

Technical and Professional

**Curriculum Content Frameworks for
Machine Tool**

**Curriculum Content Frameworks for
Machine Tool Technology
Developed by the
University of Arkansas at Little Rock**

**State of Arkansas
Department of Workforce Education**

NOTICE TO THE READER

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Preface

The Technical and Professional program continues to prepare students for employment and continuing education. To accomplish this preparation, teachers and employers have collaborated to modify individual programs to ensure that instruction is current and comprehensive. This document reflects essential competencies for program completers as well as all aspects of the machine tool technology industry as required by the Carl D. Perkins Act. The curriculum content frameworks for all Technical and Professional programs can be accessed through the Department of Workforce Education Web site.

Foreword

The curriculum content framework *Machine Tool Technology* supports the course that prepares students for the following career roles, which in turn correspond to the Classification of Instructional Programs (CIP) codes listed below. The courses may be sequenced with a variety of career and technical courses to form a specialization to prepare students for careers and support additional education and training in the protective services industry.

The Metals cluster of programs prepares students for careers in the fields of precision machining, sheet metal work, welding, and industrial machine maintenance and repair. Programs within the Metals cluster are as follows:

- CIP Code – 48.0501
- O-NET – 51-4041.XX
- Industrial Maintenance Technology
- Precision Machining Technology (PMT)
- Sheet Metal
- Welding

Acknowledgments

The machine tool curriculum content framework was produced by a team of program developers from the University of Arkansas at Little Rock. The framework was reviewed by a panel of experts in the field of machine tool technology. The format and content of the framework reflect the specific training needs within the state of Arkansas. The framework content and format are modeled after a document originally developed by a writing team under the auspices of the Virginia Department of Education. Grateful appreciation is expressed to the Virginia Department of Education and the Instructional Materials Laboratory, University of Missouri-Columbia, for granting the Arkansas State Department of Workforce Education access to their instructional frameworks.

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Introduction

About the Program

This framework has been developed for use in designing and implementing a competency-based program in machine tool technology. The competencies in this guide are based on the nationally developed standards of the National Tooling and Machining Association (NTMA) as approved by its program certification agency, National Institute of Metalworking Skills (NIMS). A panel of practitioners representing the machining industry in Arkansas validated the competencies.

National Industry Standards

The Arkansas Machine Tool Technology program is based on the national standards contained in the NTMA/NIMS Duties and Standards for Machining Skills Levels I and II. As recommended by NIMS, high school program completers master Level I technical skills and the knowledge, skills, and abilities that support those skills, preparing each student for entry-level employment, advanced technical education at the community college, or a registered apprenticeship. For more information, visit www.nims-skills.org.

About the Document

This document includes the following components:

- Section 1 contains a master duty/task list for the Machine Tool Technology program.
- Section 2 contains an analysis of each task, consisting of the task, task definition, and suggested skill/process questions to help assess student progress.
- Section 3 lists the Arkansas Standards of Learning for language arts, mathematics, and science that are reinforced by instruction in the Machine Tool Technology program. Academic skills in English, particularly in oral communication, are necessary for the mastery of a number of tasks performed by precision machinists on the job.

Program Description

47.135 – Machine Tool I

47.137 – Machine Tool II

Students learn the basics of industrial safety and environmental protection; planning, management, and performance of machining jobs; quality control; process improvement; general maintenance; engineering drawings and sketches; and application of measurements, metalworking theory, properties of materials, and principles of CNC.

The tasks incorporate all standards required for program certification by the National Institute of Metalworking Skills, the certification agency of the National Tooling and Machining Association.

Master Duty/Tasks Listing

Machine Tool Technology

Machine Tool I

Machine Tool II

National and state experts in the occupational field of machine tool technology have validated the duties and tasks in this section. Each is analyzed by identifying the following:

- a *duty/task statement*, which describes what the student is to do

DUTY A: Ensuring industrial safety and environmental protection
Task:
A001: Demonstrate safe workplace practices
A002: Handle hazardous materials as assigned
Duty B: Managing a career as a machinist
Task:
B001: Develop a short-term career plan
B002: Complete job application procedures
B003: Work as a member of a team to accomplish a goal
B004: Explain the management structure of a local machining company
B005: Identify rights and responsibilities of employees and employers in the machining industry
B006: Identify principles of technology that every employee should know to succeed in the machining industry
B007: Identify relationships between a machining company and the community
B008: Identify key elements of planning every employee should know to succeed in the machining industry

B009: Explain the basic principles of personal finance management
DUTY C: Planning and managing machining jobs
Task:
C001: Develop a process plan for a part requiring milling, drilling, turning, or grinding
C002: Write a set of directions for a machining-related task or project
DUTY D: Performing machining jobs
Task:
D001: Perform manual bench work operations, including deburring parts, performing press fits, and using bench vise and hand tools as applicable
D002: Perform manual layout operations, including laying out the location of hole centers and surfaces
D003: Perform between centers turning operations for straight turning
D004: Set up and carry out chucking operations for turning
D005: Perform routine power feed milling, using power feeds
D006: Perform routine vertical milling
D007: Perform routine surface grinding, location of surfaces, and squaring of surfaces, using manual surface grinders with a wheel 10" and smaller in diameter
D008: Perform routine drill press operations
D009: Set up and operate power saws for cutoff operations
D010: Explain the functions and operations of a CNC milling machine, CNC lathe, and wire-electric discharge machine (EDM)
D011: Write simple RS274-D programs, using G and M codes for a CNC milling machine and/or CNC lathe

DUTY E: Performing quality control and inspection
Task:
E001: Inspect simple parts, using precision tools and techniques
E002: Inspect samples for the required data according to a sampling plan
DUTY F: Performing process adjustment and improvement
Task:
F001: Make process adjustments or improvements to the production of a single part
F002: Participate as a member of a team for routine production process improvement
DUTY G: Performing general maintenance
Task:
G001: Perform general housekeeping and maintenance
G002: Perform preventive maintenance on machine tools
G003: Manage tooling maintenance
DUTY H: Communicating with others
Task:
H001: Demonstrate reading skills on a level required for employment in the machining industry
H002: Demonstrate writing skills on a level required for employment in the machining industry
H003: Demonstrate speaking skills on a level required for employment in the machining industry
H004: Demonstrate listening skills on a level required for employment in the machining industry

DUTY I: Applying mathematical operations
Task:
I001: Perform basic arithmetic operations
I002: Apply basic geometric concepts and terminology to machining tasks
I003: Apply basic algebraic concepts and terminology to machining tasks
I004: Apply basic trigonometric concepts and terminology to machining tasks
I005: Apply basic statistical concepts and terminology to machining tasks
DUTY J: Developing decision-making and problem-solving skills
Task:
J001: Apply decision rules
J002: Apply basic problem-solving methods
DUTY K: Developing social skills and personal qualities
Task:
K001: Apply social skills in situations requiring cooperative relations with supervisors, team leaders, and team members
K002: Apply a strong work ethic in the performance of job duties and in the maintenance of positive employment relations
DUTY L: Using engineering drawings and sketches
Task:
L001: Interpret standard orthographic blueprints
L002: Interpret geometric dimensioning and tolerancing (GDT) orthographic blueprints

L003: Sketch orthographic and isometric projections of parts
L004: Interpret engineering drawings having multiple auxiliary views
L005: Interpret geometric dimensioning and tolerancing (GDT) drawings with multiple datums
DUTY M: Applying measurements
Task:
M001: Apply basic measuring instruments
M002: Apply precision measuring instruments
M003: Apply surface plate instruments
DUTY N: Applying metalworking theory
Task:
N001: Apply cutting theory
N002: Select tooling
N003: Apply material properties theory
N004: Apply machine tools theory
N005: Apply cutting fluids and coolants theory
DUTY O: Applying properties of materials
Task:
O001: Apply the properties of various metals to cutting problems
O002: Apply the properties of various nonmetals to cutting problems

DUTY P:
Using computers in machining

Task:

P001: Demonstrate computer literacy on a level required for employment in the field of machining

P002: Use the computer as a tool for research and reporting of information

Task Definitions

Tasks in this section are founded on the NIMS standards, primarily those identified as Level I for program certification. Most tasks correspond directly to the NIMS standards. National and state experts in the occupational field of machine tool technology have validated tasks in this section. Each task is analyzed by identifying the following:

- a *task definition* (criteria for acceptable performance), which explains what the student has to do to perform the task at the expected level of mastery.
- *process/skill questions*, which assess student knowledge and performance.

Tasks are arranged by instructional duty area only. The placement of tasks into specific courses and the sequencing of tasks for instruction are local decisions based on student needs, employer demand, and school schedules.

DUTY A: Ensuring industrial safety and environmental protection
Task:
A001: Demonstrate safe workplace practices <i>Definition:</i> Process should include the following: <ul style="list-style-type: none">• adhere to safety rules while carrying out assigned responsibilities as outlined in tasks in Duty Area 4 of this document• demonstrate procedures related to first aid for injury or work-related illness• document safety activities as required Process/Skill Questions:
A002: Handle hazardous materials as assigned <i>Definition:</i> Process should include the following: <ul style="list-style-type: none">• identify, move, and store hazardous materials in compliance with OSHA and EPA requirements and guidelines• work as a member of a team to deal with routine handling and storage issues• document safety activities as required Process/Skill Questions

DUTY B:
Managing a career as a machinist

Task:

B001: Develop a short-term career plan

Definition: Process should include the following:

- research the industry to determine career opportunities in the machining industry
- write a career plan (1-4 years) that includes career objectives, strategies for obtaining required training and education, and employment opportunities
- create a resume appropriate to the machining industry
- make an oral presentation of the career plan and resume

Process/Skill Questions

B002: Complete job application procedures

Definition: Process should include the following:

- gather information about a potential employer; include employer's products and/or services, its management structure, and type of ownership through financial reports, safety and environmental protection records, and community reputation
- complete a job application accurately, completely, and legibly
- prepare for an interview by reviewing research, determining answers to frequently asked interview questions, writing down questions for the interviewer, and ensuring that appearance is appropriate
- participate in a job interview with an employer's representative
- follow up with a letter or telephone call expressing appreciation for the opportunity and continuing interest in the position (or politely declining further contact)

Process/Skill Questions

B003: Work as a member of a team to accomplish a goal

Definition: Working as a team member should include the following:

- contribute ideas for setting goals and designing objectives and strategies
- encourage contributions from others
- complete individual assignments
- evaluate and report team progress and process
- negotiate to resolve conflicts as they arise
- keep on task
- participate in group decision-making and problem-solving processes

Process/Skill Questions

B004: Explain the management structure of a local machining company

Definition: Explanation should include the following:

- purposes/goals of the company
- corporate chain of command
- responsibilities each department has to the company and effects each department has on the job
- machinist job performance and effect it has on each department
- management approach and supervision of employees
- employee recruitment procedures, training opportunities, evaluation methods, and retention strategies

Process/Skill Questions

B005: Identify rights and responsibilities of employees and employers in the machining industry

Definition: Process should include identification of the following key labor issues that employees should understand:

- uses of a written job description
- local, state, and federal legislation affecting employer and employee rights
- barriers to employment or job success faced by nontraditional and minority workers and ways to overcome these barriers
- requirements for hiring and promotion
- policies related to layoff and dismissal
- right to a safe and secure workplace
- career enhancement programs and advantages of participating in such programs
- certification requirements for specific jobs in the machining industry

Process/Skill Questions

B006: Identify principles of technology every employee should know to succeed in the machining industry

Definition: Process should include describing and/or predicting the following:

- major uses of technology in the industry
- potential impacts of new equipment on the company
- importance of continual upgrading of employee skills
- importance of cross-training

Process/Skill Questions

B007: Identify relationships between a machining company and the community

Definition: Process should identify the following:

- implications of good corporate citizenship
- ways companies and communities help each other
- potential effects of the public perception of the machining industry
- ways in which the individual employee can become reflective of the company's image

Process/Skill Questions

B008: Identify key elements of planning every employee should know to succeed in the machining industry

Definition: Process should include the following:

- a company's internal and/or external customers and advantages of responding to their wants and expectations
- comparison between companies that deliver products and those that deliver services
- various tools for planning
- ways companies use input from employees to make decisions
- effects of regulatory laws on operation
- methods of forecasting trends

Process/Skill Questions

B009: Explain the basic principles of personal finance management

Definition: Process should include the following:

- necessity for keeping financial records
- common payroll deductions
- compensation plans

Process/Skill Questions

**DUTY C:
Planning and managing machining jobs**

Task:

C001: Develop a process plan for a part requiring milling, drilling, turning, or grinding

Definition: Process should include the following:

- formulate a set of strategies to manufacture the part—one for fastest production, one for most accuracy
- fill out an operation sheet reflecting the chosen strategies, including the required speeds and feeds
- explain each of the steps in the process plan
- identify all major components and functions of the machine tools, all major hand tools, measuring tools, fixtures, and work materials
- provide the rationale for the speeds and feeds selected

Process/Skill Questions

C002: Write a set of directions for a machining-related task or project

Definition: Process should include the following:

- provide clear and accurate directions, sequenced correctly and sufficiently for the person receiving them to complete the task

Process/Skill Questions

**DUTY D:
Performing machining jobs**

Task

D001: Perform manual bench work operations, including deburring parts, performing press fits, and using bench vises and hand tools as applicable

Definition: Process should include the following:

- use files, scrapers, and coated abrasives to deburr parts until they are free of sharp edges or burrs
- tap holes in a newly machined part with holes prepared for tapping
- use an arbor press to a bushing in a hole prepared for the press fit
- install a stud, saw to within 1/32" of basic dimension, and square to the surface

Process/Skill Questions

D002: Perform manual layout operations, including laying out the location of hole centers and surfaces

Definition: Manual layout operations include laying out hole locations, radii, and surfaces, matching the specifications within an accuracy of $\pm.015"$ and based on the following criteria:

- apply layout ink to the surface appropriately
- strike lines once
- ensure intersections are clean and clear
- center punch marks on intersections

Process/Skill Questions

D003: Perform between centers turning operations for straight turning

Definition: Process should include the following:

