missed, the competitor will receive 0 points. Remember, save early, save often.

Competitors will be provided with project documents mentioned above on the day of their competition, but **competitors must provide the following items to compete successfully.**

- (Required) Laptop or PC with access to CAM software (Mastercam or Fusion360)
- (Required) Pen or pencil for notes or written calculations
- (Optional) Basic calculator

Recommended Competitor Preparation

Set yourself up for success by committing to continuous learning. Haas Automation, and other supporting partners, offer an array of opportunities for everyone to learn about the principles of CNC machining. Get ahead by preparing yourself as a competitor before and after competitions.

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CAM Programming Training and Software

Partners Mastercam and Autodesk Fusion360 provide access to software and video training programs. Please visit the links below for information on accessing software and training resources.

Mastercam Learning Content: https://university.mastercam.com/

Mastercam Software Access for SkillsUSA: https://www.mastercam.com/skillsusa/

Contact Email: education@mastercam.com

Autodesk Fusion360 Training Courses: https://help.autodesk.com/view/fusion360/ENU/courses/#manufacturing-milling-turning-and-inspection

Autodesk Fusion360 Software Access: https://damassets.autodesk.net/content/dam/autodesk/www/fusion-360/Fusion%20Single%20Install%20Instructions.pdf

Autodesk Fusion360 Webinars:

One-Hour Webinar

Educators will get a high-level walkthrough of Autodesk, specifically focusing on our integrated, cloud-based Fusion 360 CAD/CAM software. Topics include: how to download Fusion 360 for free, how to assign students licenses, and how to build a class.

Two-Hour Hands-On Webinar

Educators will learn the basics of Fusion 360 by walking through an introductory, real-world, classroom-ready project. Topics include 2D sketching, 3D extrusions, creating assemblies, and exporting 3D models for manufacturing.

Visit https://www.autodesk.com/campaigns/education/webinar-series to register for one of our free Fusion 360 webinars.

Autodesk Fusion360 Contact Email: amy.shapiro@autodesk.com

Decimal Equivalent Chart .0059 – .0980

Decimal Equiv.	Drill Size	mm	Tap Sizes	Decimal Equiv.	Drill Size	mm	Tap Sizes
.0059	97	0.150		.0320	67	0.813	
.0063	96	0.160		.0330	66	0.838	
.0067	95	0.170		.0350	65	0.889	
.0071	94	0.180		.0360	64	0.914	
.0075	93	0.191		.0370	63	0.940	
.0079	92	0.201		.0380	62	0.965	
.0083	91	0.211		.0390	61	0.991	
.0087	90	0.221		.0400	60	1.016	
.0091	89	0.231		.0410	59	1.041	
.0095	88	0.241		.0420	58	1.067	
.0100	87	0.254		.0430	57	1.092	
.0105	86	0.267		.0465	56	1.181	
.0110	85	0.279		.0469	3/64	1.191	#0-80
.0115	84	0.292		.0520	55	1.321	
.0120	83	0.305		.0550	54	1.397	
.0125	82	0.318		.0595	53	1.511	#1-64 - #1-72
.0130	81	0.330		.0625	1/16	1.588	
.0135	80	0.343		.0635	52	1.613	
.0145	79	0.368		.0670	51	1.702	
.0156	1/64	0.397		.0700	50	1.778	#2-56 - #2-64
.0160	78	0.406		.0730	49	1.854	
.0180	77	0.457		.0760	48	1.930	
.0200	76	0.508		.0781	5/64	1.984	
.0210	75	0.533		.0785	47	1.994	#3-48
.0225	74	0.572		.0810	46	2.057	
.0240	73	0.610		.0820	45	2.083	#3-56
.0250	72	0.635		.0860	44	2.184	
.0260	71	0.660		.0890	43	2.261	#4-40
.0280	70	0.711		.0935	42	2.375	#4-48
.0292	69	0.742		.0938	3/32	2.381	
.0310	68	0.787		.0960	41	2.438	
.0313	1/32	0.794		.0980	40	2.489	

