Precision Machining Technology II

8540/36 weeks

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Acknowledgments

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Course Description

Suggested Grade Level: 11 or 12

The demand for precision machinists is growing along with the resurgence of the U.S. manufacturing industry. Machinists are highly skilled, creative problem solvers who are task-oriented and self-directed individuals. In this advanced course, CNC machining operations are emphasized. Students have the opportunity to increase their skills in applying precise measurements, using engineering drawings and sketches, and applying metalworking theory in order to safely and efficiently plan, manage, and perform general machine maintenance and machining jobs. This program helps to prepare students for the National Institute for Metalworking Skills (NIMS) credentials, which the industry uses to recruit, hire, place, and promote individual workers. This course specifically aligns to Machining Knowledge Requirements and Dimensional Measurements Knowledge Requirements.

As noted in Superintendent's Memo #058-17 (2-28-2017), this Career and Technical Education (CTE) course must maintain a maximum pupil-to-teacher ratio of 20 students to one teacher, due to safety regulations. The 2016-2018 biennial budget waiver of the teacher-to-pupil ratio staffing requirement does not apply.

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<td>Write programs for a CNC machine using a machine control unit and a personal computer.</td>
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<td>Manage the CNC tooling library.</td>
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<td>Describe the main computer systems used across the industry.</td>
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<td>Describe the variety of machines in the industry that are controlled by CNC programming.</td>
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<td>Write a basic G-code program.</td>
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<td>Produce the designed part, using a 3D printer or CNC machine.</td>
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<td>Analyze the part design for improvements.</td>
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<td>Identify sub-assembly and complete product assembly or packaging techniques.</td>
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<td>Describe the advantages of automation.</td>
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</table>

Legend: ✌️Essential ☐Non-essential ❋Omitted

**Curriculum Framework**
Ensuring Industrial Safety and Environmental Protection

Task Number 39

Comply with federal, state, and local safety requirements.

Definition
Compliance should include

- understanding the roles of the Occupational Safety and Health Administration (OSHA), Virginia Occupational Safety and Health (VOSH), and the Environmental Protection Agency (EPA)
- identifying the OSHA Hazard Communication Standard (HazCom)
- interpreting the information included on safety data sheets (SDS)
- describing the responsibilities of employers and employees under HazCom.

Process/Skill Questions

- Where should hazardous materials be stored?
- What information can be found on an SDS?
- Where can employees receive updates on industrial safety?

Task Number 40

Identify personal protective equipment (PPE) requirements.

Definition
Identification should include procedures for inspecting, wearing, and removing

- eye protection
- respirator
- gloves
- hearing protection
- safety shoes.

Identification should also include explaining when particular PPE is required.

Process/Skill Questions

- Why is wearing jewelry and/or loose clothing prohibited while in the lab or on the job site?
- When should hand protection be used in the machine shop?
- When should ear protection be used in the machine shop?
- What are the possible hazards of grinding dust and producing hazardous fumes in the machine shop?
- What type of foot protection is required in the machine shop?

Task Number 41

Identify emergency first-aid procedures.
**Definition**

Identification should include standard first-aid procedures and school policies regarding incidents involving

- bodily fluids
- electrical injuries
- eye injuries
- falls
- burns.

**Process/Skill Questions**

- What are the steps that should be followed after an accident?
- Why is knowing cardiopulmonary resuscitation (CPR) an important skill in the construction trades?
- Why is it important to be certified to administer first aid?
- Where might one locate the Automated External Defibrillator (AED) in a machine shop?
- What are the different degrees of electrical burns?

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**Task Number 42**

**Identify the types of fires and the methods used to extinguish them.**

**Definition**

Identification should include classifications of fires (e.g., Classes A, B, C, and D), causes and prevention of fires, types of extinguishers, and, when possible, the demonstrated use of a fire extinguisher, in accordance with government regulations and instructor guidelines.

**Process/Skill Questions**

- Why do fires have different classifications, and what are they?
- What is the fire triangle and the fire tetrahedron?
- What are the three things necessary to start a fire?
- Why is it important to know the classification of fire when trying to extinguish it?
- Why should extinguishers be inspected, and how often should they be inspected?
- What are the classifications of extinguishers?
- What is the proper technique to extinguish a fire?
- Where might one locate the fire extinguisher in the machine shop?

