Instructional Framework

Precision Machining

48.0510.00

This Instructional Framework identifies, explains, and expands the content of the standards/measurement criteria, and, as well, guides the development of multiple-choice items for the Technical Skills Assessment. This document corresponds with the Technical Standards endorsed in July 2020.

Domain 1: Measurement, Materials, Safety and Layout **Instructional Time: 25 - 30%**	
STANDARD 2.0 APPLY INDUSTRY SAFETY STANDARDS FOR PRECISION MACHINING	
2.1 Explain the purpose of the Occupational Safety and Health Administration (OSHA)	• Enforce safety rules • Protect employees
2.2 Identify Personal Protective Equipment (PPE) appropriate for working in a machining environment	• Safety glasses • Apron • Closed-toed shoes • Respirators/masks • Face shield • Ear plugs • Surgical gloves
2.3 Interpret basic Safety Data Sheet (SDS) information	• Protocols for chemical exposure • Location of SDS

2.4 Identify potential shop accidents and causes that lead to them	• Lack of cleanliness
	• Shop clutter
	• Drugs/alcohol
	• Horseplay
	• Using equipment without training
	• Entanglement
	  ○ Loose clothing or jewelry
	  ○ Untied long hair

2.5 Follow shop safety rules (e.g., clothing/jewelry, PPE, and accepted behavior)	• Hair tied back • No long sleeves • No jewelry • No horseplay

	• Safety guard in place
STANDARD 3.0 APPLY PRINT READING AND KNOWLEDGE AND SKILLS	
3.1 Use industry language to describe prints, engineered drawings, line conventions and lettering, title blocks and parts lists, and GD&T (geometric dimension and tolerance)	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*
3.2 Identify shapes, geometric terms and constructions, multiview drawings, section views, auxiliary views, and screw thread representation	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*
3.3 Identify fundamentals of size descriptions (e.g., dimensioning, tolerancing, machining specifications and drawing notes, surface texture symbols, geometric dimensioning and tolerancing, classes of fit, and drawing revision systems)	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*
3.4 Explain industrial drawing types (e.g., detailed and assembly drawings)	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*
3.5 Describe specialized parts and prints (i.e., welding prints, precision sheet metal parts, plastic parts, springs and fasteners, gears, splines, serrations, cam diagrams, instrumentation, etc.)	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*
STANDARD 4.0 IMPLEMENT PRECISION AND SEMI-PRECISION MEASUREMENT	
4.1 Explain the purpose of quality assurance, process planning, and quality control systems in the machining industry [e.g., Statistical Process Control (SPC), and International Organization for Standardization (ISO)]	• Fit • Form • Function
4.2 Perform machine tool math (e.g., fractional operations, fractional/decimal conversion, ratios and proportions, English/metric conversions, basic geometry, angles, Cartesian coordinates, and basic trigonometry)	*The teacher committee reviewed the criteria and determined that it can guide instruction and assessment item development without any additional clarification*
4.3 Use semi-precision measurement tools (e.g., machinist's rule, combination sets, protractors, and scales)	*The teacher committee reviewed the criteria and determined that it can guide instruction and assessment item development without any additional clarification*
4.4 Use precision measurement tools (e.g., gage blocks, dial calipers, sine tools, micrometers, optical comparators, dial/test indicators, and height gages)	• Pin sets • Coordinate Measuring Machine (CMM) • Faro arm

