



OREGON  
DEPARTMENT OF  
EDUCATION

**INDUSTRIAL AND ENGINEERING SYSTEMS**

# Statewide Program of Study Framework: Manufacturing Career Cluster

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**Knowledge and Skill Statements/Suggested Performance Indicators**

**Employability**



**Career Cluster**



**Focus Areas**

Machining

Welding

# Overview

The Industrial and Engineering Systems career learning area is comprised of five Career Clusters, which include: (1) Architecture and Construction, (2) Manufacturing, (3) Engineering Technology, (4) Transportation, Distribution and Logistics, and (5) Automotive and Heavy Equipment. This document details the knowledge and skill statements comprising the Program of Study for the Manufacturing Career Cluster. The Statewide Program of Study Framework addresses two focus areas: (1) Machining, and (2) Welding.

When reading the document, note that:

- **A Program of Study spans secondary and postsecondary education**, meaning that students are expected to master the identified skills upon completion of their programming. It is not expected that all Knowledge and Skill Statements will be taught at the high school level.
- **Knowledge and skill statements** (indicated in bold) identify the career readiness expectations that employers seek in entry-level workers.
- **Suggested performance indicators** illustrate how students might demonstrate their understanding of each knowledge and skill statement. They are offered as examples and are not required to be taught.

Secondary and postsecondary educators will collaborate to select the number, type, specificity, and educational level at which performance indicators will be taught.

For more detailed information, see the Manufacturing Resource Guide contained in this Google Drive.

# Manufacturing Knowledge and Skill Statements

## Employability Knowledge and Skill Statements

Applicable to all Career Clusters in the Statewide Program of Study Framework.

E-01	Adhere to workplace practices
E-02	Exhibit personal responsibility and accountability
E-03	Practice cultural competence
E-04	Demonstrate teamwork and conflict resolution
E-05	Communicate clearly and effectively
E-06	Employ critical thinking to solve problems
E-07	Demonstrate creativity and innovative thinking
E-08	Demonstrate fluency in workplace technologies
E-09	Plan, organize, and manage work
E-10	Make informed career decisions

## Cluster Level Knowledge and Skill Statements

Applicable to all Programs of Study in the Manufacturing Statewide Program of Study Framework.

CC-MN01	Describe the manufacturing industry and its contributions to society and the economy
CC-MN02	Demonstrate an understanding of and adherence to safe working practices
CC-MN03	Demonstrate the safe use of tools
CC-MN04	Demonstrate knowledge about materials used in the manufacturing industry
CC-MN05	Describe government policies and industry standards that apply to manufacturing
CC-MN06	Demonstrate pre-task planning to ensure a safe and efficient jobsite
CC-MN07	Demonstrate basic principles of mathematics and measurement used in manufacturing
CC-MN08	Describe the major components in the manufacturing process
CC-MN09	Describe different manufacturing processes and evolving trends

## Focus Area Level Knowledge and Skills

Knowledge and Skill Statements for the updated Statewide Program of Study Framework in:

1) Machining, and 2) Welding.

### Machining

FA-MNMF01	Demonstrate knowledge of technology and materials
FA-MNMF02	Demonstrate ability to interpret blueprints and layout
FA-MNMF03	Demonstrate knowledge of machining operation and control
FA-MNMF04	Demonstrate knowledge of machining production and processing
FA-MNMF05	Demonstrate knowledge of tool setup and required best-practices
FA-MNMF06	Demonstrate ability to use CNC machines to manufacture parts
FA-MNMF07	Apply quality control tools and techniques to manufacturing processes, systems, and products
FA-MNMF08	Describe knowledge of lifting devices
FA-MNMF09	Apply mathematical and measurement concepts to the machining process