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**Task Number 43**

**Inspect course-specific hand and power tools to visually identify defects.**

**Definition**

Inspection of tools should include

- identifying components of machinery (e.g., guards, blades, moving parts, start/stop switches)
- identifying standard safety procedures (i.e., lab practices and manufacturer recommendations)
• observing a demonstration of the safe operation and use of each piece of machinery in the lab
• identifying tool defects.

Process/Skill Questions

• What are some of the basic power tools used in precision machining technology?
• What are the proper actions to take before using a circular saw? What are the proper actions to take before using a power drill?
• Why should a power tool always be grounded?
• Why is it important to use a ground-fault circuit interrupter (GFCI) when using power equipment?
• What should be done if power tools become damaged?

Task Number 44

Demonstrate lifting and carrying techniques.

Definition
Demonstration involves lifting and carrying materials and equipment based on the principles of

• lifting with the legs
• keeping the back straight
• holding the load close to the body
• getting help, if necessary.

Process/Skill Questions

• What are common injuries associated with improper lifting techniques?
• What can one do to prevent injury?
• How does positioning affect technique?

Task Number 45

Report personal injuries and environmental and equipment safety violations to the appropriate authority.

Definition
Report should include

• providing a verbal or written statement
• identifying the violation
• documenting the date when the incident or behavior was observed
• following the protocol for submitting the report to the instructor, supervisor, or the local OSHA inspector.

Process/Skill Questions

• What ethical considerations might be involved when reporting coworkers?
• Why is it important to follow reporting procedures?
• What is liability?
Task Number 46

Pass a safety exam for lab/site safety and the use of tools and equipment specific to the manufacturing industry.

Definition
Assessment must measure participation in safety training programs, including attending safety meetings and periodically demonstrating knowledge and skills gained from program topics (e.g., interpretation of SDS).

Process/Skill Questions
- How often should one participate in safety training programs?
- Why are retraining programs relevant to a company's insurance policy?
- What is workers' compensation?

Task Number 47

Demonstrate safe workplace practices.

Definition
Demonstration should include
- adhering to safety rules while carrying out assigned responsibilities
- following procedures relating to first aid for injury or work-related illness
- documenting safety activities as required.

Process/Skill Questions
- What is considered appropriate protective clothing for working in a machine shop?
- What are some unsafe workplace practices?
- What are the main injuries associated with the machining workplace?
- What are required PPE items used by machinists? What are the safety glasses requirements?
- Why should machine guards be used?

Task Number 48

Handle hazardous materials as assigned.

Definition
Handling should include
- identifying, moving, and storing hazardous materials in compliance with OSHA and EPA requirements and guidelines
- working as a member of a team that addresses routine handling and storage issues
- documenting safety activities as required.

Process/Skill Questions
- What is an SDS?
Why should proper disposal procedures be strictly followed?
What are some disposal resources?
Why are there laws protecting the environment?
Why should hazardous material be properly labeled?
Who should train employees on the proper handling of hazardous material?

Task Number 49
Describe the importance of Occupational Safety and Health Administration (OSHA) standards and Environmental Protection Agency (EPA) regulations.

Definition
Description should include

- the importance of OSHA—safety standards are set to promote workplace safety by reducing incidents of worker injury or death and employer violations
- the importance of the EPA—regulations, based on Congressional laws, are established to protect the environment, reduce pollution, and promote conservation of environmental resources.

Process/Skill Questions

- What is the main role of the EPA in the precision machining industry?
- Why do some political groups and business owners want to reduce the regulations set by the EPA and OSHA?
- How was the industry regulated prior to the establishment of OSHA?

Applying the Fundamentals of Machining

Task Number 50
Apply the properties of various nonmetals to cutting conditions and problems.

Definition
Application should include determining the appropriate cutter geometry and speeds and feeds for cutting various nonmetal materials during

- turning
- milling
- drilling
- radial drilling
- CNC operations.

Process/Skill Questions

- How are geometry skills essential in cutting?
- How do speed and feed affect cutting?
• What are the advantages of using insert cutters?
• What are examples of nonmetal materials?
• How does dust affect cutting?

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Task Number 51

Describe the importance of quality assurance, process planning, and quality control.

Definition

Description should include

• quality management systems
• inspection reports
• documentation and traceability
• statistical process control
• standards and specifications (e.g., mean, median, mode).

Process/Skill Questions

• What is a bell curve?
• What are mean, median, average, and standard deviation.

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Applying Measurements

Task Number 52

Apply surface plate instruments.