- produce a part that matches process plan and blueprint specifications, using appropriate trade techniques, speeds, and feeds
- produce a part as specified with at least one shaft diameter within $\pm.0005"$, one UNC external thread, and one UNF external thread, and require an end-for-end swap
- produce finishes to at least 125 micro inches, with no sharp edges

Process/Skill Questions

D004: Set up and carry out chucking operations for turning

Definition: Process should include the following:

- produce a part that matches process plan and blueprint specifications, using appropriate trade techniques, speeds, and feeds
- produce a part as specified with at least three diameters within $\pm.005$ ", one bore within $\pm.001$ ", one UNC external thread, and one UNF internal thread
- complete at least two chucking or other work holding setups
- produce finishes to at least 125 micro inches, with no sharp edges

Process/Skill Questions

D005: Perform routine power feed milling, using power feeds

Definition: Process should include the following:

- set up and operate a horizontal or vertical milling machine, using power feeds
- produce a part matching the process plan and blueprint specifications
- square up the part from the unfinished state to within $.005$ " over 4"
- finish surfaces to 125 micro inches

Process/Skill Questions

D006: Perform routine vertical milling

Definition: Process should include the following:

- produce a part matching the process plan and blueprint specifications, using appropriate techniques, speeds, and feeds
- produce a part with at least one milled slot, squaring up part to within $.005$ " over 4"
- locate at least two drilled and reamed holes within $+.001$, $-.002$
- finish surfaces to 125 micro inches

Process/Skill Questions

D007: Perform routine surface grinding, location of surfaces, and squaring of surfaces, using manual surface grinders with a wheel 10" and smaller in diameter

Definition: Process should include the following:

- ensure safety by ring testing grinding wheels
- perform visual safety inspection
- mount and dress a grinding wheel to prepare for surface grinding
- use appropriate trade techniques to produce part to match process plan and blueprint specifications
- finish six surfaces of block, square to within $.001$ " over 4"
- produce finishes to at least 32 micro inches or better
- produce surfaces free of sharp edges

Process/Skill Questions

D008: Perform routine drill press operations

Definition: Process should include the following:

- set up and operate drill presses
- produce a part to match the process plan and blueprint specifications
- finish four center-drilled locations provided and laying out a fifth location; at least one hole must be a blind hole and one a through hole
- complete secondary operations, including reaming, spot facing, countersinking, counter-boring, and counter drilling
- produce finishes to at least 125 micro inches
- produce holes square to within .005 per inch; drilled diameters, +.006, -.000; reamed diameters +.001, -.000

Process/Skill Questions

D009: Set up and operate power saws for cutoff operations

Definition: Process should include the following:

- install appropriate blade in the power saw
- cut length of material to match cut list on process plan, accurate to within $\pm 1/64$ " and free of sharp edges

Process/Skill Questions

D010: Explain the functions and operations of CNC milling machine, CNC lathe, and wire-electric discharge machine (EDM)

Definition: Process should include the following:

- Explain formation of process plan and selection of appropriate tooling and work holding devices

Process/Skill Questions

D011: Write simple RS274-D programs, using G and M codes for CNC milling machine and/or CNC lathe

Definition: Process should include the following:

- create a program written with attention to speeds and feeds and enable end user to drive end-mill or cutting tool through a continuous path

Process/Skill Questions

**DUTY E:
Performing quality control and inspection**

Task:

E001: Inspect simple parts, using precision tools and techniques

Definition: Process should include the following:

- develop an inspection plan
- identify and select required measuring instruments
- complete required written inspection report
- make decision to reject or accept each part
- provide a brief oral report of inspection procedures, results, and decisions

Process/Skill Questions

E002: Inspect samples for the required data according to a sampling plan

Definition: Process should include the following:

- follow sampling plan
- collect data required for the process control chart
- work with the supplied control and warning limits to place the data, produce new data as needed, and graph the data
- take Stop or Go actions as indicated by the results
- provide brief oral explanation regarding decisions

Process/Skill Questions

**DUTY F:
Performing process adjustment and improvement**

Task:

F001: Make process adjustments or improvements to a production of a single part

Definition: Process should include the following:

- analyze performance of a single part production process
- propose process adjustments or improvements as appropriate
- seek authorization to implement process adjustments or improvements
- carry out process adjustments or improvements
- explain corrective actions and reason used to perform diagnosis

Process/Skill Questions

F002: Participate as a member of a team for routine production process improvement

Definition: Process should include the following:

- analyze performance of a routine production process, using fishbone diagram or other appropriate tool for cause-and-effect analysis

- propose process adjustments or improvements as appropriate
- seek authorization to implement process adjustments or improvements
- carry out process
- explain corrective actions and reasoning; connect root cause analysis to the remedial actions taken

Process/Skill Questions

**DUTY G:
Performing general maintenance**

Task:

G001: Perform general housekeeping and maintenance

Definition: Process should include the following:

- keep duty station clean and safe for work
- keep tools, workbenches, and manual equipment clean, maintained, and safe for work
- respond appropriately to safety hazards
- maintain cleanliness of general work area

Process/Skill Questions

G002: Perform preventive maintenance on machine tools

Definition: Process should include the following:

- inspect and assess general condition of an assigned machine tool
- make routine adjustments as authorized, or report problems to supervisor
- carry out daily, weekly, and/or monthly routine upkeep chores cited on checklists for given machine tools
- fill out history forms for tracking maintenance
- make brief oral report explaining condition of machine tools and actions taken
- keep maintenance and repair record on each machine tool

Process/Skill Questions

G003: Manage tooling maintenance

Definition: Process should include the following:

- inspect and assess condition of insert and conventional turning, milling, and drilling tools, refurbish tooling where appropriate, and refer tooling for repair or regrind where appropriate
- demonstrate the following skills
 - proper preparation of the grinding wheel
 - offhand grinding of a drill between the diameter of .125" and 1.000"
 - use of drills to produce holes within .005" of their nominal size
 - use of turning tool that cuts freely to produce a finish of 125 micro inches
 - cleanliness when working on the insert cutter body
 - correct rotation and replacement of inserts in an insert style milling cutter body
 - use of an indicator to show that all inserts are same height within .001"
 - ability of all inserts to cut as designed when cutter is placed into service

Process/Skill Questions

DUTY H:**Communicating with others****Task:****H001: Demonstrate reading skills on a level required for employment in the machining industry**

Definition: Process should include the following:

- locate and interpret written technical and nontechnical information commonly found in the machining industry (e.g., blueprints, tool crib inventory, handbook, inspection plan sampling plan, charting instructions, process plans, team documents, checklists, manuals, safety instructions)
- apply information gained from reading to plan, execute, evaluate tasks, and answer questions about the content or meaning of the written information

Process/Skill Questions

H002: Demonstrate writing skills on a level required for employment in the machining industry

Definition: Process should include the following:

- communicate machining-related technical and nontechnical information, messages, and ideas in writing (e.g., process plans, history forms, records of job activities, inspection activities, adjustment and improvement activities, maintenance activities, and materials handling and storage activities), using technical vocabulary and standard English

Process/Skill Questions

H003: Demonstrate speaking skills on a level required for employment in the machining industry

Definition: Process should include the following:

- demonstrate speaking skills commonly used in the machining industry (e.g., propose process remedies; explain process plans, job execution activities, inspections procedures, control charts and their role in process control, corrective actions, fishbone charts, root cause reasoning, condition of machine tools, maintenance actions, and safety activities; discuss ideas and strategies in group settings; question to gather information or encourage development of ideas; give instructions)
- communicate technical and nontechnical information, messages, multistep directions, and ideas orally in conversations, discussions, and group meetings, using standard English and related cues and communication aids
- respond appropriately to listener feedback, asking questions when needed in two-way and group conversations

Process/Skill Questions

H004: Demonstrate listening skills on a level required for employment in the machining industry

Definition: Process should include the following:

- demonstrate listening skills commonly used in the machining industry (e.g., following oral instructions; gathering information from conversation, interviews, or oral presentations; taking messages for others)
- receive, interpret, and recall specific details, ideas, and multistep instructions in oral presentations, conversations, discussions, and group meetings conducted in standard English and supported by written materials and other communication cues and aids
- use active listening skills to comprehend simple technical and nontechnical information given orally

Process/Skill Questions

**DUTY I:
Applying mathematical operations**

Task

I001: Perform basic arithmetic operations

Definition: Process should include the following:

- perform arithmetic operations commonly used in machining industry (e.g., calculating speeds and feeds, operation times, dimensions from blueprints, statistics required by control charts, impact of a change of speed or feed, length of time spent in a preventive maintenance activity; ascertaining volume of material stored)
- add, subtract, multiply, and divide whole numbers without a calculator
- convert between fractions and decimals, and perform calculations involving fractions and decimals with aid of a calculator

Process/Skill Questions

I002: Apply basic geometric concepts and terminology to machining tasks

Definition: Process should include the following:

- apply basic geometric concepts and terminology common to machining industry (e.g., select and sequence operations, hold work, produce surfaces, locate surfaces and centerlines, analyze operations and sequences, troubleshoot a machine tool or cutting tool)
- analyze parts for plane perpendicularity, Cartesian coordinates, concentricity, parallelism, straightness, flatness, circularity, and symmetry with an accuracy required by blueprints and industry standards

Process/Skill Questions

I003: Apply basic algebraic concepts and terminology to machining tasks

Definition: Process should include the following:

- apply basic algebraic concepts commonly used in machining industry (e.g., use trade formulas to prepare process plan, perform bench work and layout, operate machine tools, and perform inspection and control functions), solving for one unknown with standard trade formulas, with or without a calculator

Process/Skill Question

I004: Apply basic trigonometric concepts and terminology to machining tasks

Definition: Process should include the following:

- apply basic trigonometric concepts and terminology commonly used in machining industry (e.g., use trigonometry-based formulas to prepare process plan, perform bench work and layout, operate machine tools, perform inspection and control functions), consisting of solving for unknowns in right triangles, with or without a calculator

Process/Skill Question

I005: Apply basic statistical concepts and terminology to machining tasks

Definition: Process should include the following:

- apply basic statistical concepts commonly used in the machining industry (e.g., use SPC [statistical process control] as part of a process plan to control quality, analyze process performance, and evaluate safety performance), consisting of calculating means, medians, modes, and ranges, with or without a calculator

Process/Skill Question

**DUTY J:
Developing decision-making and problem-solving skills****Task:****J001: Apply decision rules**

Definition: Process should include the following:

- apply decision rules commonly used in the machining industry (e.g., sequence operations, follow process and quality plans, deviate according to decision rules where necessary; apply checklists and decision rules to process improvement; apply company procedures to housekeeping, PM, and TM; apply OSHA and EPA decision rules to the storage and handling of materials), consisting of following a set of instructions laid out in sequence and interpreting and following "if...then" instructions

Process/Skill Questions

J002: Apply basic problem-solving methods

Definition: Process should include the following:

- apply basic problem-solving methods commonly used in the machining industry (e.g., sequence operations, provide alternatives according to availability of tools and equipment, follow a process plan, improvise new methods where unavailability of tooling makes plan obsolete), consisting of responding to a variety of problems with "if...then" statements

Process/Skill Questions

**DUTY K:
Developing social skills and personal qualities**

Task:

K001: Apply social skills in situations requiring cooperative relations with supervisors, team leaders, and team members

Definition: Process should include the following:

- apply social skills commonly used in the machining industry (e.g., work cooperatively to develop a process plan, respond to need to share common work spaces, participate in SPC activities, develop process improvements, return common tools to their appropriate storage sites), demonstrating understanding, friendliness, politeness, and empathy toward others, including men, women, and people from a variety of ethnic, social, and educational backgrounds
- work cooperatively with others, and contribute to group efforts with ideas, suggestions, and positive feedback
- use negotiation and communication skills to resolve conflicts with supervisors, team leaders, and team members

Process/Skill Questions

K002: Apply a strong work ethic in the performance of job duties and in the maintenance of positive employment relations

Definition: Process should include the following:

- apply strong work ethic necessary to success in machining industry (e.g., demonstrate honesty and integrity in reporting findings of inspection processes; demonstrate attendance and punctuality in attending meetings for the development of process improvement; demonstrate honesty and perseverance in handling of materials according to EPA requirements), consisting of recognizing and demonstrating appropriate codes of conduct and values in the workplace
- demonstrate honesty and integrity in exhibiting appropriate workplace behaviors
- assume responsibility for performance of tasks according to high standards
- maintain high standards of attendance, punctuality, and involvement in all major work tasks

Process/Skill Questions

DUTY L:
Using engineering drawings and sketches

Task:

L001: Interpret standard orthographic blueprints

Definition: Process should include the following:

- interpret standard orthographic blueprints
- gather geometric and dimensional data to sequence operations
- perform layout
- perform inspection of a finished part
- prepare a checklist for determining dimensional compliance of a finished part

Process/Skill Questions

L002: Interpret geometric dimensioning and tolerancing (GDT) orthographic blueprints

Definition: Process should include the following:

- interpret GDT orthographic blueprints
- gather geometric and dimensional data to sequence operations
- perform layout
- perform inspection of a finished part
- prepare a checklist for determining dimensional compliance of a finished part

Process/Skill Questions

L003: Sketch orthographic and isometric projections of parts

Definition: Process should include the following:

- sketch an assigned part or detail in a support quality report

Process/Skill Question

L004: Interpret engineering drawings having multiple auxiliary views

Definition: Process should include the following:

- interpret engineering drawings commonly used in the machining industry (e.g., interpret drawings during CNC programming, process planning, and inspection using CMM [Coordinate Measuring Machine]), using a print with auxiliary views to inspect a part for compliance

Process/Skill Questions

L005: Interpret geometric dimensioning and tolerancing (GDT) drawings with multiple datums

Definition: Process should include the following:

- interpret geometric dimensioning and tolerancing commonly used in the machining industry (e.g., interpret drawings during CNC programming, process planning, and inspection using CMM), using GDT principles to inspect a part for compliance

Process/Skill Questions

**DUTY M:
Applying measurements**

Task:

M001: Apply basic measuring instruments

Definition: Process should include the following:

- take basic measurements in machining industry (e.g., set length of layout tools, inspect dimensions of a finished part), using rules, protractors, and basic transfer tools, such as simple inside and outside calipers, to determine the compliance of a part of selected dimensions

Process/Skill Questions

M002: Apply precision measuring instruments

Definition: Process should include the following:

- apply precision instruments in machining industry (e.g., determine the concentricity of a turned part to a lathe's spindle, inspect dimensions of a finished part), using a micrometer, vernier, dial, electronic calipers, dial indicators, and precision transfer tools, such as telescoping gauges and adjustable parallels, to determine the compliance of a part of selected dimensions

Process/Skill Questions

M003: Apply surface plate instruments

Definition: Process should include the following:

- use precision tools and instruments for surface plate work, such as precision angle plates and tool blocks, precision transfer gauges, and precision height gauges

Process/Skill Questions

DUTY N:
Applying metalworking theory

Task:

N001: Apply cutting theory

Definition: Process should include the following:

- explain ideas of heat, shock, friction, zone of distortion, cutting interface, machinability, cutter presentation, cutter geometry, and chip-holding capacity as they relate to machining applications
- select speeds, feeds, and appropriate tooling to manufacture a part
- discuss part rigidity

Process/Skill Questions

N002: Select tooling

Definition: Process should include the following:

- identify a variety of cutting tools, tool-holding devices, and work-holding devices and appropriate application of these cutters and devices

Process/Skill Questions

N003: Apply material properties theory

Definition: Process should include the following:

- apply material properties theory (e.g., predict speeds, feeds, and tooling requirements based on known properties of a material; respond to cutting conditions imposed by material properties), identifying common materials and their principal properties relevant to machining tasks
- recognize differences among ferrous, nonferrous, magnetic, and ductile materials
- explain the changes to materials caused by heat-treating
- predict machinability of a part based on its appearance, its call-out value on the blueprint, and its supplied hardness value

Process/Skill Questions

N004: Apply machine tools theory

Definition: Process should include the following:

- apply machine tools theory (e.g., select appropriate machine tools for a given set of operations, operate machine tools to execute a specific operation, participate in machine capability study)
- identify common classes of machine tools
- explain function of major subsystems of machine tools

- select and apply given machine tool appropriately

Process/Skill Questions

N005: Apply cutting fluids and coolants theory

Definition: Process should include the following:

- apply cutting fluids and coolants theory (e.g., select appropriate coolants and delivery systems for a selected set of operations, operate machine tools to execute a specific operation, use specified coolants and coolant delivery systems) by identifying, selecting, and using appropriate coolants and coolant delivery systems

Process/Skill Questions

**DUTY O:
Applying properties of materials**

Task:

O001: Apply the properties of various metals to cutting problems

Definition: Process should include the following:

- determine appropriate cutter geometry and speeds and feeds for cutting various metals during turning, milling, drilling, radial drilling, and CNC operations

Process/Skill Questions

O002: Apply the properties of various nonmetals to cutting problems

Definition: Process should include the following:

- determine appropriate cutter geometry, speeds, and feeds for cutting various nonmetal materials during turning, milling, drilling, radial drilling, and CNC operations

Process/Skill Questions

**DUTY P:
Using computers in machining**

Task:

P001: Demonstrate computer literacy on a level required for employment in the field of machining

Definition: Process should include the following:

- demonstrate computer literacy needed to perform tasks common to machining industry (e.g., complete records and storage and retrieval of maintenance records)
- use common software to accomplish word processing, construction of simple spreadsheets, and keying in and retrieving information from databases
- transfer operating principles of one application to another similar application
- use knowledge of computer logic, operating systems, and basic troubleshooting techniques to identify problems (e.g., insufficient memory, misplaced files)

- use special job-specific computer equipment, software, and other technology

Process/Skill Questions

P002: Use the computer as a tool for research and reporting of information

Definition: Process should include the following:

- search the Internet for appropriate sources of information
- download information and evaluate it for accuracy and adequacy
- follow procedures for ethical use of Web information or e-mail
- enhance reports with graphics or other design elements

Process/Skill Questions

SkillsUSA

Task Definitions

DUTY A: Self-improvement
Task:
<p>A001: Complete a self-assessment, and identify individual learning styles</p> <p><i>Definition:</i> Process should include the following:</p> <ul style="list-style-type: none"> • Identify and list individual strengths • Identify and list areas in need of improvement <p>Process/Skill Questions</p>
<p>A002: Discover self-motivation techniques, and establish short-term goals</p> <p><i>Definition:</i> Process should include the following:</p> <ul style="list-style-type: none"> • Develop a list of short-term goals • Discuss ways to change or improve lifestyle, appearance, and behavior <p>Process/Skill Questions</p>
<p>A003: Determine individual time-management skills</p> <p><i>Definition:</i> Process should include the following:</p> <ul style="list-style-type: none"> • Prepare and keep a time journal • Discuss ways to improve time-management skills <p>Process/Skill Questions</p>
<p>A004: Define future occupations</p> <p><i>Definition:</i> Process should include the following:</p> <ul style="list-style-type: none"> • Search the Internet for career opportunities within specified fields of study • Prepare a presentation on a specified career area <p>Process/Skill Questions</p>
<p>A005: Develop awareness of cultural diversity and equity issues</p> <p><i>Definition:</i> Process should include the following:</p> <ul style="list-style-type: none"> • Research a tradition modeled by individual's family • Develop personal philosophy statements regarding gender equity <p>Process/Skill Questions</p>

A006: Define the customer

Definition: Process should include the following:

- Differentiate between external and internal customers
- Discuss factors that contribute to poor customer relationships

Process/Skill Questions

A007: Recognize benefits of doing a community service project

Definition: Process should include the following:

- Discuss and list ways to become involved in the community
- Develop a community service project

Process/Skill Questions

A008: Demonstrate effective communication with others

Definition: Process should include the following:

- Identify and list personal barriers to listening
- Develop personal plan to overcome barriers to listening

Process/Skill Questions

A009: Participate in a shadowing activity

Definition: Process should include the following:

- Summarize experience of job-shadowing activity

Process/Skill Questions

A010: Identify the components of an employment portfolio

Definition: Process should include the following:

- Identify parts of a portfolio
- Design a personal employment portfolio

Process/Skill Questions

A011: List proficiency in program competencies

Definition: Process should include the following:

- Complete an interpersonal competency assessment

Process/Skill Questions

DUTY B:
Civic, Social, and Business Awareness

Task:

B001: Measure/Modify short-term goals

Definition: Process should include the following:

- Discuss steps to pursue short-term goal(s)

Process/Skill Questions

B002: Identify stress sources

Definition: Process should include the following:

- List personal sources of stress
- Discuss techniques to cope with individual sources of stress

Process/Skill Questions

B003: Select characteristics of a positive image

Definition: Process should include the following:

- Discuss actions and traits that lead to a positive image
- Discuss actions and traits that lead to a negative image

Process/Skill Questions

B004: Demonstrate awareness of government, professional organizations, and trade unions

Definition: Process should include the following:

- Identify state governor, legislators, and senators
- Identify professional organizations pertaining to specific career areas

Process/Skill Questions

B005: Apply team skills to a group project

Definition: Process should include the following:

- Form a team to develop a class project

Process/Skill Questions

B006: Observe and critique a meeting

Definition: Process should include the following:

- Attend a formal meeting held within the community
- Critique the attended meeting

Process/Skill Questions

B007: Demonstrate business meeting skills

Definition: Process should include the following:

- List and discuss the basic rules to ensure an orderly and businesslike meeting
- Role-play appropriate meeting skills

Process/Skill Questions

B008: Demonstrate social etiquette

Definition: Process should include the following:

- Role-play appropriate social behavior
- Differentiate between good and bad manners

Process/Skill Questions

B009: Complete survey for employment opportunities

Definition: Process should include the following:

- Gather information on a particular employment opportunity of interest
- Conduct an Internet search of a specific career area

Process/Skill Questions

B010: Review a professional journal and develop a 3- to 5-minute presentation

Definition: Process should include the following:

- Develop a presentation on the content, purpose, and distribution of a particular professional journal

Process/Skill Questions

B011: Identify customer expectations

Definition: Process should include the following:

- List and discuss customer expectations
- Discuss consequences of unmet customer expectations

Process/Skill Questions

B012: Complete a job application

Definition: Process should include the following:

- Obtain a job application from various businesses in the community
- Conduct a mock job interview

Process/Skill Questions

B013: Identify a mentor

Definition: Process should include the following:

- Define *mentor*
- Discuss ways in which a mentor can help an individual meet career goals

Process/Skill Questions

B014: Assemble your employment portfolio

Definition: Process should include the following:

- Develop employment portfolio

Process/Skill Questions

B015: Explore supervisory and management roles in an organization

Definition: Process should include the following:

- Examine an organizational chart
- Discuss responsibilities of managers and supervisors

Process/Skill Questions

B016: Recognize safety issues

Definition: Process should include the following:

- Discuss safety issues within a given career area

Process/Skill Questions

B017: Evaluate your proficiency in program competencies

Definition: Process should include the following:

- Define *task* and *competency*
- List competencies associated with a specified career area

Process/Skill Questions

Curriculum Frameworks

Purpose

This section of the framework contains material to help instructors in technical and professional programs reinforce basic skills in the areas of reading and writing, mathematics, and science. The technical portion of this guide takes a more direct approach by using specific duty and task listings, but changes in the academic section lead in a more general direction. The reason for this is simple: All good instructors do not teach in the same way. However, all good instructors share the trait of being able to connect their material to everyday life. For example, understanding concepts related to heat is important for cosmetology students as well as lathe operators in manufacturing plants. However, each program will probably take a different approach in the amount of detail and examples relating to heat concepts. Both groups require basic science knowledge of principles relating to heat, but the application of the principles will be different.

Basic Skills: The Content Areas

Included in this guide are materials to support basic skills in reading and writing, mathematics, and science. The overall approach taken here is a move toward problem-solving skills. By problem solving, we mean the ability to take information and use it for a purpose: to take action, make decisions, predict outcomes, suggest improvements. Another term for these thinking skills is a general “literacy.”

Literacy skills always have been in demand in the workplace. A quick review of workplace training programs and other literature regarding adult education demonstrates that the need for a literate workforce is still one of the most pressing problems employers face today. Indeed, many employers (from small- and medium-sized businesses to Fortune 500 companies) have spent hundreds of millions of dollars on in-house basic skills training programs.

What constitutes a literate workforce? There are many definitions for literacy and hundreds of tests that measure it, but when employers are asked what they’re looking for in potential new hires, the answers are general: They want individuals who can read and write; show up on time;

think and solve problems; and keep their personal lives in order (that is, don't bring a drinking problem into the workplace).

Viewed in this way, the words “literacy” and “literate” are good terms for what educators are trying to instill in their students, the future workforce. The more common definition (being able to read and write) is certainly appropriate, but the additional definitions (knowledgeable, educated, and well-informed) are also apt. It is this broad term, “literate,” that we use to guide instructors on what to cover in the classroom. No matter which Career and Technical Education area is being focused on, no matter how technical the terminology is, instructors are given the task of helping students take information, break it down into necessary parts, process details, and be able to come away with an understanding of some sort. This is “literacy,” and the process is the same for every subject area—teaching students how to think and solve problems.

Format

Each section includes a two-column table. Skills are listed on the left side; suggestions for implementing these skills into the curriculum are listed on the right side. Each suggestion is written in such a way that it can be tailored to most Career and Technical Education programs.

Using the Guide

This guide was prepared with four concepts in mind:

- The instructor is *aware of the need* for students to improve their basic skills.
- The instructor is the *best-qualified person* to decide how to include this material in the classroom or lab. The students' abilities and needs should drive the instructor in deciding how to use, expand, or modify these topics.
- The instructor *already has curriculum that works* for his or her students. Therefore, the suggestions for reinforcing basic skills
 - must be easy to implement.
 - must stand alone.
 - do not need to be taught in a particular order.
 - must be open-ended enough to be useful for any career and technical program.

- ***Time is limited.*** Unless there are quick ways to reinforce basic skills, changes to the curriculum will not be made. Teaching basic skills in the context of technical material will help students make connections that are more memorable and will require no additional lesson planning. Just as instructors incorporate updates in technical knowledge, they can add basic skills concepts as well. Adding a few concepts at a time will help students perform better in the lab as well as on tests and evaluations.

Methods

The following methods may help instructors decide how to increase basic skill knowledge:

- *Collaborative projects*—how could a joint project between regular education teachers and vocational instructors reinforce concepts for both programs?
- *Outside assignments*—would students benefit from an outside assignment explaining how a basic math (science, reading) concept ties to a process in the lab?
- *Extra credit*—students needing extra credit can research outside topics and turn in a short summary of material.
- “*Need-to-know*” *assignments*—students prepare a bulleted list of the basic concepts in science they need to know to correctly perform operations in the lab.
- *Question of the day*—a few daily math problems for students to answer at the beginning of class allow the instructor to set the tone for the material. This method also gives students an immediate goal when they enter the classroom and teaches them to stay on task. Bonus points may be awarded at the end of the week, quarter, semester, etc.
- *Two-minute oral presentations*—students who need to practice speaking skills can be asked to give a two-minute oral presentation at the end of class summarizing the main points for the day. Or, a two-minute presentation at the beginning of class can recap the material from a previous class.
- *Connecting with workers*—students can poll parents, friends, area employers, or other people to find out the top five basic science skills needed on the job.
- *Direct questioning*—include a few basic knowledge questions in a presentation. Award points to groups based on correct answers.

Resources

In creating the Academic Reinforcement material for the technical and professional frameworks, we used a number of source documents and resources.

- The English Language Arts, Science, and Mathematics components of the *Curriculum Improvement Project* by Dr. Willard Daggett were consulted to ensure that the top-ranked skills in those areas would be reflected in the academic support material. The English Language Arts and Science components have many linkages to the material included here. (The higher-level math skills, such as trigonometry, were not included in this document.)
- The Workplace Skills Enhancement Program (WSEP) at the University of Arkansas at Little Rock (UALR) has completed many training projects and job profiles for employers in Arkansas and has collected data from this work with Arkansas employers. Our constant contact with workers and employers provides a tremendous amount of data that we use in designing customized training programs and in working on projects such as curriculum frameworks. Also, the staff of WSEP has experience teaching in Arkansas public schools, the U.S. military, and Job Corps.
- Additionally, other groups within UALR (the Labor Education Program, the Institute for Economic Advancement, and the College of Business) provide resources regarding health and safety information, labor unions and their role in the workplace, computer and information technology, and other training and outreach program data.
- The U.S. Department of Labor (DOL) has many online documents and publications that support workers and issues regarding the workplace. (Work by Philippi and Greenan, 1988, on workplace skills was especially helpful.) Visit the Web site at www.dol.gov.
- The Occupational Safety and Health Administration (OSHA) provides online and other resources for instructors and professionals. For topics relating to safety and health, visit www.osha.gov.
- The Multistate Academic and Vocational Curriculum Consortium (MAVCC) is an organization that develops competency-based curriculum. For more on MAVCC, see www.mavcc.org.