Tap drill sizes above based on approximately 75% full thread
Tap # Sizes #0 = .060 #1 = .073 #2 = .086 #3 = .099 #4 = .112
Tap # x .013 + .060 = Thread # OD

Decimal Equivalent Chart .0995 – .2969

Decimal Equiv.	Drill Size	mm	Tap Sizes	Decimal Equiv.	Drill Size	mm	Tap Sizes
.0995	39	2.527		.1875	3/16	4.763	#12-32
.1015	38	2.578	#5-40	.1890	12	4.801	
.1040	37	2.642	#5-44	.1910	11	4.851	
.1065	36	2.705	#6-32	.1935	10	4.915	
.1094	7/64	2.778		.1960	9	4.978	
.1100	35	2.794		.1990	8	5.055	
.1110	34	2.819		.2010	7	5.105	1/4-20
.1130	33	2.870	#6-40	.2031	13/64	5.159	
.1160	32	2.946		.2040	6	5.182	
.1200	31	3.048		.2055	5	5.220	
.1250	1/8	3.175		.2090	4	5.309	
.1285	30	3.264		.2130	3	5.410	1/4-28
.1360	29	3.454	#8-32 - #8-36	.2188	7/32	5.556	1/4-32
.1405	28	3.569		.2210	2	5.613	
.1406	9/64	3.572		.2280	1	5.791	
.1440	27	3.658		.2340	A	5.944	
.1470	26	3.734		.2344	15/64	5.953	
.1495	25	3.797	#10-24	.2380	B	6.045	
.1520	24	3.861		.2420	C	6.147	
.1540	23	3.912		.2460	D	6.248	
.1563	5/32	3.969		.2500	1/4&E	6.350	
.1570	22	3.988		.2570	F	6.528	5/16-18
.1590	21	4.039	#10-32	.2610	G	6.629	
.1610	20	4.089		.2656	17/64	6.747	
.1660	19	4.216		.2660	H	6.756	
.1695	18	4.305		.2720	I	6.909	5/16-24
.1719	11/64	4.366		.2770	J	7.036	
.1730	17	4.394		.2810	K	7.137	
.1770	16	4.496	#12-24	.2813	9/32	7.144	5/16-32
.1800	15	4.572		.2900	L	7.366	
.1820	14	4.623	#12-28	.2950	M	7.493	
.1850	13	4.699		.2969	19/64	7.541	

Tap drill sizes above based on approximately 75% full thread
Tap # Sizes #5 = .125 #6 = .138 #8 = .164 #10 = .190 #12 = .216
Tap # x .013 + .060 = Thread # OD

Decimal Equivalent Chart .3020 – 1.000

Decimal Equiv.	Drill Size	mm	Tap Sizes	Decimal Equiv.	Drill Size	mm	Tap Sizes
.3020	N	7.671		.5625	9/16	14.288	5/8-18
.3125	5/16	7.938	3/8-16	.5781	37/64	14.684	5/8-24
.3160	O	8.026		.5938	19/32	15.081	
.3230	P	8.204		.6094	39/64	15.478	11/16-12
.3281	21/64	8.334		.6250	5/8	15.875	
.3320	Q	8.433	3/8-24	.6406	41/64	16.272	11/16-20 - 11/16-24
.3390	R	8.611		.6563	21/32	16.669	3/4-10
.3438	11/32	8.731	3/8-32	.6719	43/64	17.066	
.3480	S	8.839		.6875	11/16	17.462	3/4-16
.3580	T	9.093		.7031	45/64	17.859	3/4-20
.3594	23/64	9.128		.7188	23/32	18.256	
.3680	U	9.347	7/16-14	.7344	47/64	18.653	13/16-12
.3750	3/8	9.525		.7500	3/4	19.050	13/16-16
.3770	V	9.576		.7656	49/64	19.447	13/16-20 - 7/8-9
.3860	W	9.804		.7813	25/32	19.844	
.3906	25/64	9.922	7/16-20	.7969	51/64	20.241	7/8-14
.3970	X	10.084		.8125	13/16	20.637	
.4040	Y	10.262	7/16-28	.8281	53/64	21.034	7/8-20
.4063	13/32	10.319		.8438	27/32	21.431	
.4130	Z	10.490		.8594	55/64	21.828	15/16-12
.4219	27/64	10.716	1/2-13	.8750	7/8	22.225	15/16-16 - 1.0-8
.4375	7/16	11.113		.8906	57/64	22.622	15/16-20
.4531	29/64	11.509	1/2-20	.9063	29/32	23.019	
.4688	15/32	11.906	1/2-28	.9219	59/64	23.416	1.0-12
.4844	31/64	12.303	9/16-12	.9375	15/16	23.813	
.5000	1/2	12.700	9/16-18	.9531	61/64	24.209	1.0-20
.5156	33/64	13.097	9/16-24	.9688	31/32	24.606	
.5313	17/32	13.494	5/8-11	.9844	63/64	25.003	
.5469	35/64	13.891		1.000	1	25.400	