### Welding

FA-MNWL01	Demonstrate an understanding of the Properties of Metallurgy
FA-MNWL02	Demonstrate an understanding of material removal techniques
FA-MNWL03	Demonstrate an understanding of safety hazards, protective devices used, and operations of Shielded Metal Arc Welding (SMAW) equipment
FA-MNWL04	Demonstrate understanding of set-up and procedure for Gas Metal Arc Welding (GMAW)
FA-MNWL05	Demonstrate proper set-up and procedure for Flux Cored Arc Welding (FCAW)
FA-MNWL06	Demonstrate proper set-up and procedure for Gas Tungsten Arc Welding (GTAW)
FA-MNWL07	Successfully apply various quality control methods to the welding process
FA-MNWL08	Demonstrate knowledge of math and blueprints that apply to welding design and layout
FA-MNWL09	Demonstrate knowledge of welding standards and certifications

## Employability Knowledge and Skill Statements with Suggested Performance Indicators

<b>E-01</b>	<b>Adhere to workplace practices</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Explain and follow workplace standards, rules, and regulations</li> <li>B. Show up on time and prepared to work</li> <li>C. Demonstrate the ability to take direction, be proactive, and work independently</li> </ul>
<b>E-02</b>	<b>Exhibit personal responsibility and accountability</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Apply professional and ethical standards of the industry to personal conduct</li> <li>B. Maintain integrity and promote personal and professional integrity in co-workers</li> <li>C. Take responsibility and carry out work assignments</li> </ul>
<b>E-03</b>	<b>Practice cultural competence</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Demonstrate awareness of issues related to diversity, equity, and inclusion</li> <li>B. Work effectively with colleagues of differing abilities, cultures, and backgrounds</li> <li>C. Describe issues relating to workplace harassment</li> <li>D. Model behaviors that are respectful and sensitive of others</li> </ul>
<b>E-04</b>	<b>Demonstrate teamwork and conflict resolution</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Demonstrate the ability to collaborate and contribute to the work of a diverse team</li> <li>B. Explain when it is appropriate to lead and when to follow another's lead</li> <li>C. Demonstrate strategies for resolving issues with coworkers</li> </ul>
<b>E-05</b>	<b>Communicate clearly and effectively</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Listen attentively, and speak and write clearly to convey information correctly</li> <li>B. Interpret information and instructions presented in verbal and written form</li> <li>C. Demonstrate effective communication with colleagues, supervisors, customers, and suppliers</li> <li>D. Demonstrate the ability to communicate verbally, in writing, and using electronic communication tools</li> </ul>
<b>E-06</b>	<b>Employ critical thinking to solve problems</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Recognize problems in the workplace and diagnose their root causes</li> <li>B. Develop well-reasoned plans to solve identified challenges</li> <li>C. Apply and follow through on plans to ensure that problems are resolved</li> </ul>

<b>E-07</b>	<b>Demonstrate creativity and innovative thinking</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Develop ideas to solve problems in new and different ways</li> <li>B. Investigate one’s own and others’ ideas to find those with greatest applicability</li> <li>C. Develop and deploy plans to implement new ideas in the workplace</li> </ul>
<b>E-08</b>	<b>Demonstrate fluency in workplace technologies</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Demonstrate knowledge and application of general technology skills, including hardware and software commonly used in the industry</li> <li>B. Use online communication, networking tools and social networks to access, manage, evaluate, and create information to successfully function in a knowledge economy</li> <li>C. Describe and demonstrate a fundamental understanding of the ethical, legal, and security issues surrounding access to and use of information technologies</li> </ul>
<b>E-09</b>	<b>Plan, organize, and manage work</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Identify an intended project outcome including available inputs, materials, labor, timeline for producing work, and job-site obligations</li> <li>B. Effectively plan, monitor, and complete projects on time and within budget using available resources and materials</li> <li>C. Demonstrate ability to write coherent reports and project summaries to communicate the progress of project work and its adherence to schedule</li> </ul>
<b>E-10</b>	<b>Make informed career decisions</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Identify job and entrepreneurial opportunities in the industry and the required education and credentials to obtain employment</li> <li>B. Set short- and long-term career goals based on personal interests and aptitudes</li> <li>C. Maintain a project portfolio</li> <li>D. Develop a professional resume</li> <li>E. Explain and demonstrate how to cultivate and maintain a professional presence in an online environment, including the appropriate use of social media and networking platforms</li> </ul>