ACADEMIC STANDARDS FOR READING AND WRITING

Strategies for Reinforcement in the Career and Technical Education Classroom

Note:

* indicates industry-related materials, handouts, notes, etc.

Objective	Classroom Applications to Industry
<p><i>Present</i> <i>Review, and discuss</i> Master the list of skills employers want for the workplace regarding reading and writing</p>	<p>Use the list of skills employers want to introduce students to the requirements of the workplace.</p> <p>Depending on students' ability levels, any of the following methods may be used to increase their understanding of the concepts:</p> <ul style="list-style-type: none"> • Discussion • Interviewing parents or other adults in the workplace about the skills required • Interviewing employers about the skills in terms of importance • Identifying workplace situations in which certain skills become more important than others • Researching adult education programs to learn why deficits in these areas must be remediated and the cost spent yearly on these programs • Researching the topic of adult literacy
<p><i>Answer</i> simple comprehension or recall questions from a lecture or from written material</p>	<p>Provide two examples of workplace materials* on students' reading level. With the first, allow students to read information and then answer brief recall questions. With the second example, read aloud the material but do not give a handout. Ask brief recall questions.</p> <p>Compare the differences. How do students retain information better—orally or visually? Discuss learning styles and impact on the job.</p>

<i>Follow, give</i> oral instructions	Using instructions for a hands-on task, have students give <u>oral</u> instructions to a partner or group. Rate the effectiveness of the speaker.
<i>Follow, give</i> written instructions	Using a short list of instructions for a hands-on task, have students give <u>written</u> instructions to a partner or group. Rate the effectiveness of the speaker.
<i>Show the difference between relevant and irrelevant details</i>	Using a copy of workplace materials*, students underline relevant or important details in red, irrelevant or less important details in blue.
<i>Sort objects based on x number of criteria</i>	Using workplace materials*, sort a group of objects based on characteristics identified by instructor (e.g., by color, shape, defect, or a combination of these).
<i>Recognize, identify</i> technical vocabulary	Using workplace materials*, highlight technical vocabulary terms. Create a class dictionary of industry-related technical vocabulary. Students may add illustrations or diagrams. Each student receives a copy of the final product. Emphasize skills such as alphabetical order, guidewords, prefixes, suffixes, and pronunciation guides.
<i>Read aloud</i>	Read aloud from workplace materials* in groups or individually.
<i>Identify, explain</i> symbols, abbreviations, and acronyms relevant to subject area	Using workplace materials*, highlight symbols, abbreviations, and acronyms. Create a table with one column for each: symbols, abbreviations, acronyms. Classify each one and write in the meaning.
<i>Understand, use</i> rules of grammar, usage, spelling, punctuation	Identify the missing punctuation marks, misspelled words, and incorrect use of grammar from workplace materials*. Correct the mistakes.

<i>Discuss</i> uses and purposes of a variety of workplace communication tools	Find examples of a business letter, memo, report, brochure, proposal, schematic, map, and diagram.
<i>Duplicate</i> process demo by instructor	Using a workplace process, demonstrate steps to complete and have students perform individually or in groups.
<i>Notice, apply</i> word analysis techniques	Using workplace materials*, identify prefixes, suffixes, or roots that indicate meaning (e.g., therma = heat). ¹
<i>Match</i> parts from photographs or diagrams to actual objects	Using workplace materials*, follow a sequence of pictures or diagrams to build, create, or copy an item or process.
<i>Read</i> for main ideas and details	Use a graphic organizer ¹ to show main ideas and supporting details.
<i>Distinguish</i> between fact, opinion, and inference	Collect examples of materials based on fact or opinion/inference. Ask students to underline key terms that indicate the presence of facts or opinions.
<i>Distinguish</i> between rows and columns	Using charts or tables from workplace materials*, discuss the reasons for this format.
<i>Identify</i> a cell as a block where a row and column intersect	Identify the quantity in a particular cell.
<i>Select, use</i> appropriate resources and reference tools	<p>Explain the uses for the following: dictionary, thesaurus, almanac, atlas, card catalog, encyclopedia.</p> <p>List reasons for choosing one reference tool over another.</p> <p>Use reference tools to answer questions related to industry or current events.</p>
<i>Paraphrase</i> written or oral material into summary form	<p>Using workplace materials*, determine the best way to condense or shorten the material so as to give an overview to a layperson.</p> <p>Using a set of guidelines appropriate to</p>

	students' level in length and detail, summarize the information into bullet points.
<i>Interpret, fill out/complete forms and records</i>	Using workplace materials*, answer basic questions (e.g., summarize the list of parts from an inventory). Using blank forms or documents, fill in details. Pay close attention to directions. Students critique work with a partner. Create a form or document to be used in a workplace process.
<i>Use, develop a process for remembering details</i>	Use pneumatic devices to organize and remember details. Pneumatic devices ¹ include Semantic Maps, Thought Webs, and other creative tools to organize thinking.
<i>Proofread, correct mistakes in written drafts</i>	Using a newspaper article, locate and mark mistakes in grammar, punctuation, or usage. Correct mistakes in written drafts.
<i>Examine different types of writing used in the workplace (reports, memos, brochures, logs, blueprints, formulas, etc.)</i>	Gather samples of workplace materials*. Identify each by type. Compare and contrast the difference between: <ul style="list-style-type: none"> • audience (who the document is written for) • length • background information/education needed to understand material • level of detail • organization and layout of the document
<i>Understand the writing process</i>	In order to apply the writing process, create a workplace communication tool to be used for a specific purpose. Prewrite: Brainstorm, gather facts, or do research to create a <u>business letter, memo, report,</u>

	<p><u>brochure, proposal, schematic, map, or diagram.</u></p> <p>Identify the audience.</p> <p>Determine the purpose of the document.</p> <p>Write: Create a first draft.</p> <p>Revise and edit: Make changes to ensure accuracy.</p> <p>Look at the writing from a different point of view.</p> <p>Shorten or make more concise where possible.</p> <p>Use white space, bold print, and other formatting details to make the document easy to read.</p> <p>Publish: Decide on the best format for the final copy (size, type of material, layout, graphics, etc.)</p> <p>Publish the final draft.</p>
<p><i>Identify, create</i> sentences of different types</p>	<p>Using workplace materials*, find sentences of varying types. Examples include simple sentences (subject + predicate) and complex sentences (subject + predicate including clauses).</p> <p>Write sentences, paragraphs, or essays using sentences of different types (e.g., write a two-paragraph summary of today's lesson).</p>
<p><i>Identify, use</i> contractions correctly</p>	<p>Using workplace materials*, locate contractions (e.g., isn't, I'll).</p> <p>Identify misuses of contractions.</p> <p>Write a short list of directions relating to an</p>

	industry process, and use as many contractions as possible.
<i>Identify, use correctly</i> commonly misspelled words	<p>Using a list of commonly misspelled words¹, locate errors in the media (newspaper articles, Internet sites, magazines).</p> <p>Ask each student to identify his/her problem words from the list.</p> <p>Attempt to incorporate problem words into class activities (e.g., add them to a list of work instructions).</p> <p>Give short weekly quizzes focusing on five words per week. Award bonus points.</p>
<i>Identify, use correctly</i> the English irregular verbs	<p>From a list of irregular verbs, review the uses of each.</p> <p>Ask each student to identify his/her problem irregular verbs from the list.</p> <p>Attempt to incorporate problem verbs into class activities, such as making a collection of mistakes from print sources.</p>
<i>Identify, use</i> signal words and other cues to improve writing	<p>Use a list of signal words¹ and discuss their purpose in writing (signal words are words that raise a flag to a reader to pay attention). Examples --</p> <p>Signal words showing emphasis: Most of all, It should be noted, Of course</p> <p>Signal words showing a conclusion: Lastly, In summary, Finally</p> <p>Identify common signal words in workplace writing, especially in sequenced lists.</p> <p>Write a list of work instructions using signal words.</p>
<i>Identify</i> components of workplace documents such as blueprints, schematics, floor plans, and other	Label the parts of a workplace document.

industry-related documents	
<i>Place steps in proper sequence</i>	Using a list of steps or pictures, cut them apart so students can place them in the proper order.
<i>Analyze cause and effect</i>	Experiment with cause and effect in the classroom (e.g., change the sequence of events in a process).
<i>Determine missing information</i>	Locate the information that is missing from a problem, and explain why the problem cannot be solved without it. To reinforce concepts, use a completed problem and remove the important details. Ask students if they can identify what's missing.
<i>Differentiate between tools used for a job</i>	Given a list of tools and a list of functions, identify the most efficient tool for each task.
<i>Assemble or disassemble objects</i>	From a list of oral or written instructions, assemble an object or complete a process. Have students write the instructions for disassembly.
<i>Cross-reference materials to compare information</i>	Using more than one source document, compare the information given.
<i>Interpret reasoning behind rules or regulations</i>	Using workplace materials*, make a list of possible reasons or justifications for a safety guideline, regulation, etc.
<i>Show contrasts between approaches</i>	Given a workplace scenario, write a brief approach to solving the problem. (Working in groups would be beneficial.) Compare and contrast each approach from the perspective of a worker, manager, supervisor.
<i>Organize data in a new format</i>	Using workplace materials*, organize the information into a new format.

<i>Prove a rule or method's sufficiency</i>	Perform an experiment to determine how much tolerance is acceptable in a case study (e.g., find the range of drops of red dye sufficient to match the standard red color used in latex paint).
<i>Show relationships between two or more systems</i>	Using two or more partners related to industry, show or explain how they are interrelated (e.g., explain the relationship between social workers and hospitals).
Given examples of emergency situations, identify a real-world course of action	Using an emergency situation common to your industry, outline a step-by-step plan for action.
<i>Identify variables that affect the outcome of a process</i>	Experiment with or predict variables that affect the outcomes for a process (e.g., weather patterns that adversely affect a process, such as building a road).
<i>Infer situations that meet guidelines when complete information is not available</i>	Given a policy or industry standard that has debatable interpretations, list possible situations that can arise that do not have clear solutions in the policy. Discuss or debate the issues.
<i>Compare finished products to a set of guidelines</i>	Compare a set of objects to a set of guidelines (e.g., analyze a batch of parts and document how they do or do not meet a set of Quality Assurance guidelines). List any discrepancies (parts that do not meet guidelines) and categorize them by type (e.g., burns, holes, etc).
<i>Identify preventive measures for maintenance of a system</i>	List the needed routine maintenance to keep a system working properly.
<i>Predict new standards or rules that may become necessary in the future</i>	Identify recent areas of change or development in your industry. Discuss potential future needs or developments that may occur (e.g., potential need for better training requirements for airport personnel).

<p><i>Improve a process by streamlining (locating waste) or decreasing lost time</i></p>	<p>Examine a process in industry in step-by-step detail. Suggest ways to decrease time needed or make the process more efficient.</p> <p>Isolate the cause of failure in a process by performing an experiment.</p>
<p><i>Prepare a model explaining a concept</i></p>	<p>Build, draw, or create a model that explains a concept (e.g., show a need for environmental standards for water or air pollution).</p>

¹ Fry, Edward; Kress, Jacqueline; Fountoukidis, Dona. *Reading Teacher's Book of Lists*, 4th ed. ISBN 0-13-028185-9.

ACADEMIC STANDARDS FOR MATHEMATICS

Strategies for Reinforcement in the Career and Technical Education Classroom

Note:

* indicates industry-related materials, handouts, notes, etc.

Topics Listing

- Problem Solving
- Operations and Calculations
- Applications
- Data Analysis and Display

Objectives

Classroom Applications to Industry

<p><i>Present</i> <i>Review and discuss</i> Master the list of skills employers want for the workplace regarding mathematics</p>	<p>Use the list of skills employers want to introduce students to the requirements of the workplace.</p> <p>Depending on students' ability levels, any of the following methods may be used to increase their understanding of the concepts:</p> <ul style="list-style-type: none"> • Discussion • Interviewing parents or other adults in the workplace about the skills required • Interviewing employers about the skills in terms of importance • Identifying workplace situations in which certain skills become more important than others • Researching adult education programs to learn why deficits in these areas must be remediated and the cost spent yearly on these programs • Researching the topic of adult literacy
<p>PROBLEM SOLVING</p>	
<p><i>Examine, apply problem-solving process</i></p>	<p>Define the problem What is being asked?</p> <p>Decide on a type of solution. Multistep or single-step question?</p>

	<p>Try any of these:</p> <ul style="list-style-type: none"> • Estimate an answer • Draw a diagram • Find a pattern • Guess and check • Logical reasoning • Make a graph • Make an organized list • Make a table • Solve a simpler problem • Use a simulation • Work backwards • Write an equation <p>Locate information you need. Do you have all the components?</p> <p>Get missing information. You may need to perform some other calculations</p> <p>Calculate. Look at the answer. How should the remainder be expressed?</p> <p>Check the solution. Is it reasonable?</p>
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OPERATIONS AND CALCULATIONS

<i>Read, write and count numbers</i>	<p>Read and write numbers (especially focus on very large and very small numbers where mistakes are common).</p> <p>Give a weekly quiz asking students to compare and sequence numbers. Example: 0.4445 ___ 0.4455 > or <</p> <p>Put these in order from smallest to largest: 0.66, 0.677, 0.67</p>
<i>Round numbers</i>	<p>Discuss your industry's use of decimals.</p> <p>Identify the place values needed to adequately perform a job. For example, a Quality Assurance Technician who works on the line</p>