Tap drill sizes above based on approximately 75% full thread
A decimal equivalent chart can be displayed on a Haas control by pressing the HELP/CALC button, and then selecting the Drill Table tab. Use the jog handle or cursor keys to scroll through the chart.

Mill and Lathe Formulas

Cutting Speed (surface feet/min.)
SFM = 0.262 x DIA x RPM

Revolutions Per Minute
RPM = 3.82 x SFM ÷ DIA

Feed Rate (in/min.)
IPM = FPT x T x RPM

Feed Per Revolution
FPR = IPM ÷ RPM

Feed Per Tooth (in)
FPT = IPM ÷ (RPM x T)

Metal Removal Rate
MRR = W x d x F

Converting IPR to IPM
IPM = IPR x RPM

Converting IPM to IPR
IPR = IPM ÷ RPM

Converting SFM to SMPM
SMPM = SFM x .3048

Converting IPR to MMPR
MMPR = IPR x 25.40

Distance over Time (in minutes)
L = IPM x TCm

Time Cutting over Distance (Mill) (minutes)
TCm = L ÷ IPM

Time Cutting over Distance (Mill) (seconds)
TCs = L ÷ IPM x 60

INCH METRIC CONVERSION

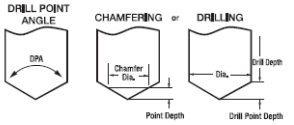
mm x 0.03937 = in.	in. x 25.4 = mm
m x 39.37 = in.	in. x 0.0254 = m
m x 3.2808 = ft	ft x 0.3048 = m
m x 1.0936 = yd	yd x 0.9144 = m
km x 0.621 = mi	mi x 1.6093 = km
Celsius to Fahrenheit (°C x 1.8) + 32 = °F	Fahrenheit to Celsius (°F - 32) ÷ 1.8 = °C

Drill Point Depth & Countersink Diameter Formulas

To calculate drill tip depth for a chamfer diameter, or drill point depth for a required drilling depth:

Drill Point Angle (DPA)	Factor
60°	0.866 x Dia. = Point Depth
82°	0.575 x Dia. = Point Depth
90°	0.500 x Dia. = Point Depth
118°	0.300 x Dia. = Point Depth
120°	0.288 x Dia. = Point Depth
135°	0.207 x Dia. = Point Depth

Example: To calculate for a 118-degree drill tip depth, multiply the dia. by 0.3
i.e., 0.250 drill diameter x .3 = 0.075 drill tip depth



SERIES: METAL TRADES A

CONTEST: CNC 2-AXIS TURNING PROGRAMMER

(formerly CNC Turning)

Online Resumé Submission

Series Director: BRUCE BOISSELLE • (978) 373-4101 • bboisselle@whittier.tec.ma.us
Series Director Assistant: MARIAH WATTERSON • mwatterson@sersd.org
Competition: Blackstone - Machine Shop Room 130 with Event Manager: Scott Brooks

REQUIREMENTS AND SCOPE OF CONTEST

Advisors will be sent log-on information for the Learning Management System, which will be open on April 10.
Contestants must submit an electronic copy of their resumé to the LMS by April 26, by 5:00pm.