## Manufacturing Career Cluster Knowledge and Skill Statements with Suggested Performance Indicators

<b>CC-MN01</b>	<b>Describe the manufacturing industry and its contributions to society and the economy</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Identify the role and major functions of manufacturing businesses</li> <li>B. Describe how manufacturing businesses and the products they produce contribute to improving people’s lives and strengthening the economy</li> <li>C. Describe how the manufacturing sector functions in the domestic and global marketplaces and the relationship and competitive challenges between the two</li> <li>D. Explain how products are designed and the various professions involved (e.g., engineers, designers, fabricators, suppliers)</li> <li>E. Identify the customers, suppliers, and stakeholders of manufacturing businesses, their roles, and how they relate to one another</li> </ul>
<b>CC-MN02</b>	<b>Demonstrate an understanding of and adherence to safe working practices</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Describe the importance of a safety culture in the manufacturing trades</li> <li>B. Demonstrate safe working practices that promote personal and group health</li> <li>C. Demonstrate awareness of common manufacturing hazards and the steps needed to correct them</li> <li>D. Demonstrate the use of and care for personal protective equipment</li> </ul>
<b>CC-MN03</b>	<b>Demonstrate the safe use of tools</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>E. Demonstrate the ability to use measuring, marking, and layout tools</li> <li>F. Identify the hand and power tools commonly used in the field and describe their uses</li> <li>G. Use hand and power tools in a safe manner</li> <li>H. Demonstrate how to maintain, clean, and store hand and power tools commonly used in the field</li> </ul>
<b>CC-MN04</b>	<b>Demonstrate knowledge about building materials used in the manufacturing industry</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Identify various types of materials used in production and their uses</li> <li>B. Identify the different types and grades of materials used in the industry</li> <li>C. Demonstrate proper techniques for ordering, handling, using, and storing materials</li> </ul>

<b>CC-MN05</b>	<b>Describe government policies and industry standards that apply to manufacturing</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. State the purpose of regulations and certification requirements</li> <li>B. Explain the types of governmental regulations and federal, state, and local regulations that apply in the industry and how the professions engage with them</li> <li>C. Describe how government agencies ensure compliance with environmental regulations and the consequences that manufacturing organizations suffer when they fail to comply</li> <li>D. Describe how the Americans with Disabilities Act applies in the workplace</li> <li>E. Describe requirements related to handling and disposal of environmentally hazardous materials in accordance with the material safety data sheet (MSDS), the Occupational Safety and Health Administration (OSHA), and the Environmental Protection Agency (EPA) regulations</li> <li>F. Describe how to apply quality control and assurance procedures within the industry and why they are important</li> </ul>
<b>CC-MN06</b>	<b>Demonstrate pre-task planning to ensure a safe and efficient jobsite</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Describe the daily scope of work and sequence of activities to perform it</li> <li>B. Identify and safely assemble the equipment required to conduct the daily scope of work</li> <li>C. Estimate the time and materials needed to perform the daily scope of work</li> <li>D. Identify jobsite hazards related to the daily scope of work and take steps to mitigate them</li> </ul>
<b>CC-MN07</b>	<b>Demonstrate basic principles of mathematics and measurement used in manufacturing</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Add, subtract, multiply, and divide whole numbers, fractions, and decimals with and without a calculator</li> <li>B. Demonstrate how to determine area, volume, and length measurements using square feet, cubic feet, and yards</li> <li>C. Recognized and apply basic measuring instruments (e.g., rules, protractors, go-no-go gages, gage blocks, and checking fixtures)</li> <li>D. Recognize and apply precision measuring instruments such as micrometers, vernier, dial, and electronic calipers, dial indicators, telescoping gages, gage blocks, adjustable parallels and optical comparators</li> </ul>