	<p>in a manufacturing plant may need to use numbers through the ten-thousandths decimal place.</p> <p>Take a series of sample measurements, and round them to the nearest decimal place identified by the instructor.</p>
<i>Estimate numbers</i>	<p>The skill of making close estimations is tied to understanding accuracy. Discuss real-life situations in which estimation is used.</p> <p>Discuss the practice of estimation before calculation. Regular practice in estimating before calculating will teach students where they make errors and will increase their estimation skills.</p> <p>Discuss work situations in which estimation skills are required and possible consequences of making estimation errors. For example, is an estimate appropriate for inventory purposes? For ordering supplies?</p>
<i>Compute averages</i>	<p>Discuss averages in general terms. Calculate the average temperature, average rainfall or precipitation, average number of students per class, and other relevant examples.</p> <p>Using workplace materials*, calculate a series of averages. For example:</p> <ul style="list-style-type: none"> • Take 10 different measurements of a piece of pipe using a micrometer. • Compare the measurements. • Find the average of all the measurements. • Compare the average to the smallest and largest measurement. • Discuss the effects on quality. When is an average an acceptable benchmark measurement?
<i>Calculate with whole numbers; perform one-step problems with basic operations</i>	<p>Understand, at a level of complexity appropriate to your industry and to students' ability levels, basic principles of addition,</p>

	subtraction, multiplication, and division.
Perform problems that require an understanding of the order of operations	<p>Using workplace materials*, make a list of situations or problems that need more than one step to perform them.</p> <p>If the procedures (add, subtract, multiply, divide, etc.) are on the same level of importance, such as adding or subtracting, then the order of operations will not impact the way the problem is solved.</p> <p>If a problem requires more than one level of operation to solve (example, dividing and adding), work the problem correctly by performing the division part first and then the addition. Rework the problem using addition first. Compare the answers.</p> <p>Discuss the importance of reasoning skills to verify that an answer makes sense.</p>
Understand the relationship between decimals, fractions, and percentages	Make a table comparing fractions, decimals, and percentages.
Compute with fractions, decimals, and percentages, and show an understanding of the relationship between them	<p>Create sample problems using fractions that relate to everyday situations.</p> <ul style="list-style-type: none"> ▪ Poll the class on interesting topics (favorite food). Convert whole numbers to fractions. Votes: Pizza- 10 Salad- 2 BBQ- 8 <p>$10+2+8 = 20$ (recognize denominator value)</p> <p>$\frac{10}{20}$ Pizza $\frac{2}{20}$ Salad $\frac{8}{20}$ BBQ</p> <ul style="list-style-type: none"> ▪ Add the fractions. $\frac{10}{20} + \frac{2}{20} + \frac{8}{20} = \frac{20}{20}$ ▪ Convert the fractions to a whole number. (Total answer equals one class' worth of answers.)

	$\frac{10}{20} + \frac{2}{20} + \frac{8}{20} = \frac{20}{20} = 1$ <ul style="list-style-type: none"> ▪ Convert the fractions to percentages. $\frac{10}{20}$ means 10 divided by 20 = 0.50 0.50 = 50% <p>Move the decimal two places to the right. 0.50 = 50%</p> <ul style="list-style-type: none"> ▪ $\frac{2}{20}$ means 2 divided by 20 = 0.10 0.10 = 10% <ul style="list-style-type: none"> ▪ $\frac{8}{20}$ means 8 divided by 20 = 0.40 0.40 = 40% <p>50% + 10% + 40% = 100% Notice the totals add to 100%.</p> <p>So, $\frac{20}{20} = 1 = 100\%$</p> <p>Using workplace materials*, calculate work-related questions using fractions, decimals, and percentages.</p> <p>Calculate shipping costs for Internet purchases (such as music from amazon.com).</p>
Solve formulas and equations	<p>Understand, at a level of complexity appropriate to your industry and to students' ability levels, basic principles of equations.</p> <ul style="list-style-type: none"> ▪ Work left to right ▪ Use order of operations ▪ Place numbers on one side, variables on the other side
Obtain squares and square roots	<p>Review the methods for calculating squares, square roots, cubes, and cube roots. Use industry-related formulas to demonstrate examples.</p> <p>Compare the difference between the two common answers to 32 (answer = 9, not 6).</p>

	How would an incorrect value affect the work on the job?
<i>Convert units of measure:</i> <i>Recognize components of measuring systems (U.S. and metric) for length</i>	Discuss industry measures and terms relating to length.
<i>Convert units of measure:</i> <i>Recognize components of measuring systems (U.S. and metric) for mass/weight</i>	Discuss industry measures and terms relating to mass/weight.
<i>Convert units of measure:</i> <i>Recognize components of measuring systems (U.S. and metric) for volume</i>	Discuss industry measures and terms relating to volume.
<i>Measure with a certain degree of accuracy</i>	Estimate measurements. Using workplace materials* and tools, take measurements of work-related and classroom items. Depending on ability level, students may measure to the nearest foot, inch, centimeter, etc.
APPLICATIONS	
<i>Solve word problems</i>	Help students feel more comfortable with word problems by placing simpler problems in word problem form; or take concepts students have already mastered and ask them to write word problems for each other to solve.
<i>Select/apply mathematical formulas</i>	Review a set of math formulas and then a list of sample problems. Decide which formula(s) apply to each problem.
<i>Understand the importance of time in the workplace</i>	Using workplace materials*, make a list of workplace scenarios that require using time correctly, such as keeping a time card or heating a liquid solution for 20 minutes.
<i>Recognize components of time systems (clocks and calendars)</i>	<ul style="list-style-type: none"> • a.m. and p.m. • Leap year • Military time
<i>Discuss, identify, understand terms relating to measuring time</i>	Discuss the units of time measurement and time vocabulary: second, minute, hour, day,

	<p>week, month, year, leap year, fiscal year, quarter, annual, biannual, etc.</p>
<p>Understand that time can be expressed in terms of equivalencies</p>	<p>Show the time equivalencies using fractions. For example:</p> <p>$1 \frac{1}{2}$ days = ___ hours</p> <p>1 day = 24 hours $+ \frac{1}{2}$ day = <u>+12 hours</u> $1 \frac{1}{2}$ days = 36 hours</p>
<p>Compute time conversions</p>	<p>Make a table that shows the equivalencies of time units.</p> <p>Compute conversion problems at the appropriate level of difficulty. Examples include</p> <ul style="list-style-type: none"> • Convert minutes to hours • Convert hours to days • Convert seconds to years
<p>Calculate ratio and proportion</p>	<p>Review fractions when discussing ratio and proportion.</p> <p>Draw common classroom items to scale by finding a conversion rate (1 foot equals 1 inch).</p> <p>Make predictions using ratios. (If each student in the class has three children, how many children will there be altogether? Write the ratios.)</p>
<p>Apply geometry principles: Use formulas for measuring shapes of two dimensions</p>	<p>Determine the formulas that apply to two dimensions: perimeter, area, surface area.</p> <p>Find the perimeter of the classroom.</p> <p>Discuss the perimeter of objects that are not shaped as perfect squares. How does this change the formula for perimeter?</p> <p>Find the area of the tiles on the floor.</p> <p>Find the area of the classroom.</p>

	Review that all areas are expressed in terms of square units (square inches, square miles, etc.).
<i>Apply geometry principles: Use formulas for measuring shapes of three dimensions</i>	Review the formulas that apply to three dimensions of objects: volume. Review that volume is expressed in cubic units. Find the volume of common objects such as soda cans, pizza boxes, etc. Discuss industry-specific needs for these formulas. For example, find the volume of a tank or silo.
<i>Define terms relating to money</i>	Understand, at a level of complexity appropriate to your industry and to students' ability levels, basic principles relating to money. For more advanced students, include terms and principles of economics, finance, or statistics.
<i>Perform one-step problems involving money</i>	Make change. (Count up—rather than backwards—to make change.)
<i>Perform multiple-step problems using money</i>	Calculate gross and net earnings. Calculate: <ul style="list-style-type: none"> ▪ Interest ▪ Sales tax ▪ Percent off ▪ Sale price ▪ Profit percentages Perform banking transactions.
<i>Perform business-related financial activities</i>	At a level of complexity appropriate to your industry and to students' ability levels, solve income/expense problems, prepare budgets, etc.
<i>Use a calculator to perform computations</i>	Identify appropriate activities that can be performed using a calculator (calculators

	<p>allow students to concentrate on problem-solving strategies).</p> <p>Award prizes for weekly activities or competitions.</p>
Calculate measurements taken from measuring devices	Add, subtract, multiply, and divide measurement numbers by plugging them into formulas.
Perform/prepare an inventory	<p>Use a sample group of items to prepare an inventory. Discuss the math processes that would apply to the inventory process.</p> <p>Review inventory vocabulary terms.</p>
DATA ANALYSIS AND DISPLAY	
Recognize types of visual representations	<ul style="list-style-type: none"> • Charts • Graphs • Tables
Interpret charts, graphs, and tables	<p>Answer simple questions about charts, graphs and tables.</p> <p>Solve multistep problems involving the correlation of graphs and tables.</p>
Collect/record data	<p>As appropriate to industry, practice sampling methods. Discuss safety precautions for sampling. Visit OSHA at the Department of Labor Web site for more details.</p> <p>Practice collecting and recording sample data from your industry (such as measurements taken using a micrometer). Compare class answers.</p> <p>Find the range of answers (maximum and minimum). Find the average. Discuss an acceptable range of answers (\pm), and graph the results showing the number that fell inside and outside the acceptable range.</p>
Review and apply principles of probability	Use real-life examples that are highly motivating to direct the students' attention to probability principles. (Example, "I am thinking of a number between 1 and 50. The

	<p>person who guesses the number will receive that many bonus points if s/he can tell me the probability of choosing the number correctly.”)</p>
<p>Use probability models to predict chance events</p>	<p>Calculate <u>theoretical probability</u> of an event (e.g., the probability of rolling a 5 on a die is 1/6).</p> <p>Find <u>empirical probability</u> of an event by performing repeated experiments. Compare the two probabilities.</p>
<p>Calculate and interpret statistics</p>	<p>Identify the importance of using statistics correctly. Bring examples of statistics from the news or media and analyze them: Are they ambiguous? Are they correct? What data is the advertisement trying to get the public to see?</p> <p>For a humorous look at statistics, see <i>How to Lie with Statistics</i> by Huff and Geis.</p>
<p>Interpret plans/blueprints</p>	<p>Review vocabulary and terms for plans, blueprints, and schematics.</p> <p>Build a plan or blueprint one layer at a time, starting with the basic identifying information.</p> <p>Add layers of wax paper or other transparent drawing material on top of the first layer that allows each layer to be viewed individually or the entire drawing as a whole.</p>
<p>Construct charts and tables</p>	<p>Discuss chart types and chart vocabulary.</p> <p>Using workplace or sample data from the class, construct tables and charts. For a daily example, consult <i>USA Today</i> online and look for the snapshots section that shows a graph of some sort. Ask weekly bonus questions about the data.</p> <p>Challenge students to bring in examples of charts and graphs containing errors.</p>

ACADEMIC STANDARDS FOR SCIENCE
Strategies for Reinforcement
in the Career and Technical Education Classroom

Note:

* indicates industry-related materials, handouts, notes, etc.

Topics Listing

General Science: Topics not specific to a content area

Physical Science: Mechanics and Physics

Energy and Waves

Thermodynamics

Electromagnetism

Chemistry

Optics

Life Science: Cell Biology

Evolution

Genetics and Heredity

Human and Animal Development

Anatomy: Ecology

Viruses

Bacteria

Plants

Earth Science: Earth in Space

Solar System/Astronomy

Atmosphere and Weather

Oceans and Water

Earth Resources

Objective

Classroom Applications to Industry

GENERAL SCIENCE	
<p><i>Present</i> <i>Review and discuss</i> Master the list of skills employers want for the workplace regarding science skills</p>	<p>Use the list of skills employers want to introduce students to the requirements of the workplace.</p> <p>Depending on students' ability levels, any of the following methods may be used to increase their understanding of the concepts:</p> <ul style="list-style-type: none"> • Discussion • Interviewing parents or other adults in the workplace about the skills required • Interviewing employers about the skills in terms of importance • Identifying workplace situations in which certain skills become more important than others • Researching adult education programs to learn why deficits in these areas must be remediated, and discover the cost to employers to educate adult workers • Researching the topic of adult literacy
<p>Perform computations as required to solve problems</p>	<p>Use the metric system to convert units of measure.</p> <p>Round numbers to correct number of significant figures.</p> <p>Determine percentage of error.</p> <p>Understand validity, reliability, accuracy, and precision.</p>
<p>Apply scientific method of inquiry</p>	<p>Identify the steps of the scientific method.</p> <p>Conduct experiments.</p> <p>Understand the following terminology:</p> <ul style="list-style-type: none"> • Conclusions vs. inferences • Variables • Replications • Samples/sample size
<p>Investigate science history as it applies to industry</p>	<p>In groups, research topics in science pertaining to your industry. Have students assign roles for each</p>

	<p>member of the group.</p> <p>Present findings in report format or in oral presentations.</p> <p>Investigate science ethics.</p> <p>Recognize the processes available for accountability in industry. For example, OSHA has a Safety and Health Program Assessment Worksheet whereby employers can be rated for safety issues. See http://www.osha.gov/SLTC/safetyhealth_ecat/mod3.htm</p> <p>[Note: Safety and Health is a mandatory subject of bargaining when a workplace is unionized; in both unionized and non-unionized workplaces, an employer cannot create and dominate workplace safety committees (see the National Labor Relations Act).]</p>
<i>Use scientific instruments to measure aspects of the environment</i>	Gather data on time, length, mass, pressure, volume, acceleration, or other measurables using instruments from the job.
<i>Demonstrate an understanding of data</i>	<p>List the processes involved in gathering data.</p> <p>Suggest ways that data can be grouped or organized.</p> <p>Collect specimens.</p> <p>Show how data can be represented (graphically, charts and diagrams, etc.).</p> <p>Construct a model to depict a basic concept.</p>
<i>Identify the seven basic S I (Systeme International) units</i>	<p>Length: meter, m</p> <p>Mass: kilogram, kg</p> <p>Time: second, s</p> <p>Electric current: ampere, A</p> <p>Temperature: Kelvin, K</p> <p>Amount of substance: mole, mol</p> <p>Luminous intensity: candela, cd</p>

	For a dictionary of units, see http://www.ex.ac.uk/cimt/dictunit/dictunit.htm
<i>Identify S.I. (Systeme International) Derived units</i>	Choose units appropriate to your industry (hertz, ohm, volt, watt, etc.). Create a picture dictionary demonstrating the concepts.
<i>Review relevant theories, laws, and models</i>	As relating to your industry, discuss important theories, laws, and models.
<i>Use reference tools to solve problems</i>	Use scientific reference tools (such as the Periodic Table of Elements) to learn more about specific industry concepts.
<i>Practice safe lab procedures</i>	Handle equipment with care. Demonstrate safety and first aid procedures. Identify harmful substances.
PHYSICAL SCIENCE	
<i>Understand the cyclical nature of systems</i>	Show, demonstrate, model, track the cycles of any of the following systems: <ul style="list-style-type: none"> • Growth and decay • Food webs • Weather • Water
<i>Analyze/classify matter according to type</i>	Identify types of matter (solids, liquids, gases). Which types are predominantly used in your area of industry?
<i>Explain the concepts of work and power</i>	Identify machines used in industry. Identify how energy levels change when work or power is increased/decreased. Identify fuel sources used in your industry. Discuss internal and external combustion. Create a model demonstrating the uses of levers and pulleys.