Clothing Requirements: avoid a clothing penalty

Blue work pants, as shown	Safety shoes	Safety glasses with side shields or goggles
SkillsUSA Massachusetts T-Shirt, provided	NO jeans	NO cell phones or SmartWatches allowed

Safety: avoid a safety violation or being removed from the contest

NO loose/long hair (must be secured)	NO loose clothing	NO jewelry	NO sneakers

Tool Requirements: Contestants must submit online a one-page type-written resume, failure to do so will result in a 50-point penalty

Provided by the Technical Committee:

CNC Lathe with proper holding devices	Workbench Necessary hand tools and cutting tools	
Necessary information and furnishings for judges and technical committees		

Provided by the Contestants:

0-1" micrometer	6 inch caliper (digital or vernier)	Non-programmable calculator
Sharpened pencils and blank paper	Machinery's Handbook (optional)	Deburring tools (files, Emory cloth, etc.)
add 1- laptop computer with notepad or similar text editor program		

Purpose: To evaluate each contestant's preparation for employment in Computer Numeric Control turning. To recognize outstanding students for excellence and professionalism in the CNC turning field.

State Skills:

Each contestant will receive a dimensioned drawing and material to CNC-turn a part. Participants are expected to write a CNC program, set up the machine and tool offsets and turn a part without the use of CAD/CAM software. Only the part will be evaluated, not the CNC program. Participants are given 15 minutes to study the task and ask questions before beginning. The competition may run 6-8 hours, depending on the project design.

Competencies:

Programming

a. Write and verify CNC program without the use of CAM software (competitor has the opportunity to correct any program errors on the machine.)
b. Display complete knowledge of DIN/ISO programming (G and M codes)
c. Apply the correct use of cutter compensation (G41/G42)
d. Adjust speeds and feeds as needed

Setup

a. Setup machine and establish a zero reference point for machining the part
b. Select and mount necessary tools from the provided set
c. Establish tool offsets and enter them into the CNC machine control
d. Enter any necessary tool corrections into the CNC machine control

Measuring

a. Measure test part to the nearest 0.001"

Perform mathematical calculations

a. Calculate CNC speeds and feeds
b. Calculate programming coordinates from the drawing
c. Calculate radius tangent points

Communication

a. Read and interpret technical blue prints
b. Understand all symbols on technical blue prints, such as geometric tolerances, surface-finish symbols, corner-break symbols, etc.

Test Project Scoring, the three evaluation criteria for the test part are:

Conformity to Print:

a. Visual conformity and accuracy of part to drawing. (Look for shape and features of part)
b. Edges broken
c. Transition of surfaces
d. Part is burr-free
e. Damage to part (clamp marks, scratches)

Dimensions:

This is an objective scoring. Scores will only be granted if dimension is in compliance with the print. The score for each dimension will either be full points or zero points.

Use of Material:

Contestant will receive on piece of stock for the contest. Material may be Steel, Aluminum, Wax, or Delrin.

Observers: Observers will be allowed to view the students during the competition from the designated area only. Any infraction will result in contestant disqualification. Talking or gesturing by the observers may result in contestant disqualification. Observers will not be permitted to communicate with contestants in the holding/assembly area. Talking to judges will not be permitted. All communications are to be directed to the series director only and only at the end of the contest. Contestants are to stay until they are debriefed at the end. Any communication from observers will result in contestant disqualification. No prints or information will be allowed to leave with the student participants/school personnel. No videotaping of contests. (Still photography only)

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- (Required) Pen or pencil for notes or written calculations
- (Optional) Basic calculator