<b>CC-MN08</b>	<b>Describe the major components in the manufacturing process</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Describe how planning and budgeting are used to accomplish organizational goals.</li> <li>B. Demonstrate accepted planning and layout procedures (e.g., print reading)</li> <li>C. Summarize how materials can be processed using tools and machines (e.g., additive, subtractive, injection modeling)</li> <li>D. Describe various types of assembling processes (e.g., mechanical fastening, mechanical force, joining, fusion bonding, adhesive bonding)</li> <li>E. Explain finishing processes (e.g., types of finishing materials, surface preparation, methods of application)</li> <li>F. Explain inspection and quality control processes</li> </ul>
<b>CC-MN09</b>	<b>Describe different manufacturing processes and evolving trends</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Describe how different processes make use of specific manufacturing processes (e.g., casting and molding, forging, separating, assembling, digital and additive manufacturing, finishing, stamping)</li> <li>B. Analyze recent trends in the manufacturing sector and evolving technologies and processes shaping the field (e.g., additive and digital manufacturing, industrial robots, bio- and nano-manufacturing, sustainable manufacturing)</li> <li>C. Explain advanced manufacturing and how it applies information, automation, computation, software, sensing, and networking to make traditional processes more efficient</li> </ul>

## Machining Focus Area Knowledge and Skill Statements with Suggested Performance Indicators

<b>FA-MNMF01</b>	<b>Demonstrate knowledge of technology and materials</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Describe key material properties as they relate to machining efficiency</li> <li>B. Explain material properties and tooling processes to created finished products</li> <li>C. Describe the different types and uses of metal (e.g., ferrous metals, non-ferrous metals, high temperature metals and rare metals) and woods (e.g., hardwood, softwood)</li> <li>D. Determine the hardness values of different materials</li> <li>E. Explain types of tool wear and their consequences</li> <li>F. Discuss which parameters to change to improve unfavorable tool failures and/or poor surface finish of parts</li> </ul>
<b>FA-MNMF02</b>	<b>Demonstrate ability to interpret blueprints and layout</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Examine and interpret engineering drawings to manufacture an object</li> <li>B. Apply knowledge of engineering drawing to machining process</li> <li>C. Use modern-day electronic systems to look up most current version of engineering drawings need for manufacturing</li> <li>D. Define the information necessary to complete a machining task such as materials to be used, required surface finish, tolerances, quantity of units etc.</li> <li>E. Distinguish between detail and assembly drawings</li> <li>F. Use precision measuring and layout instruments and inspection processes to ensure quality of a finished product</li> </ul>
<b>FA-MNMF03</b>	<b>Demonstrate knowledge of machining operation and control</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Manage and coordinate the operation of the cutting pieces, feeds, and mounts associated with both manual and computer-numerical controlled (CNC) machining tools to complete advanced projects involving mills, lathes, and grinders</li> <li>B. Correctly, safely, and efficiently schedule, configure, administer, and verify heat-treatments to machined parts according to blueprint specifications</li> <li>C. Demonstrate the following higher functions: cutter diameter compensation; comfort with built-in risk management systems</li> <li>D. Demonstrate how to inspect and assess the condition of tools and maintain them so that they are safe and operational</li> </ul>

<b>FA-MNMF04</b>	<b>Demonstrate knowledge of machining production and processing</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Describe and demonstrate various machining techniques including procedures on drill press, lathe, saw grinders, and milling machines</li> <li>B. Solve manufacturing-related problems by analyzing and weighing the constraining factors including schedule, cost, materials, and equipment, as well as productivity, regulations, maintenance, and quality</li> <li>C. Employ statistical quality control test methods and techniques, especially on large volume processes, to minimize defects and waste due to poor quality</li> </ul>
<b>FA-MNMF05</b>	<b>Demonstrate knowledge of tool setup and required best-practices</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Demonstrate tool and holder assembly with use height gage and pre-setter</li> <li>B. Demonstrate tool and holder balancing to required standards</li> <li>C. Follow best practices for assembly of tools using: Shrink Fit system, Collet systems, Weldon-Flats, and bold on systems</li> <li>D. Rotate inserts on indexable cutting tools</li> </ul>
<b>FA-MNMF06</b>	<b>Demonstrate ability to use CNC machines to manufacture parts</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Produce parts to specifications or drawings provided on a computer numerical controlled mill or lathe</li> <li>B. Employ basic G and M Programming focusing on the use of the Cartesian coordinate system and machine axis</li> <li>C. Demonstrate methods by which programs can be entered into a controller</li> <li>D. Demonstrate the setup and safe operation of a CNC turning or milling center</li> <li>E. Demonstrate a tool change and tool selection to complete a multistep process on a CNC milling or turning center</li> <li>F. Demonstrate operation and preventive daily maintenance of a CNC Lathe machine</li> <li>G. Demonstrate operation and preventive daily maintenance of a CNC Mill machine</li> </ul>