Domain 2: Manual Operations **Instructional Time: 25 - 30%**	
STANDARD 5.0 DISTINGUISH AMONG TYPES OF MATERIALS AND ROUTINE MAINTENANCE REQUIREMENTS	
5.1 Differentiate between ferrous and nonferrous materials	• Magnetic vs. nonmagnetic
5.2 Identify national standards of materials classifications [e.g., AISI (American Iron and Steel Institute), SAE (Society of Automotive Engineers), ASTM (American Society for Testing and Materials), and UNS (Unified Numbering System)] (i.e., marking methods, identification, etc.)	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*
5.3 Explain common heat treatment processes	• Annealing (adding heat) • Normalizing
5.4 Assess the importance of a routine maintenance program (e.g., lubrication methods, inspection points, and cutting fluids)	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*
STANDARD 6.0 DESIGN AND APPLY A JOB PROCESS PLAN INCLUDING BENCHWORK, LAYOUT, AND SIMPLE MACHINING	
6.1 Perform basic layout process and procedures including mathematical calculations using semi-precision and precision layout tools (i.e., material selection, tool selection, machining order of operations, use of drill and tap charts, etc.)	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*
6.2 Demonstrate proper tool use and related safety precautions (i.e., hand drill, drill press, hammers, files, etc.)	• Use the right tool for the right job • Proper training before operation
6.3 Demonstrate safe operation of saws, cutoff machines, and drill press (e.g., safety glasses, securing workpieces, shutting off spindle, cleaning, and good housekeeping rules)	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*
6.4 Explain the uses of offhand grinding and related safety precautions	• Check that grinding wheel is not rusted/broken • Cutting wheels not wet/broken • Cords not nicked/damaged • Guards on and secure
6.5 Identify major components of a drill press and their functions	• Chuck • Chuck key • Table • Column • Feed wheel

	• Speed adjustment • Depth stop • On/off switch
6.6 Demonstrate drilling, reaming, threading, and tapping operations	• Hand operation • CNC • Read appropriate chart for the operation
6.7 Apply proper tooling (e.g., tools, toolholding, and workholding)	• Use right tool for right job
STANDARD 7.0 PERFORM BASIC TURNING OPERATIONS	
7.1 Identify major components of a lathe and their functions (i.e., headstock, chuck, ways, cross slide, saddle, apron, compound, etc.)	• Taper bar
7.2 Explain safe operation of a lathe (e.g., shirts, sleeves, hair, chuck key, and chip management)	• Emergency stop
7.3 Apply proper tooling (e.g., tools, toolholding, and workholding)	• Use right tool for right job
7.4 Demonstrate safe operation of a lathe [e.g., cutting threads and tapers, OD (outside diameter), ID (inside diameter), chucking, between centers, facing, and grooving)]	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*
STANDARD 8.0 PERFORM BASIC MILLING OPERATIONS	
8.1 Identify major components of a vertical milling machine and their functions (i.e., quill, ram, head, knee, table, column, travel indicator dials, etc.)	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*
8.2 Explain safe operation of a mill (e.g., shirts, sleeves, hair, and chip management)	• Emergency stop • Feeds and speeds • X-,Y-, and Z Axis locks
8.3 Apply proper tooling (e.g., tramming head, indicating vice, tools, toolholding, workholding, edge finder, and indicating part features)	• Use right tool for right job
8.4 Explain use of accessories to increase efficiency when operating a mill (e.g., rotary table, right angle heads, and sine plates)	• Jigs and fixtures
8.5 Demonstrate safe operation of a mill (e.g., squaring blocks, pocket milling, and boring holes)	• Feeds and speeds

Domain 3: CNC Operations and Programming **Instructional Time: 25 - 30%**	
STANDARD 10.0 DESCRIBE BASIC OPERATIONS OF CNC MACHINES	
10.1 Compare and contrast Cartesian and polar coordinate systems in CNC programming (e.g., X-, Y-, and Z-axis, primary axis, and secondary axis)	*The teacher committee reviewed the criteria and determined that it can guide instruction and assessment item development without any additional clarification*
10.2 Describe absolute and incremental positioning systems	• G90 (absolute) • G91 (incremental)
10.3 Describe the purpose of codes and commands (e.g., G-codes, M-codes, S-commands, and F-commands)	• G-code controls movement • M-code controls machine functions • S-command controls spindle speed • F-command controls feed rate
10.4 Identify types of machine controls (i.e., Fanuc, Haas, Mazak, Mitsubishi, Siemens, etc.)	*The teacher committee reviewed the criteria and determined that it can guide instruction and assessment item development without any additional clarification*
10.5 Identify types of CNC machines (i.e., CNC Lathe, CNC Mill, EDM, laser, waterjet, part marker, etc.)	• Router
STANDARD 11.0 PERFORM BASIC CNC TURNING OPERATIONS	
11.1 Identify parts of CNC turning machines (i.e., chuck, spindle, turret, tailstock, steady rest, control, bar feeder/puller, machine guards, etc.)	*The teacher committee reviewed the criteria and determined that it can guide instruction and assessment item development without any additional clarification*