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Haas Certification Program

These online courses are designed to provide the basic knowledge necessary to get started as a CNC machine operator or CNC machinist. They introduce basic CNC machine operation, proper machine safety, and fundamental machining processes. For more information and to sign-up for the free online courses, visit: https://www.learn.haascnc.com

Haas Programming Workbooks

These programming workbooks provide the basic principles to program Haas Mills and Haas Lathes. Numerous exercises throughout the workbook enable users to build their skills at their own pace. Answer Books are also available. To download, visit the Haas Learning Resources webpage: https://www.haascnc.com/myhaas/Haas_Learning_Resources.htm

Haas Video Library

The Haas Video Library gives you access to thousands of videos recorded specifically to help Haas CNC users everywhere to grow their skills and understanding of CNC machining to maximize their abilities. Access videos directly from the Haas Video Library via the Haas YouTube channel or using the Quick Picklist of the Haas Learning Resources page, which organizes a handful of entry- to advanced-level videos to help get you started. For the complete Video Library, visit: https://www.haascnc.com/video.html Or, for the shortened Quick Picklist, visit: https://www.haascnc.com/myhaas/Haas_Learning_Resources.html

CAM Programming Training and Software

Partners Mastercam and Autodesk Fusion360 provide access to software and video training programs. Please visit the links below for information on accessing software and training resources.

Mastercam Learning Content: https://university.mastercam.com/

Mastercam Software Access for SkillsUSA: https://www.mastercam.com/skillsusa/

Contact Email: education@mastercam.com

Autodesk Fusion360 Training Courses: https://help.autodesk.com/view/fusion360/ENU/courses/#manufacturing-milling-turning-and-inspection

Autodesk Fusion360 Software Access: https://damassets.autodesk.net/content/dam/autodesk/www/fusion-360/Fusion%20Single%20Install%20Instructions.pdf

Autodesk Fusion360 Webinars:

One-Hour Webinar

Educators will get a high-level walkthrough of Autodesk, specifically focusing on our integrated, cloud-based Fusion 360 CAD/CAM software. Topics include: how to download Fusion 360 for free, how to assign students licenses, and how to build a class.

Two-Hour Hands-On Webinar

Educators will learn the basics of Fusion 360 by walking through an introductory, real-world, classroom-ready project. Topics include 2D sketching, 3D extrusions, creating assemblies, and exporting 3D models for manufacturing.

Visit https://www.autodesk.com/campaigns/education/webinar-series to register for one of our free Fusion 360 webinars.

Autodesk Fusion360 Contact Email: amy.shapiro@autodesk.com

Decimal Equivalent Chart .0059 – .0980

Decimal Equiv.	Drill Size	mm	Tap Sizes	Decimal Equiv.	Drill Size	mm	Tap Sizes
.0059	97	0.150		.0320	67	0.813	
.0063	96	0.160		.0330	66	0.838	
.0067	95	0.170		.0350	65	0.889	
.0071	94	0.180		.0360	64	0.914	
.0075	93	0.191		.0370	63	0.940	
.0079	92	0.201		.0380	62	0.965	
.0083	91	0.211		.0390	61	0.991	
.0087	90	0.221		.0400	60	1.016	
.0091	89	0.231		.0410	59	1.041	
.0095	88	0.241		.0420	58	1.067	
.0100	87	0.254		.0430	57	1.092	
.0105	86	0.267		.0465	56	1.181	
.0110	85	0.279		.0469	3/64	1.191	#0-80
.0115	84	0.292		.0520	55	1.321	
.0120	83	0.305		.0550	54	1.397	
.0125	82	0.318		.0595	53	1.511	#1-64 - #1-72
.0130	81	0.330		.0625	1/16	1.588	
.0135	80	0.343		.0635	52	1.613	
.0145	79	0.368		.0670	51	1.702	
.0156	1/64	0.397		.0700	50	1.778	#2-56 - #2-64
.0160	78	0.406		.0730	49	1.854	
.0180	77	0.457		.0760	48	1.930	
.0200	76	0.508		.0781	5/64	1.984	
.0210	75	0.533		.0785	47	1.994	#3-48
.0225	74	0.572		.0810	46	2.057	
.0240	73	0.610		.0820	45	2.083	#3-56
.0250	72	0.635		.0860	44	2.184	
.0260	71	0.660		.0890	43	2.261	#4-40
.0280	70	0.711		.0935	42	2.375	#4-48
.0292	69	0.742		.0938	3/32	2.381	
.0310	68	0.787		.0960	41	2.438	
.0313	1/32	0.794		.0980	40	2.489	