<b>FA-MNMF07</b>	<b>Apply quality control tools and techniques to manufacturing processes, systems, and products</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Analyze production controls and manufactured parts specifications using quality control techniques and precision measuring tools</li> <li>B. Measure, weigh, and visually inspect machine parts, surface finish measurements</li> <li>C. Use the appropriate instrumentation to measure tolerances as required in the engineering drawings</li> <li>D. Apply data collection for part buyoff and related documentation</li> <li>E. Validate that a provided part meets specifications from its engineered drawing by comparing specifications</li> <li>F. Record and compare data to given project specifications; interpret results</li> <li>G. Demonstrate ability to prove out a program using single block, lowered rapid rates, and using Distance to Go screen on control</li> </ul>
<b>FA-MNMF08</b>	<b>Describe knowledge of lifting devices</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Demonstrate safe use of lifting devices and rigging equipment (e.g., cranes, jibs, slings, magnets, specialized lifting devices)</li> <li>B. Demonstrate ability to use lift trucks, stackers, pallet jacks for moving material</li> </ul>
<b>FA-MNMF09</b>	<b>Apply mathematical and measurement concepts to the machining process</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Select appropriate tools and accurately measure solid shapes and parts</li> <li>B. Perform basic mathematical calculations and/or calibrations using tools such as micrometers, verniers, and gages</li> <li>C. Calculate the speeds, feeds, and depth of cut for various machines and materials</li> <li>D. Determine the appropriate units and record accurate and repeatable measures of length, diameter, and thickness to complete projects using appropriate tools</li> <li>E. Apply principles of trigonometry, Cartesian geometry, and/or polar geometry, distinguishing which principles apply to a given machining tool and when</li> <li>F. Use angle gages, a plate contractor, a universal bevel protractor with vernier scale, square and/or a sine bar and gage clocks or adjustable parallel</li> <li>G. Determine the appropriate units and record accurate and repeatable measurement of material properties such as hardness, pH, and load elongation test curves of stress, strain, modulus and yield</li> <li>H. Interpret test values and curves and use calculated results to make informed decisions</li> </ul>

## Welding Focus Area Knowledge and Skill Statements with Suggested Performance Indicators

<b>FA-MNWL001</b>	<b>Demonstrate an understanding of the Properties of Metallurgy</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Describe the mechanical properties of metals and their importance in the welding process including tensile, strength, hardness, elasticity, ductility, toughness, and brittleness</li> <li>B. Demonstrate techniques to mitigate the effects of thermal expansion and contraction that occur during the welding process</li> <li>C. Explain the effect that thermal conductivity and specific heat have on various metals such as steel and aluminum</li> </ul>
<b>FA-MNWL02</b>	<b>Demonstrate an understanding of material removal techniques</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Demonstrate knowledge of angle grinder, die grinders and abrasives</li> <li>B. Demonstrate knowledge of Oxy-fuel Cutting (OFC-A)</li> <li>C. Demonstrate knowledge of Plasma Arc Cutting (PAC)</li> <li>D. Demonstrate knowledge of Air Carbon Arc Cutting (CAC-A)</li> </ul>
<b>FA-MNWL03</b>	<b>Demonstrate an understanding of safety hazards, protective devices used, and operations of Shielded Metal Arc Welding (SMAW) equipment</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Recognize the AWS filler metal specification system and various electrode characteristics</li> <li>B. Describe characteristics of the four main electrode groups</li> <li>C. Explain how to select electrodes and describe their proper care and handling</li> <li>D. Select the proper electrodes for any given welding task</li> <li>E. Perform multi-pass groove welds in all positions according to industry standards</li> <li>F. Demonstrate the proper handling and storage of electrodes</li> </ul>
<b>FA-MNWL04</b>	<b>Demonstrate understanding of set-up and procedure for Gas Metal Arc Welding (GMAW)</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Safely set up equipment for gas metal arc welding (GMAW)</li> <li>B. Explain the advantages of GMAW over conventional electro-type arc (stick) welding</li> <li>C. Explain factors that affect electrode selection for gas metal arc welding (GMAW)</li> <li>D. Use the gas metal arc welding method and various metal transfer methods to demonstrate how to pad beads and make fillet welds on plain carbon steel in all feasible positions</li> <li>E. Set-up and perform SMAW-S (short-circuit) multiple-pass V-groove welds on carbon steel plate coupons in multiple positions using solid or composite wire and shielding gas</li> <li>F. Perform fillet and groove welds in all positions</li> </ul>