<p><i>Be familiar with concepts of motion</i></p>	<p>Measure acceleration and deceleration. Understand the relationship between speed and velocity by performing experiments. Recognize waves and vibrations as a type of motion.</p> <p>Understand action and reaction. Review laws pertaining to motion.</p>
<p><i>Understand concepts related to force</i></p>	<p>Show the need for balance of forces acting on an object.</p> <p>Observe centrifugal and centripetal forces in action.</p> <p>Show how friction is created and must be accounted for in using and preserving equipment.</p> <p>Create a chart showing types of lubricants needed in a factory and schedule of maintenance.</p> <p>Understand, at a level of complexity appropriate to your industry and to students' ability levels, basic principles of inertia.</p> <p>Show the relationship between pressure, mass, and weight.</p>
<p><i>Understand and apply principles relating to the atom</i></p>	<p>Understand that atoms have a positive, negative, or neutral charge. Classify protons, electrons, and neutrons. Identify ions.</p>
<p><i>Investigate forms of and changes in energy</i></p>	<p>Discuss how energy is measured.</p> <p>Observe changes in energy relationships. Identify catalysts and reactants.</p> <p>Identify sources of kinetic and potential energy in your industry.</p>
<p><i>Discuss, apply principles of electricity and electric currents</i></p>	<p>Identify types of circuits and switches.</p> <p>Show the difference between direct and alternating currents. Give examples of the best/most efficient use of each.</p>

	<p>Determine how electricity is measured, and solve problems using these terms. (Example, use Ohm's law to calculate current, resistance, and voltage.)</p> <p>Identify good conductors and insulators, and discuss how to choose them.</p> <p>Understand grounding, and create a visual display of grounding safety practices. Include the threat of static electricity.</p> <p>Show the uses of a vacuum tube by building a model.</p> <p>Compare the following ways of generating electricity:</p> <ul style="list-style-type: none"> • Hydroelectricity • Motors • Solar power • Steam/nuclear • Transformers • Incandescent (light) <p>Show the implications for your industry.</p> <p>As appropriate to your industry, identify electrochemical energy sources (cells, electrodes, batteries) and the processes of oxidation and reduction.</p>
<p><i>Be familiar with sound waves</i></p>	<p>Compare how sound waves travel between liquids, solids, and air.</p> <p>Examine different types (lengths) of sound waves.</p> <p>Examine decibels safe for human hearing.</p> <p>Identify safety precautions for industry regarding sound tolerance.</p> <p>Be able to use correctly the terms below as they relate to your industry. For example, ask students to write a short essay explaining a demonstration from class and include the following terms:</p> <ul style="list-style-type: none"> • Amplification • Audible range • Frequency

	<ul style="list-style-type: none"> • Acoustics • Resonance • Speed
<i>Be familiar with principles of heat</i>	<p>Differentiate between the three types of heat transfer (conduction, convection, radiation).</p> <p>Understand that substances expand and contract due to heating and cooling.</p> <p>Identify purpose and types of insulations used.</p> <p>Differentiate between heat and temperature.</p>
<i>Investigate and apply concepts relating to temperature</i>	<p>Use the temperature scales; convert between Celsius and Fahrenheit.</p>
<i>Explain the concepts of magnetism</i>	<p>Understand that currents create magnetic fields.</p> <p>Identify materials that are good conductors and the properties that make them such.</p> <p>Understand electromagnetic forces present in earth.</p>
<i>Investigate/apply chemical properties</i>	<p>Differentiate between acids and bases. Find pH for substances used in industry.</p> <p>Identify substances used in your industry and classify them by type.</p> <p>Name the major drugs, fertilizers, or additives used in your industry.</p> <p>Define and state examples of chemical reactions.</p> <p>Be familiar with solutions used in your industry.</p> <p>Compare saturated and unsaturated solutions.</p> <p>Determine whether a solution is soluble or insoluble.</p> <p>Explain solute and solvent.</p>

<p><i>Investigate forms of and changes in matter</i></p>	<p>Compare and contrast physical and chemical changes. Discuss the types of physical or chemical changes that take place in your industry from processing raw materials to manufacturing.</p>
<p><i>Understand and apply concepts relating to the elements</i></p>	<p>Examine the four elements that make up 99% of living organisms [hydrogen (H), oxygen (O), nitrogen (N), and carbon (C)].</p> <p>Element groups:</p> <ul style="list-style-type: none"> • Alkali metals • Alkaline earth metals • Transition metals • Other metals • Metalloids • Nonmetals • Halogens • Noble gases • Rare earth elements
<p><i>Be familiar with principles of light</i></p>	<p>Discuss light as a form of energy. Examine the light spectrum and note the relative smallness of visible light.</p> <p>Describe types of lighting systems.</p> <p>Define reflection and refraction.</p> <p>Explain how light carries information (by lasers), and show examples of the impact on technology/industry.</p> <p>Identify types of lenses.</p>
<p><i>Be familiar with principles of color</i></p>	<p>Diagram the main parts of the eye involved in seeing color (rods, cones).</p> <p>Use prisms to split light into the visible spectrum.</p> <p>Briefly explore color blindness. What precautions should colorblind people take regarding workplace safety?</p> <p>Define situations in which colorblindness impacts a worker's ability to do his/her job.</p>

LIFE SCIENCE

<p><i>Explain the presence of cells as the identifier of all living organisms</i></p>	<p>Examine the cells of organic material used in your industry, using books, the Internet, or a microscope.</p> <p>Recognize that cells divide or replicate to promote growth of an organism.</p> <p>Examine the parts of a cell. Compare the cell to a machine. How do the parts function and rely on each other?</p> <p>Give examples of one-celled and multiple-celled organisms.</p> <p>Review the classification system of all organisms (kingdom, phylum, etc.).</p> <p>Create a circle graph or pie chart (totaling 100%) showing the relationship (in numbers) between the groups of organisms:</p> <ul style="list-style-type: none"> • Bacteria • Fungi • Viruses • Insects • Plants • Vertebrates • Invertebrates <p>Compare some of the cell processes (active and passive transport) with the processes in your industry.</p>
<p><i>Understand the progress of evolution of organisms</i></p>	<p>Recognize how a species will adapt to better fit in its environment over time.</p>
<p><i>Explain the role of genetics in human development</i></p>	<p>Understand, at a level of complexity appropriate to your industry and to students' ability levels, basic principles of heredity, including:</p> <ul style="list-style-type: none"> • Half of an individual's genes are contributed by each parent • Traits that are inherited are either dominant or recessive from the parent(s) • Cell division by mitosis vs. meiosis • Disabilities are caused either by

	<p>genetic/inherited conditions (such as Down's Syndrome) or in accidents occurring after birth, such as brain damage due to a car accident or a stroke</p>
<p><i>Investigate/apply</i> principles of human development</p>	<p>Describe the life cycle of humans and other animals.</p> <p>Use the concept of human development to explain the need for understanding foundation skills in your area. (For example, children do not run before they walk.) Use this concept to explain other events that occur in a natural order in your industry.</p>
<p><i>Explore</i> additional concepts pertaining to humans and other animals</p>	<p>Give examples of ways organisms adapt to their environment.</p> <p>As relating to industry, review the concepts of:</p> <ul style="list-style-type: none"> • Aging • Immune system • Skin and Tissues • Blood and hemoglobin • Disease
<p><i>Compare/contrast</i> the differences between sexual and asexual reproduction</p>	<p>Determine instances when understanding the concepts of sexual reproduction are important for your industry.</p> <p>Highlight the effects of unsafe working practices on unborn fetuses or the dangers present for pregnant women working in industry.</p>
<p><i>Show</i> a general understanding of the importance of health</p>	<p>Explore the cost of lost wages and worker's compensation in the past year due to health problems.</p> <p>Research the most common health problems among workers (workers with safe jobs; workers with most hazards to health, etc.).</p>
<p><i>Investigate</i> the food cycle</p>	<p>Identify food chains, food webs, food pyramids. Show how changes to the food cycle affect the environment and humans. Name the food groups.</p>

<p><i>Understand</i> nutrition and the body’s need for a diet that provides vitamins and minerals</p>	<p>Show an understanding of body systems (circulatory, nervous, digestive, etc.) as they relate to industry.</p> <p>Identify deficient vitamins and minerals among a particular population (American workers, workers in specific environments, workers who do not go outdoors, or those who always work outdoors) and the health risks associated with job types (office work, mining work, etc.).</p>
<p><i>Observe</i> health code/sanitation requirements</p>	<p>Research the development of health code and sanitation requirements, including OSHA.</p> <p>Compare/contrast workplaces of 1850, 1900, 1950, and 2000 regarding health and safety.</p> <p>Discuss the most common workplace violations of health requirements and present in a graphic format (e.g., maps, charts).</p> <p>Discuss potential effects of ignoring health requirements.</p> <p>After identifying workplace hazards, create several plans to treat the problem. Debate the benefits of each.</p> <p>To avoid the threat of employers choosing ineffective means of ensuring safety on the job, locate MSDS sheets, first aid stations, personal protective equipment, worker’s compensation claims offices/paperwork, etc.</p> <p>Using workplace materials*, locate the section on safety regulations. Ask students to rank the items. Debate the importance of each. Determine the threat of ignoring regulations. Research which regulations are often disregarded.</p> <p>Explore proactive measures students can take to extend their health.</p> <p>Understand the importance of mental health in addition to physical health.</p>

<p><i>Investigate/apply</i> principles of anatomy and physiology</p>	<p>As relating to your industry, explore issues relating to anatomy and physiology.</p> <p>Study the skeletal system--the bones of the arm, hand, and neck. Research carpal-tunnel syndrome.</p> <p>Identify the types of fractures and those most common to your line of work. Learn how to prevent falls.</p>
<p><i>Understand</i> basic principles of ecology</p>	<p>Define ecology.</p> <p>Identify five major ways in which people interact with the environment, especially as relating to your industry.</p> <p>Discuss the effectiveness of the media as compared with pro-science groups (such as Greenpeace) on the public's awareness of important environmental issues.</p> <p>Identify any areas of concern regarding waste/waste management in your industry.</p> <p>Show the difference between a niche, community, habitat, and ecosystem.</p> <p>Give examples of herbivores, carnivores, and omnivores. How does your industry use and serve each group?</p> <p>Understand predators' effects on food chains. Identify predators of industry.</p> <p>Explain the process of decomposition and decay. How does industry interfere with or interrupt these processes?</p>
<p><i>State</i> the differences between viruses and bacteria</p>	<p>Define viruses and bacteria. Explore viral and bacterial threats present in the workplace. How can they be prevented? How can they be treated?</p> <p>State the benefits of viruses and bacteria.</p> <p>Explain the recent increased resistance to drugs and antibiotics.</p>

<p><i>Understand</i> basic concepts relating to plants</p>	<p>Describe the interchange of oxygen and carbon dioxide between plants. Contrast it with the way humans exchange oxygen and carbon dioxide. As relating to industry, review the concepts of:</p> <ul style="list-style-type: none"> • Fertilization • Parts of a plant and functions of each • Effects of temperature on plants • Need for water and light • Photosynthesis
<p>EARTH SCIENCE</p>	
<p><i>Recognize</i> earth's position in the universe</p>	<p>As relating to your industry, identify relevant topics regarding:</p> <ul style="list-style-type: none"> • Asteroids • Comets • Stars • Galaxies <p>Identify the planets in the solar system. Compare and contrast earth with other planets.</p> <p>Create a model showing the relative size of earth within our solar system. Use mathematical relationships to make sure the scale is correct (earth is the size of ____, so the sun should be the size of ____).</p> <p>How do the phases of the moon and sun affect the hemispheres?</p>
<p><i>Investigate</i> the history of the earth</p>	<p>Identify geological, chemical, and other methods of determining the age of an object.</p> <p>Demonstrate that fossils and rocks are indicators of previous eras.</p> <p>As a class, create a timeline indicating the age of the earth. Include the various ages (Ice Age, etc.) and the length of each. Make sure the timeline is drawn to scale. Assign each age to a group and research the following:</p> <ul style="list-style-type: none"> • Weather • Major events at beginning and end of age • Organisms living during this time • Factors that made the age unique

<p><i>Investigate</i> physical characteristics of the earth</p>	<p>Label/model the components of the earth.</p> <p>Understand, at a level of complexity appropriate to your industry and to students' ability levels, basic principles of gravity.</p> <p>Solve problems of longitude, latitude, and time zones.</p> <p>Create a model of the ratio of land and water on earth.</p>
<p><i>Investigate</i> physical forces acting on the earth</p>	<p>Examine erosion and depletion of nonrenewable resources.</p> <p>Identify natural disasters such as hurricanes and earthquakes. Research the effects of a past disaster on a specific industry.</p> <p>Understand, at a level of complexity appropriate to your industry and to students' ability levels, basic principles of plate tectonics (the earth's surface is broken into large plates; movement of these plates over time causes earthquakes and other geologic activity).</p>
<p><i>Explain</i> the basic components of earth's rotation</p>	<p>Understand that the earth spins on its axis at an angle of 23 ½ degrees. Identify the period of one complete rotation as a day; longer cycles of rotations identify the seasons.</p> <p>Discuss time zones.</p>
<p><i>Identify</i> the earth's atmosphere and its components</p>	<p>Identify the main elements in the earth's atmosphere (nitrogen and oxygen).</p> <p>Identify layers of the atmosphere and ozone layer.</p> <p>Explain concepts of air pressure.</p>
<p><i>Understand</i> basic principles of the solar system</p>	<p>Demonstrate how the sun strikes the earth at different angles depending on location.</p>
<p><i>Demonstrate</i> the relationship between climate and weather</p>	<p>Identify the factors that create weather.</p> <p>Show how landscape features are affected by</p>