Definition

Application should include

• using precision tools and instruments for surface plate work, such as
  o precision angle plates
  o tool blocks
  o precision transfer gauges
• considering
  o surface roughness
  o basic and custom gauging
  o environmental influences
  o documentation and traceability.

Process/Skill Questions

• Why is it important to keep a surface plate clean?
• What are the proper cleaning techniques for surface plates?
• What is the correct way to handle gauge blocks?
• What are proper environmental conditions for surface plate work?
• What are the materials used for gauge blocks, and why are they used?
Task Number 53

Convert measurements.

Definition
Conversions should include

- describing the significance of the task in the industry
- listing common standard and metric measurements
- identifying the associated equations
- converting fractions to decimals and vice versa.

Process/Skill Questions

- Why is it important to convert between systems?
- How many millimeters are in an inch?
- What is the formula for converting inches to millimeters?
- What is the formula for converting millimeters to inches?

Task Number 54

Inspect samples for the required data, according to a sampling plan.

Definition
Inspection should include

- developing a sampling plan
- following the sampling plan
- collecting data required for the process-control chart
- working with the supplied control and warning limits to place the data, produce new data as needed, and graph the data
- taking Stop or Go actions as indicated by the results
- providing a brief explanation of decisions made.

Process/Skill Questions

- What does the acronym SQC stand for?
- What is the importance of calibration when using measuring devices?
- What are the benefits of running quality control?

Planning and Managing Machining Jobs

Task Number 55

Develop a process plan for a part requiring milling, drilling, turning, and/or grinding.
Definition
Development should include

- formulating a set of strategies to manufacture the part
- filling out an operation sheet reflecting the chosen strategies
- including the required speeds and feeds and explaining each of the steps in the process plan
- identifying all major components and functions of the machine tools, all major hand tools, measuring tools, fixtures, and work materials
- providing the rationale for the speeds and feeds selected.

Process/Skill Questions

- Why is it important to follow a process plan?
- What are some possible consequences of not following a process plan?
- How can a bad plan affect the completion of a job?

Task Number 56

Write instructions for producing a part.

Definition
Written instructions should be

- clear and accurate
- sequenced correctly in an enumerated process
- sufficiently detailed for the person receiving the directions to complete the task
- focused on the CNC and automation areas.

Process/Skill Questions

- What might be the consequences of not writing legibly or concisely?
- Why is it important to create specific directions?
- How does the quality of directions affect the time and resources needed to complete a job?

Task Number 57

Make process adjustments or improvements to the production of a single part.

Definition
Making adjustments or improvements should include

- analyzing the performance of a single-part production process
- proposing process adjustments or improvements as appropriate
- seeking authorization to implement the process adjustments or improvements
- carrying out the process adjustments or improvements
- explaining the corrective actions and the reasoning used to perform the diagnosis.
Process/Skill Questions

- What are the goals of part improvements?
- How can improvements save money?
- How can improvements affect overall production efficiency?

Performing Machining Jobs

Task Number 58
Perform routine power feed milling, using power feeds.

Definition

Performance should include

- setting up and operating a horizontal or vertical milling machine, using power feeds
- producing a part matching the process plan and blueprint specifications
- squaring up the part from the unfinished state to within .005 inch over 4 inches
- finishing surfaces to 125 microinches.

Process/Skill Questions

- What is the difference between manual and power feeds?
- What is the difference between conventional and climb milling?
- What are the advantages of power feeding?

Task Number 59 Optional
Perform routine surface grinding, using manual surface grinders with a wheel 10 inches or smaller in diameter.

Definition

Performance should include

- using a pedestal grinder
- sharpening drill bits
- grinding or sharpening lathe tooling
- ensuring safety by ring testing grinding wheels, performing visual safety inspection, and mounting and dressing a grinding wheel to prepare for surface grinding
- producing a part to match the process plan and blueprint specifications
- finishing the six surfaces of the block so they are square within .001 inch over 4 inches; finishes to be at least 32 microinches or better; and surfaces with no sharp edges.

Process/Skill Questions

- What is the importance of dressing a wheel before running the job?
- What are the different types of grinding wheels?
- Why is it important that a part is relatively flat before it is positioned for grinding?
Task Number 60

Explain the functions and operations of various CNC machines.

**Definition**

Explanation could include

- summarizing the history of CNC machining
- identifying safety procedures for CNC machining operations
- listing advantages and disadvantages of CNC machines
- following the procedures for writing programs for two-axis CNC lathes
- creating one CNC lathe project
- describing types of working and tool-holding devices
- identifying miscellaneous codes that are used
- identifying G and M code programs
- naming digital file types (e.g., txt, docx, xlsx).