11.2 Describe the X- and Z-axis used for turning (i.e., live tooling, multi-axis, etc.)	• Live tooling also uses:
	  ○ C-axis is rotational
	  ○ Y-axis is vertical

11.3 Apply turning programming codes (e.g., G- and M-code programming, cutter compensation, calculating feeds and speeds)	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*
11.4 Apply CNC-specific turning operations and canned cycles (e.g., roughing/finishing turning cycles, drilling, and tapping cycles)	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*
11.5 Perform basic set-up procedures (e.g., workholding, offsets, proper use of toolholders, and indicating drills and reamers)	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*

11.6 Demonstrate program prove-out procedures (e.g., single block, rapid points, shadow paths, graphics, position screen, and selecting and loading programs)	• Option stop • Dry run
11.7 Perform maintenance program (e.g., maintain machine maintenance log sheets, inspection points, and cutting fluids)	• Refer to manuals for manufacturer-recommended maintenance
STANDARD 12.0 PERFORM BASIC CNC MILLING OPERATIONS	
12.1 Identify parts of CNC milling machines (i.e., spindle, ATC, table, way covers, chip conveyer, controller, machine guards, etc.)	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*
12.2 Describe the X-, Y-, and Z-axis used for milling (i.e., 4/5-axis, A-axis, B-axis, C-axis, etc.)	• Linear movement of X-, Y-, Z- • Rotational movement of A-, B-, C-
12.3 Apply milling programming codes (e.g., G- and M-code programming, cutter compensation, and calculating feeds and speeds)	• S controls spindle speed • F controls feed rate • I and J codes used for cutting circles and arcs
12.4 Apply CNC-specific milling operations and canned cycles (e.g., drilling, tapping, and boring cycles)	• Thread
12.5 Perform basic set-up procedures (e.g., workholding, offsets, and proper use of toolholders)	• Tool offsets • Work offsets
12.6 Demonstrate program prove-out procedures (e.g., single block, rapid points, shadow paths, graphics, position screen, and selecting and loading programs)	• Option stop • Dry run
12.7 Perform maintenance program (e.g., maintain machine maintenance log sheets, inspection points, and cutting fluids)	• Refer to manuals for manufacturer - recommended maintenance

Domain 4: CAD/CAM
Instructional Time: 5 - 10%

STANDARD 13.0 DESCRIBE ADVANTAGES OF USING COMPUTER AIDED-DESIGN (CAD) AND COMPUTER-AIDED MANUFACTURING (CAM) SOFTWARE	
13.1 Describe basic applications of CAD and CAM	*The teacher committee reviewed the criteria and determined that it can guide instruction and assessment item development without any additional clarification*