	<p>changes in climate or weather.</p> <p>Identify the greenhouse effect. How does industry contribute to it?</p> <p>Describe the relationship between altitude and weather.</p> <p>Understand that changes in the weather may be seen as fronts that are put in motion by the jet stream.</p> <p>Identify types of precipitation.</p> <p>Differentiate between types of clouds.</p> <p>Understand the effect of winds, wind speeds, and impacts on vegetation.</p>
<p><i>Learn and apply concepts relating to the oceans</i></p>	<p>Label the major oceans and seas. Determine the elements in ocean water (nearly all elements are present).</p> <p>Identify or draw the structural components of the ocean floor.</p> <p>Explain the relationship between the moon and the tides.</p> <p>Explore ways the ocean is used for power and business.</p>
<p><i>Investigate principles of water</i></p>	<p>Identify the parts of the water cycle and the effects of the processes involved.</p> <p>Define water's chemical properties:</p> <ul style="list-style-type: none"> • Water is the universal solvent • Water has a neutral pH of 7 • Chemically, water is one atom of oxygen bound to two atoms of hydrogen <p>Measure salinity. Which industries rely heavily on water?</p> <p>Define water's physical properties:</p> <ul style="list-style-type: none"> • Water is the only natural substance that exists as solid, liquid, and gas

	<ul style="list-style-type: none"> • Water's surface has a high density • Water has a high tolerance for heat (heat index) • Water's weight • Water as a coolant • Specific gravity
<i>Investigate conservation of physical and natural resources</i>	<p>As relating to your industry, discuss or debate the issues of:</p> <ul style="list-style-type: none"> • Allocation of resources • Recovering resources • Best/worst methods of using resources <p>Compare/contrast renewable and nonrenewable resources.</p> <p>Note the important developments in your industry regarding mineral, soil, water, and wildlife conservation.</p> <p>Discuss alternative sources of energy as relating to your industry.</p>
<i>Investigate issues regarding scientific technology</i>	<p>As relating to your industry, discuss the uses of technology. What are the newest developments? What effects does the technology have on our society? Political system? Discuss the role of economics on technology.</p>
<i>Apply science principles/laws to environmental issues</i>	<p>Discuss how humankind alters the earth and environment through pollution and the use of resources and technology.</p>

Crosswalk to SkillsUSA Precision Machining Technology

SkillsUSA, the co-curricular student organization for Career and Technical Education, provides many opportunities through its program of work for students to apply the knowledge, skills, and processes learned in a variety of courses. A correlation of the Precision Machining technical contest to selected tasks/competencies in Arkansas's Machine Tool courses is provided as a supplement to this framework.

Purpose

To evaluate each contestant's preparation for employment and to recognize outstanding students for excellence and professionalism in the field of precision machining technology

Clothing Requirement

Official SkillsUSA khaki work shirt and pants, black or brown leather work shoes, and safety glasses with side shields or goggles. (Prescription glasses can be used only if they are equipped with side shields. If not, they must be covered with goggles.) To purchase official work clothes, contact Midwest Trophy Manufacturing Co., Inc., by calling 1-800-324-5996 or order online at <http://www.mwtrophy.com/vica/index.html>.

Eligibility

Open to active SkillsUSA members enrolled in programs with precision machining technology as the occupational objective.

Equipment and Materials

- Supplied by the technical committee
 - All necessary machines, work-holding devices, and work-piece materials
 - All necessary hand tools and precision measuring instruments needed by contestants and/or judges
 - All necessary personal computers and software for offline part programming

- All necessary reference material, charts, and work instructions to be used by contestants and/or judges
- Supplied by the contestant
 - Calculator (optional)

Note: Contestants are not to bring any tools or reference materials to the contest.

Scope of the Contest

Overview of competencies assessed

Each contestant in the SkillsUSA Championships is expected to demonstrate competency in both manual and CNC machining performance skills and precision machining technology-related knowledge (theory). This includes

- Applying fundamental computational skills.
- Interpreting engineering drawings, technical data, and other graphics.
- Applying physical science principles.
- Setting up and operating manual metalworking machines.
- Meeting industrial safety and hygiene requirements.
- Using a PC and keyboarding skills; using offline CNC programming software; demonstrating the ability to program, set up, and operate basic CNC machines.

Competency assessments involve both hands-on skills and knowledge areas.

Technical Committee role and participation

Selections of the competencies to be tested are determined by the SkillsUSA Championships technical committee. Committee membership includes the Association for Manufacturing Technology (AMT), Brown-Covey Inc., Clausing Industrial Inc., Crossland Machinery, Denford Inc., General Electric, Hamilton Standard, IAM Crest, Kelmar Associates, L.S. Starrett Co., Mead School and Office Products, National Institute for Metalworking Skills (NIMS), National Tooling & Machining Association (NTMA), Newport News Shipbuilding, North Central State College, Northern University of Illinois, Remmele Engineering Inc., Sandvik Coromant, and Ultra-Tech Inc.

Contest based on NIMS skill standards

The contest will be based on and be consistent with NIMS' Duties and Standards for Machining Skills, Levels I and II. Information on how to obtain these skill standards may be obtained directly from NIMS by calling (703) 352-4971 or visiting www.nims-skills.org.

Machining-related computational competencies (inch and metric)

- Apply basic arithmetic skills to solve problems.
- Apply functional algebra, geometry, and trigonometry to solve problems.
- Use formulas, handbook tables, charts, and technical reports to solve problems or make decisions.
- Be able to chart, interpret, and explain statistical process control and inspection data.
- Be able to calculate the correct amount of grind stock to be left on a part when doing roughing operations.
- Calculate center offsets for taper turning and compound slide settings for angle turning.

Professional development competencies

Each year, the committee will devise and conduct an interview with each contestant as part of the contest. Contestants may be asked to

- Explain a technical issue related to precision machining technology, *or*
- Analyze a specific machining-related problem and then make an oral report (244 *SkillsUSA Championships Technical Standards [2002–2004]*), *or*
- Respond to general questions that typically would be part of an employment type interview.
- The contestant will be judged on poise, confidence, knowledge of the subject, oral communication skills, the ability to react to new situations and to make sound decisions.

Communication competencies

- Read, interpret, conceptualize, and be able to report (orally, handwritten note, or paper document) common manufacturing processes related to precision machining, and relate them to features of a part or engineering drawing of a part.

- Interpret engineering drawings or sketches (inch or metric) to determine features to be machined.
- Translate geometric tolerance symbols and other part specifications contained within feature control symbols used in machining and measurement (*ASME Y14.5-1982*).
- Demonstrate knowledge and understanding of projection theory and other engineering drawing principles.
- Be able to produce an appropriate freehand orthographic, oblique, isometric, or perspective sketch of a part to be machined.
- Write or letter legibly.
- Enter, retrieve, update, change, or analyze computer-stored data related to machining or inspection.
- Be able to orally explain machining procedures and/or practices.

Physical science competencies

- Demonstrate fundamental knowledge of principles of mechanics, machines, heat, light, sound, and other forms of energy in relation to cutting and work-holding tooling used in both manual and CNC machining.
- Be able to describe the physical and/or metallurgical characteristics of cast irons, steels, nonferrous metals, composites, plastics, and other materials that could be machined.
- Understand and be able to discuss the effects of heat-treating and coating processes on materials used for work pieces and/or cutting tools.
- Be able to explain the process by which carbide and/or ceramic cutting tool inserts are made.
- Be able to read and use machinability tables to determine the effect the work piece material has on such things as cutting speed, feed rate, depth of cut, cutter selection, tool wear, surface finish, etc.

Safety and hygiene competencies

- Understand and practice safe operation of the machines now being used.
- Know and demonstrate an understanding of safety codes and rules used to safeguard self, other workers, and the equipment and tooling.

- Apply good hygiene in the use of cutting fluids and/or other chemicals typically used for machining.
- Be able to read, understand, and follow a Material Safety Data Sheet (MSDS).
- Demonstrate safe work habits when performing any of the machining, bench work, material handling, or measurement competencies listed for this precision machining competition.

Manual turning (lathe) operation competencies

- Be able to set up machine for single or multiple part production, which includes setting machine stops, proper speeds, feeds, and depth of cuts for the material to be machined and the type of cutting tools available.
- From the cutting tools available (could be HSS, cast alloys, or carbide), select the best tool for the operation and mount properly.
- Perform basic turning operations: work between centers, three- or four-jaw chuck work, collet work, center drilling, straight turning, shoulder and end facing, chamfering, radius turning, grooving, cutting off, drilling, boring, reaming, taper and angle turning, roughing (leaving grind stock) and finishing, knurling, filing and polishing, and internal and external thread chasing.
- Demonstrate the ability to hold inch and/or metric dimensional, geometric, and surface finish tolerance requirements.
- Be able to identify and discuss the application of other types of lathes and the advantages of each.

Manual milling machine operation competencies

- Be able to set up machine for single or multiple part production, which includes setting machine stops, calculating proper cubic feet per minute, chip load, depth of cut, speeds and feeds for the material being machined, and the type of cutters available.
- Be able to select the proper work-holding device and set it up properly to withstand the cutting forces present.
- Be able to make table setups, using straps and clamps, vise setups, V-block setups, and indexing devices.

- Be able to select the proper cutting tool holding device; mount it properly; determine correct direction of rotation; determine when a cutter is dull; be able to change inserts and chip breakers.
- Perform basic milling operations that include plain, face, end, side, form, angle, grooving, keyway/keyseat, and cut-off.
- Demonstrate ability to set up and use a dividing head and/or rotary table (*sponsored by Goodheart-Willcox Publisher 245*).
- Demonstrate knowledge of cutter types, styles, and materials.

Manual drill press competencies

- Prepare machine, including selecting proper RPM for the cutting tool being used.
- Select and safely mount work-holding device.
- Properly mount work piece in work-holding device.
- Select the proper cutting tool for the job.
- Perform drilling, countersinking, counter boring, spot facing, reaming, and tapping operations.
- Demonstrate knowledge of drill press classifications and their applications.
- Demonstrate knowledge of common drill press cutting tool types and applications.
- Demonstrate knowledge of common drill press work-holding devices and their applications.

Manual grinding machine competencies

- Demonstrate knowledge of surface, cylindrical, center less, and internal grinding machines and their applications.
- Show ability to set up and operate a manual horizontal reciprocating surface grinder.
- Perform surface-grinding operations to produce flat, parallel, stepped, and angle surfaces.
- Show ability to use a permanent magnet chuck (table) on a surface grinder.
- Show ability to determine proper infeed, work speed, and crossfeed speed.
- Show ability to dress the wheel.

- Demonstrate knowledge of grinding wheel characteristics, construction, standards, and selection, including: wheel markings, wheel shapes, proper storage for wheels, and how to inspect a grinding wheel.
- Demonstrate knowledge of cutting fluids used in grinding operations.
- Demonstrate knowledge of super abrasive technology and applications.

Bench and hand tool competencies

- Demonstrate ability to use layout hand tools (in conjunction with the Measuring Tool Competencies listed in the next section), including coating materials, surface plates, v-blocks, scribes, dividers, trammels, keyseat rules, hermaphrodite calipers, angle plates, surface gage, and prick and center punches.
- Be able to find the center of a square, cylindrical, rectangular work piece; lay out bolt circles and hole locations; lay out features to be produced.
- Demonstrate ability to properly use hammer, screwdrivers, files, chisels, wrenches, hand taps and tap wrenches, threading dies, hand reamers, hand hacksaws and blade applications, and bench vises.
- Know how to deburr work pieces after machining or hand operations.
- Be able to hand letter or number stamp parts.

Process control and measurement competencies

- Using current industrial engineering drawings and work pieces, make precision measurements for specific features.
- Demonstrate ability to select and use the proper measuring device (inch or metric) for the feature to be measured.
- Understand the reason for using calibrated measuring tools.
- Be able to make the appropriate calculations to set up the measuring device or to mathematically determine location of part features.
- Demonstrate knowledge of and be able to select, assemble, and disassemble gauge block sets, using the least block method.
- Demonstrate knowledge of and ability to measure surface finishes.

- Be able to effectively use common precision machining measuring tools (inch or metric), such as steel rules, combination square sets, depth gauges, spring calipers, outside/inside/depth micrometers, vernier/dial/digital calipers, vernier/digital height gauge, protractor, mechanical/electronic indicators, go/no-go gauges, comparators, surface plates, angle plates, parallel blocks, inspection centers, sine bars/plates, and profilometer/surface finish comparison devices.
- Be able to physically measure for parallelism, squareness, roundness, concentricity, axial runout, flatness, hole location/size, angles, tapers, threads, linear.
- Know which manufacturing processes are capable of producing specific surface finishes economically.
- Demonstrate knowledge of the general classes of fits.
- Demonstrate a knowledge of statistical process control (SPC) terminology and ability to use quality.

Power sawing competencies

- Demonstrate knowledge of power and hacksawing and band sawing processes, including machine types and applications, work-holding accessories, basic setup considerations, blade/band selection, special safety precautions.

Machinability knowledge competencies

- Be able to demonstrate an understanding of the components that boost machine performance and cut costs.
 - Use of optimum speeds and feeds when machining
 - Selection of the best cutting tool for the material being machined
 - Selection of proper cutting tool geometry related to horsepower of machine and the material being machined (*246 SkillsUSA Championships Technical Standards [2002–2004]*)
 - Capability of the machine to produce the tolerance required
 - Selection of the most suitable measuring tool for the tolerance specified
 - Maintaining of machine adjustments in top shape
 - Use of new precision machining technologies

- Be able to discuss the variables that could cause machining problems such as tool/work overhang, tool grade/geometry, machine condition/power, cutting fluid, shape of work, chip breakers, material hardness, etc.
- Be able to discuss what chip shape and color can tell you about optimum cutting.
- Be able to discuss the relative machinability of steels.