Tap drill sizes above based on approximately 75% full thread
Tap # Sizes #0 = .060 #1 = .073 #2 = .086 #3 = .099 #4 = .112
Tap # x .013 + .060 = Thread # OD

Decimal Equivalent Chart .0995 – .2969

Decimal Equiv.	Drill Size	mm	Tap Sizes	Decimal Equiv.	Drill Size	mm	Tap Sizes
.0995	39	2.527		.1875	3/16	4.763	#12-32
.1015	38	2.578	#5-40	.1890	12	4.801	
.1040	37	2.642	#5-44	.1910	11	4.851	
.1065	36	2.705	#6-32	.1935	10	4.915	
.1094	7/64	2.778		.1960	9	4.978	
.1100	35	2.794		.1990	8	5.055	
.1110	34	2.819		.2010	7	5.105	1/4-20
.1130	33	2.870	#6-40	.2031	13/64	5.159	
.1160	32	2.946		.2040	6	5.182	
.1200	31	3.048		.2055	5	5.220	
.1250	1/8	3.175		.2090	4	5.309	
.1285	30	3.264		.2130	3	5.410	1/4-28
.1360	29	3.454	#8-32 - #8-36	.2188	7/32	5.556	1/4-32
.1405	28	3.569		.2210	2	5.613	
.1406	9/64	3.572		.2280	1	5.791	
.1440	27	3.658		.2340	A	5.944	
.1470	26	3.734		.2344	15/64	5.953	
.1495	25	3.797	#10-24	.2380	B	6.045	
.1520	24	3.861		.2420	C	6.147	
.1540	23	3.912		.2460	D	6.248	
.1563	5/32	3.969		.2500	1/4&E	6.350	
.1570	22	3.988		.2570	F	6.528	5/16-18
.1590	21	4.039	#10-32	.2610	G	6.629	
.1610	20	4.089		.2656	17/64	6.747	
.1660	19	4.216		.2660	H	6.756	
.1695	18	4.305		.2720	I	6.909	5/16-24
.1719	11/64	4.366		.2770	J	7.036	
.1730	17	4.394		.2810	K	7.137	
.1770	16	4.496	#12-24	.2813	9/32	7.144	5/16-32
.1800	15	4.572		.2900	L	7.366	
.1820	14	4.623	#12-28	.2950	M	7.493	
.1850	13	4.699		.2969	19/64	7.541	

Tap drill sizes above based on approximately 75% full thread
Tap # Sizes #5 = .125 #6 = .138 #8 = .164 #10 = .190 #12 = .216
Tap # x .013 + .060 = Thread # OD