13.2 Explain the use of drawings (e.g., wireframe, solid model, and surface)	*The teacher committee reviewed the criteria and determined that it can guide instruction and assessment item development without any additional clarification*
13.3 Describe the process of toolpath creation and toolpath types	*The teacher committee reviewed the criteria and determined that it can guide instruction and assessment item development without any additional clarification*
13.4 Explain basic principles of post-processing	*The teacher committee reviewed the criteria and determined that it can guide instruction and assessment item development without any additional clarification*
STANDARD 14.0 PERFORM BASIC USE OF COMPUTER AIDED-DESIGN (CAD) AND COMPUTER-AIDED MANUFACTURING (CAM) SOFTWARE	
14.1 Perform basic applications of CAD and CAM (e.g., use of sketch tools, planes, coordinate systems, wireframe and solid creation, and different file extensions)	*The teacher committee reviewed the criteria and determined that it can guide instruction and assessment item development without any additional clarification*
14.2 Use drawing tools to create wireframe, solid models, and surfaces	*The teacher committee reviewed the criteria and determined that it can guide instruction and assessment item development without any additional clarification*
14.3 Apply toolpaths to solid model or wireframe; verify/backplot toolpaths through simulation	*The teacher committee reviewed the criteria and determined that it can guide instruction and assessment item development without any additional clarification*
14.4 Use post processor to generate and evaluate G-code	*The teacher committee reviewed the criteria and determined that it can guide instruction and assessment item development without any additional clarification*
14.5 Generate tool lists, setup sheets, and file saving through CAM software	*The teacher committee reviewed the criteria and determined that it can guide instruction and assessment item development without any additional clarification*
STANDARD 15.0 PERFORM ADDITIVE MANUFACTURING WITH CAD	
15.1 Explain principles of 3D printers, materials, and applications, legal aspects, health and safety, and impact	● Manufacturing processes ○ Planning ○ Tooling selection ○ Use of 3D printing for Medical, Aerospace, Department of Defense (DOD), etc.
15.2 Create, design, and make complex shapes, geometrics, and solid models with CAD	● Why CAD is preferred for solid complex shapes
15.3 Save file types (e.g., STL and WRL)	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*

15.4 Use 3D printing software to define part program characteristics (i.e., raft, infill, part orientation, support material, tolerance, etc.) and generate code	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*
15.5 Set up machinery and print the part	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*
15.6 Use post-manufacturing process for finished 3D printed models	● Test product for compliance and quality

Domain 5: Evolution of Machining **Instructional Time: 5 - 10%**	
STANDARD 1.0 ANALYZE THE EVOLUTION OF PRECISION MACHINING	
1.1 Explain the machining process (i.e., utilizing YouTube videos, etc.)	● The machining process videos such as: ○ MasterCAM University ○ Additive ○ Subtractive ○ Turning ○ Milling
1.2 Discuss the history of machining	● Origins (Egypt) ● Industrial Revolution
1.3 Identify the significance of machining in society	● Changed processes from manual to automatic, enabling mass production ● Everything has to be manufactured if it's not from nature ● Increased: ○ Performance ○ Repetition ○ Consistency ● Tighter tolerances ● Majority of global economy is driven by manufacturing
1.4 Discuss types of machine tools (e.g., sawing machines, drill press, lathe, milling, CNC mills, CNC lathes, and CAD CAM)	● Subspindle lathes
1.5 Discuss types of machining operations [e.g., abrasive, electrical discharge, laser, waterjet, and additive manufacturing (i.e., 3D printing, etc.)]	● Additive CNC machine

1.6 Identify the national standards and certifications for the industry	• National Institute for Metalworking Skills (NIMS)
1.7 Discuss new advances in the industry [i.e., additive manufacturing (i.e., 3D printing, etc.), multiaxis machining, etc.]	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*
STANDARD 9.0 EXPLAIN BASIC PRECISION GRINDING OPERATIONS	
9.1 Identify types of precision grinding machines [i.e., surface grinders, cylindrical grinders, thread grinders, ID (internal diameter), OD (outside diameter), etc.]	*The teacher committee reviewed the measurement criterion and determined that no additional clarification is required.*
9.2 Describe precision grinder safety guidelines (e.g., safety glasses, work shoes and clothing, machine guards and covers, locks and tags, wheels and workpieces, ring test, and blotter)	• Use manufacturing guidelines for each type of brand/tool