Arkansas' All Aspects of Industry

Defining “All Aspects”

All aspects of an industry include, with respect to a particular industry that a student is preparing to enter, planning, management, finance, technical and production skills, underlying principles of technology, labor and community issues, health and safety, and environmental issues related to that industry. Planning is examined at the level of both an individual business and the overall industry. Planning elements might include:

- Developing strategic plans—mission, vision, goals, objectives, and/or a plan of action.
- Working with planning tools such as surveys, market research, and competitive analysis.
- Anticipating needs for staffing and major purchases of equipment and supplies.
- Developing plans for training and upgrading of staff.
- Forecasting market trends.
- Developing business plans for entrepreneurial ventures.

Management addresses methods typically used to manage enterprises over time within the industry as well as methods for expanding and diversifying workers' tasks and broadening worker involvement in decisions. Key elements of management might include:

- Using an organization chart to explain how a corporate chain of command works.
- Providing input for strategic plans and communicating the company's vision and mission statements.
- Leading employees in carrying out strategic plans and action plans.
- Evaluating employee performance.
- Anticipating technology and other major purchasing needs.
- Ensuring equity and access for employees.
- Resolving conflicts.
- Developing job descriptions and written policies/procedures.
- Identifying recruitment procedures, training opportunities, methods of evaluation, and retention strategies.
- Working with professional associations and community outreach efforts.

Finance examines ongoing accounting and financial decisions and different methods for raising capital to start or expand enterprises. Finance functions might include:

- Developing budgets.
- Preparing financial statements.
- Analyzing and managing financial transactions and records.
- Implementing payroll procedures.
- Determining and paying taxes.
- Identifying indirect wage costs (benefits, FICA, insurance, worker's compensation).
- Making loans and granting credit to customers.
- Developing graphs and charts related to company finances.
- Identifying and implementing methods of sustaining profitability of a business.
- Managing 401K plans.
- Identifying sources of capital.

Technical and production skills cover specific production techniques and alternative methods for organizing the production work, including methods that diversify and rotate workers' jobs.

Technical and production skills that an employee should have to succeed in a business or industry might include:

- Developing and upgrading job-specific skills.
- Using troubleshooting and problem-solving techniques.
- Analyzing information to make decisions.
- Identifying and implementing quality assurance techniques.
- Employing communication skills, such as writing, listening, speaking, and reading.
- Participating in team efforts.
- Implementing projects and new techniques.
- Demonstrating basic computer skills; employing time-management techniques in completing projects and assigned tasks.
- Demonstrating ethical behavior and work ethic.

Underlying principles of technology provide an integrated study across the curriculum of the mathematical, scientific, social, and economic principles that underlie the industry's technology.

Principles of technology that an employee should know might be demonstrated by:

- Exhibiting proficiency in mathematical and scientific functions related to new and emerging technologies.
- Continuously upgrading job skills needed to implement new technologies.
- Participating in industry certification programs.
- Cross-training to enhance one's value to the organization and to enhance job promotion opportunities.
- Understanding and adhering to ethical issues related to technologies.

Labor issues examine worker rights and responsibilities, labor unions and labor history, and methods for expanding workers' roles. Labor issues might include:

- Understanding and implementing worker rights and responsibilities.
- Working with labor unions.
- Keeping abreast of local, state, and federal legislation affecting employee and employer rights and responsibilities.
- Negotiating and settling worker disputes.
- Identifying certification requirements for specific jobs.
- Analyzing the impact of labor agreements on business operations.

Community issues explore the impact of the industry on the community and the community's impact on and involvement with the industry. Concepts of business and community relations might include:

- Developing and working with community outreach projects.
- Participating on advisory committees and community organizations.
- Working with professional associations.
- Developing and implementing public relations plans.
- Participating in community service projects.

Health, safety, and environmental issues examine these concepts in relation to both the workers and the larger community. Concepts related to health, safety, and the environment might include:

- Identifying and implementing federal, state, and local regulations related to the health and safety of employees.
- Understanding and strictly adhering to federal, state, and local environmental regulations related to the business.
- Identifying job-specific health hazards and safety issues.
- Identifying and implementing basic safety and first aid training techniques for emergencies such as personal illness or injury, tornadoes, fires, nuclear accidents, floods, and incidences of employee-rage or violent behavior.
- Communicating safety regulations and plans to employees.
- Working with selected community groups to implement safety programs.

Knowledge, Skills, Abilities Required for Mastery of Hands-on Tasks

The NIMS document *Duties and Standards for Machining Skills Level I, II, and III* identifies certain knowledge, skills, and abilities (KSA) competencies that support machining tasks and are required for acceptable performance. For example, handling hazardous materials requires communication skills, basic math skills, decision-making and problem-solving skills, teamwork, and a knowledge of basic measurements, properties of materials, and cutting fluids and coolants. The concepts and skills included in the following charts are considered essential; therefore, they are listed as separate tasks/competencies. However, the teacher may choose to treat them as supporting material (enabling objectives) for the technical tasks listed. The charts that follow may help the teacher organize instruction to allow for the appropriate emphasis on the cognitive competencies.

- 1.1 Demonstrate safe workplace practices.
- 1.2 Handle hazardous materials as assigned.
- 3.1 Develop a process plan for a part requiring milling, drilling, turning, or grinding.
- 3.2 Write a set of directions for a machining-related task or project.
- 4.1 Perform manual bench work operations, including deburring parts, performing press fits, and using bench vise and hand tools as applicable.
- 4.2 Perform manual layout operations, including laying out the location of hole centers and surfaces.
- 4.3 Perform between centers turning operations for straight turning.
- 4.4 Set up and carry out chucking operations for turning.
- 4.5 Perform routine power feed milling, using power feeds.
- 4.6 Perform routine vertical milling.
- 4.7 Perform routine surface grinding, location of surfaces, and squaring of surfaces, using manual surface grinders with a wheel 10" and smaller in diameter.
- 4.8 Perform routine drill press operations.
- 4.9 Set up and operate power saws for cutoff operations.
- 5.1 Inspect simple parts, using precision tools and techniques.

- 5.2 Inspect samples for the required data according to a sampling plan.
- 6.1 Make process adjustments or improvements to the production of a single part.
- 6.2 Participate as a member of a team in routine production process improvement.
- 7.1 Perform general housekeeping and maintenance.
- 7.2 Perform preventive maintenance on machine tools.
- 7.3 Manage tooling maintenance.
- 8.1 Reading
- 8.2 Writing
- 8.3 Speaking
- 8.4 Listening
- 9.1 Arithmetic
- 9.2 Applied geometry
- 9.3 Applied algebra
- 9.4 Applied trigonometry
- 9.5 Applied statistics
- 10.1 Applying decision rules
- 10.2 Basic problem solving
- 11.1 Group participation
- 11.2 Personal qualities
- 12.1 Standard orthographic blueprints
- 12.2 GDT orthographic blueprints
- 12.3 Orthographic/Isometric sketching
- 12.4 Orthographic blueprints: auxiliary views
- 12.5 Orthographic blueprints: GDT multiple datums
- 13.1 Basic measurements
- 13.2 Precision measurements
- 14.1 Cutting theory
- 14.2 Tooling
- 14.3 Material properties
- 14.4 Machine tools
- 14.5 Cutting fluids and coolants

- 15.1 Metal properties and cutting
- 15.2 Nonmetal properties and cutting
- 16.1 General computer use
- 16.2 Research and reporting on computer
- 16.3 CNC programming

NIMS Standards for Levels I, II, and III Machining

The National Institute of Metalworking Skills (NIMS), the credentialing agency for the National Tooling and Machining Association, published the following standards for machining skills in its Duties and Standards for Machining Skills, Levels I, II, and III (1995). NIMS certifies on a nationwide basis secondary, postsecondary, apprentice, and company programs in the occupational areas of machining and metal forming. For more information, contact National Institute for Metalworking Skills, Inc.

1031 Democracy Lane, Suite 407

Fairfax, VA 22030

Phone: 703/352-4971 Fax: 703/352-4991 Web: www.nims-skills.org

Occupational Duties

Level I, Level II, Level III

- 1.0 Job planning and management
 - 1.1 Job process planning
- 2.0 Job execution
 - 2.1 Manual operations bench work
 - 2.2 Manual operations layout
 - 2.3 Turning operations: between centers turning
 - 2.4 Turning operations: chucking
 - 2.5 Power feed milling
 - 2.6 Vertical milling
 - 2.7a Grinding wheel safety
 - 2.7b Surface grinding
 - 2.8 Drill press operations
 - 2.9 Power saws
- 3.0 Job execution
 - 3.1 Layout bolt circles, angles, points of tangency
 - 3.2 Contour bandsawing
 - 3.3 Turning ops: between centers taper turning

- 3.4 Production: turning
- 3.5 Turning: tapers with taper attachment
- 3.6 Milling: square up a block
- 3.7 Vertical mill: precision location of holes
- 3.8 Milling: cut a keyseat
- 3.9 Milling: deep slots with a stagger-tooth cutter
- 3.10 Milling: use rotary tables
- 3.11 Milling: dividing head operations
- 3.12 Basic horizontal boring mill operations
- 3.13 Drilling: radial drill
- 3.14 Power tapping: taper reaming & pipe tapping
- 3.15 Surface grinding: finish flats to ± 0.0005
- 3.16 Surface grinding: finish flats at simple angles
- 3.17 Grinding wheel preparation and balancing
- 3.18 Cylindrical grinding
- 3.19 EDM: operate a plunge EDM
- 3.20 EDM: operate a 2-axis wire EDM
- 3.21 CNC: write simple RS274-D programs*
- 3.22 Operate a CNC mill
- 3.23 Operate a CNC lathe
- 4.0 Job execution
- 4.1 Bench operations: hand lapping
- 4.2 Angle contour bandsawing
- 4.3 Turning operations: manual contour turning
- 4.4 Turning operations: steady rest turning & boring
- 4.5 Turning operations: follower rest turning
- 4.6 Turning operations: difficult materials
- 4.7 Milling: mill compound angles
- 4.8 Milling: manual contour milling
- 4.9 Horizontal boring mill: line boring
- 4.10a Grinding: select, inspect, set up, & balance wheels

- 4.10b Grinding: tapered cylindrical grinding
- 4.11 Grinding: grind I.D. and O.D. surfaces
- 4.12 Grinding: grind tapers on a universal grinder
- 4.13 Grinding: contour grinding
- 4.14 EDM: operate a 4-axis wire EDM
- 4.15 CNC: advanced manual RS-274- D programming
- 4.16 CNC: use manufacturing modeling software to create RS-274-D programs
- 4.17 CNC: milling centers
- 4.18 CNC: turning centers
- 4.19 CNC turning centers with secondary milling

Occupational Duties

Level I, Level II, Level III

- 3.0a Quality control and inspection
 - 3.1 Part inspection
 - 3.2 Process control
- 3.0 Quality control and inspection
 - 3.1b Inspection: optical comparator
 - 3.2 Inspection: manual coordinate measuring machine
- 4.0 Process adjustment and control
 - 4.1 Process adjustment, single part production
 - 4.2 Participation in process improvement
 - 4.3 Participate in capability studies
- 5.0 General maintenance
 - 5.1 General housekeeping and maintenance
 - 5.2 Preventive maintenance
 - 5.3 Tooling maintenance
- 6.0 Industrial safety and environmental protection
 - 6.1 Machine operations and material handling
 - 6.2 Hazardous materials handling and disposal
- 7.0 Career management and employment relations

- 7.1 Career planning
- 7.2 Job applications and interviewing
- 7.3 Teamwork and interpersonal relations
- 7.4 Organizational structures and work relations
- 7.5 Employment relations

Knowledge, Skills, Abilities, and Other Characteristics

Level I, Level II, Level III

- 1.0 Written and oral communication
 - 1.1 Reading
 - 1.2 Writing
 - 1.3 Speaking
 - 1.4 Listening
- 2.0a Mathematics
 - 2.1 Arithmetic
 - 2.2 Applied geometry
 - 2.3 Applied algebra
 - 2.4 Applied trigonometry
 - 2.5 Applied statistics
- 2.0b Mathematics
 - 2.1 Geometry of simple angles and profiles of a line
 - 2.2 Coordinate axes, Cartesian and polar
 - 2.3 Trigonometry for CNC tool paths
 - 2.4 Statistics for capability studies
- 2.0c Mathematics
 - 2.1 Geometry of compound angles, profiles of a line, and profile of a surface

Knowledge, Skills, Abilities, and Other Characteristics

Level I, Level II, Level III

- 3.0 Decision making and problem solving

- 3.1 Applying decision rules
- 3.2 Basic problem solving
- 4.0 Group skills and personal qualities
- 4.1 Group participation and teamwork
- 4.2 Personal qualities
- 5.0 Engineering drawings and sketches
- 5.1 Standard orthographic blueprints
- 5.2 GDT orthographic blueprints
- 5.3. Engineering drawings and sketches
- 5.4 Isometric and orthographic sketching*
- 5.5 Interpreting: GDT*
- 5.6 Interpreting: auxiliary views*
- 6.0 Measurement
- 6.1 Basic measuring instruments
- 6.2 Precision measuring instruments
- 6.3 Surface plate instruments
- 7.0a Metalworking theory
- 7.1 Cutting theory
- 7.2 Tooling
- 7.3 Material properties
- 7.4 Machine tools
- 7.5 Cutting fluids and coolants
- 7.0b Metalworking theory
- 7.1 EDM: electrode selection and design
- 7.2 CNC machine tools
- 7.3 CNC tooling
- 7.4 Determine correct coolants and/or cutting fluids for various applications*
- 8.0 Applied materials
- 8.1 Metal properties applied to cutting problems*
- 8.2 Nonmetal properties applied to cutting problems*
- 9.0 Computers

- 9.1 Typing*
- 9.2 Use the basic services of an operating system*
- 9.3 Computer-aided manufacturing software