<b>FA-MNWL05</b>	<b>Demonstrate proper set-up and procedure for Flux Cored Arc Welding (FCAW)</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Safely set up equipment for flux cored welding (FCAW)</li> <li>B. Explain multiple factors that affect electrode and shielded gas selection for Flux Cored Arc Welding</li> <li>C. Use various electrodes and the Flux Cored Arc Welding process to demonstrate how to pad beads and make filled welds on plain carbon steel in all feasible positions</li> <li>D. Explain the distinctive features of Flux Cored Arc Welding</li> <li>E. Demonstrate how metal transfer is affected by arc-control, self-shielded, and gas-shielded FCAW</li> </ul>
<b>FA-MNWL06</b>	<b>Demonstrate proper set-up and procedure for Gas Tungsten Arc Welding (GTAW)</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Safely set up equipment for Gas Tungsten Arc Welding</li> <li>B. Explain multiple factors that affect electrode selection for Gas Tungsten Arc Welding</li> <li>C. Use various electrodes and the Gas Tungsten Arc Welding process to demonstrate hot to pad beads and make fillet welds on plain carbon steel, stainless steel, and aluminum in all feasible positions</li> <li>D. Explain the distinctive features of Gas Tungsten Arc Welding</li> </ul>
<b>FA-MNWL07</b>	<b>Successfully apply various quality control methods to the welding process</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Describe various defects found in welded products</li> <li>B. Discuss the value of having clean material before starting a weld and the importance of doing it right the first time</li> <li>C. Differentiate between destructive and nondestructive tests used as quality control techniques to prevent defects</li> <li>D. (Measure and visually inspect welded products for acceptability to American Welding Society QC-10 standards</li> <li>E. Record discontinuities and defects and compare data to given project specifications; recommend changes to reduce defects in the manufacturing process</li> <li>F. Distinguish between the guided-bend test and the free-bend test; explain when it is most appropriate to apply each test; demonstrate the use of each test and properly document results conforming to AWS requirements</li> </ul>
<b>FA-MNWL08</b>	<b>Demonstrate knowledge of math and blueprints that apply to welding design and layout</b>
Suggested Performance Indicators	<ul style="list-style-type: none"> <li>A. Demonstrate good math skills including basic geometry, fractions, decimals, multiplication, and circle math (e.g., establish radius)</li> <li>B. Interpret and demonstrate the planning and layout operations used in the welding process (e.g., interpret scaled welding blueprints, perform calculations, analyze welding symbols, drawings, and specifications)</li> <li>C. Identify, sketch, and explain the five basic weld joint designs (i.e., butt, lap, tee, outside corner, and edge)</li> </ul>

<b>FA-MNWL09</b>	<b>Demonstrate knowledge of welding standards and certifications</b>
Suggested Performance Indicators	<ul style="list-style-type: none"><li>A. Demonstrate an understanding of Welding Procedure Specification (WPS) and Procedure Qualification Record (PQR) Development as specified by the American Welding Society</li><li>B. Demonstrate the ability to review a welding procedure specification and conduct a welding procedure test</li><li>C. Demonstrate knowledge of preferred Industry Certifications for welding and the requirements for successful examination</li><li>D. Describe what is required to achieve certification in the following American Welding Society modules: Shielded Metal Arc Welding (SMAW), Gas Metal Arc Welding (GMAW), Flux Cored Arc Welding (FCAW), and Gas Tungsten Arc Welding (GTAW)</li></ul>