Decimal Equivalent Chart .3020 – 1.000

Decimal Equiv.	Drill Size	mm	Tap Sizes	Decimal Equiv.	Drill Size	mm	Tap Sizes
.3020	N	7.671		.5625	9/16	14.288	5/8-18
.3125	5/16	7.938	3/8-16	.5781	37/64	14.684	5/8-24
.3160	O	8.026		.5938	19/32	15.081	
.3230	P	8.204		.6094	39/64	15.478	11/16-12
.3281	21/64	8.334		.6250	5/8	15.875	
.3320	Q	8.433	3/8-24	.6406	41/64	16.272	11/16-20 - 11/16-24
.3390	R	8.611		.6563	21/32	16.669	3/4-10
.3438	11/32	8.731	3/8-32	.6719	43/64	17.066	
.3480	S	8.839		.6875	11/16	17.462	3/4-16
.3580	T	9.093		.7031	45/64	17.859	3/4-20
.3594	23/64	9.128		.7188	23/32	18.256	
.3680	U	9.347	7/16-14	.7344	47/64	18.653	13/16-12
.3750	3/8	9.525		.7500	3/4	19.050	13/16-16
.3770	V	9.576		.7656	49/64	19.447	13/16-20 - 7/8-9
.3860	W	9.804		.7813	25/32	19.844	
.3906	25/64	9.922	7/16-20	.7969	51/64	20.241	7/8-14
.3970	X	10.084		.8125	13/16	20.637	
.4040	Y	10.262	7/16-28	.8281	53/64	21.034	7/8-20
.4063	13/32	10.319		.8438	27/32	21.431	
.4130	Z	10.490		.8594	55/64	21.828	15/16-12
.4219	27/64	10.716	1/2-13	.8750	7/8	22.225	15/16-16 - 1.0-8
.4375	7/16	11.113		.8906	57/64	22.622	15/16-20
.4531	29/64	11.509	1/2-20	.9063	29/32	23.019	
.4688	15/32	11.906	1/2-28	.9219	59/64	23.416	1.0-12
.4844	31/64	12.303	9/16-12	.9375	15/16	23.813	
.5000	1/2	12.700	9/16-18	.9531	61/64	24.209	1.0-20
.5156	33/64	13.097	9/16-24	.9688	31/32	24.606	
.5313	17/32	13.494	5/8-11	.9844	63/64	25.003	
.5469	35/64	13.891		1.000	1	25.400	

Tap drill sizes above based on approximately 75% full thread
A decimal equivalent chart can be displayed on a Haas control by pressing the HELP/CALC button, and then selecting the Drill Table tab. Use the jog handle or cursor keys to scroll through the chart.

Mill and Lathe Formulas

Cutting Speed (surface feet/min.)
SFM = 0.262 x DIA x RPM

Revolutions Per Minute
RPM = 3.82 x SFM ÷ DIA

Feed Rate (in/min.)
IPM = FPT x T x RPM

Feed Per Revolution
FPR = IPM ÷ RPM

Feed Per Tooth (in)
FPT = IPM ÷ (RPM x T)

Metal Removal Rate
MRR = W x d x F

Converting IPR to IPM
IPM = IPR x RPM

Converting IPM to IPR
IPR = IPM ÷ RPM

Converting SFM to SMPM
SMPM = SFM x .3048

Converting IPR to MMPR
MMPR = IPR x 25.40

Distance over Time (in minutes)
L = IPM x TCm

Time Cutting over Distance (Mill) (minutes)
TCm = L ÷ IPM

Time Cutting over Distance (Mill) (seconds)
TCs = L ÷ IPM x 60

INCH METRIC CONVERSION

mm x 0.03937 = in.	in. x 25.4 = mm
m x 39.37 = in.	in. x 0.0254 = m
m x 3.2808 = ft	ft x 0.3048 = m
m x 1.0936 = yd	yd x 0.9144 = m
km x 0.621 = mi	mi x 1.6093 = km
Celsius to Fahrenheit (°C x 1.8) + 32 = °F	Fahrenheit to Celsius (°F - 32) ÷ 1.8 = °C

Drill Point Depth & Countersink Diameter Formulas

To calculate drill tip depth for a chamfer diameter, or drill point depth for a required drilling depth:

Drill Point Angle (DPA)	Factor
60°	0.866 x Dia. = Point Depth
82°	0.575 x Dia. = Point Depth
90°	0.500 x Dia. = Point Depth
118°	0.300 x Dia. = Point Depth
120°	0.288 x Dia. = Point Depth
135°	0.207 x Dia. = Point Depth

Example: To calculate for a 118-degree drill tip depth, multiply the dia. by 0.3
i.e., 0.250 drill diameter x .3 = 0.075 drill tip depth