**Process/Skill Questions**

- What are the differences among a CNC milling machine, a CNC lathe, and a wire-electric discharge machine (EDM)? In what way are they similar?
- Which is the most precise of the three machines?
- What are the processes of planning and creating a finished part?
- What are the uses of CAD and CAM software?
- Why is program formatting important?
- Why is it important to learn G and M codes for CNC lathe and CNC milling?
- What are the similarities in codes for CNC lathe and milling?

Task Number 61

Write programs for a CNC machine using a machine control unit and a personal computer.

**Definition**

Writing programs should include

- importing and exporting files
- following file naming conventions
- determining digital storage method (i.e., local, network, or cloud)
- using copy and paste functions
- proofing the program.

CNC and wire-EDM programs should be written with attention to speeds and feeds and should enable the end user to drive an endmill or cutting tool through a continuous path.
Process/Skill Questions

- How are the different medias used to program?
- How many axes are programmable on each machine?
- What is the difference between a G-code and an M-code program?

Performing General Maintenance

Task Number 62

Perform general machine maintenance.

Definition
Performance should include

- inspecting and assessing the general condition of an assigned machine tool
- making routine adjustments as authorized, or reporting problems to supervision
- carrying out daily, weekly, and/or monthly routine maintenance tasks cited on checklists for a given machine tool (e.g., chip control and removal, filters, coolant management)
- filling out the documentation forms for tracking maintenance
- making a brief oral report explaining the condition of the machine tools and the actions taken
- keeping a maintenance and repair record on each machine tool.

Process/Skill Questions

- What are the benefits of preventive maintenance?
- Why is documentation of maintenance important?
- Why is proper care, usage, and storage important for prolonging the life of a machine tool?

Task Number 63

Manage the CNC tooling library.

Definition
Management should include updating the tool library by

- determining the standard tools needed for particular machining jobs, amending either when necessary
- identifying the tool type, feeds and speeds, and sizes
- describing each tool used
- ensuring that the program runs with new tool selections.

Process/Skill Questions

- What is the importance of maintaining a tooling inventory?
- What are examples of improper tooling maintenance management?
Task Number 64 Optional

Set tool offsets on a machine.

Definition
Setting should include

- safely entering the offsets into the machine control
- editing the offsets page through the registry
  - by adding to the offset
  - by changing the offset.

Process/Skill Questions

- Should the tools be set to the workpiece for every job or to a single location?
- How can a machinist track tool offsets when the tool is removed from the machine?

Using Engineering Drawings and Sketches

Task Number 65

Interpret geometric dimensioning and tolerancing (GDT) from orthographic blueprints.

Definition
Interpretation should include

- features with and without size
- tolerance zones (e.g., basic dimensions)
- geometric tolerancing categories
- geometric tolerancing characteristics and symbols
- symbols associated with feature control frames
- maximum and minimum material condition (e.g., calculating actual position)
- datums.

Process/Skill Questions

- What are some geometric symbols associated with orthographic blueprints?
- What is the difference between geometric tolerances and standard tolerances?
- What is the importance of a datum?

Task Number 66

Interpret engineering drawings with multiple auxiliary views.
Definition
Interpretation should include the print with auxiliary views of drawings used with

- CNC programming
- process planning
- inspection for tool or part compliance.

Process/Skill Questions

- What are the different types of auxiliary views?
- Why is it necessary to show an auxiliary view on a blueprint?
- What are the advantages of an auxiliary view over an orthographic view?

Task Number 67 Optional
Interpret GDT drawings with multiple datums.

Definition
Interpretation should include

- CNC programming
- process planning
- inspection, using a coordinate measuring machine (CMM), for tool or part compliance
- datum reference frame
  - 6 degrees of freedom
  - datums
  - datum features
  - datum simulators
- placement of datum symbols.

Process/Skill Questions

- What is a datum?
- Why do some drawings use multiple datums?
- How does the added complexity of multiple datums interfere with accurate interpretation of the drawings?

Applying Metalworking Theory

Task Number 68
Create specialized fixtures.

Definition
Creating specialized fixtures should include custom tooling designed uniquely to fit a part.

Process/Skill Questions

- Why might a specialized fixture be required?
• What are two principles of location/clamping?
• How does using a fixture affect productivity?
• What types of materials are used for fixtures?

Task Number 69

Machine a variety of materials.

Definition
Machining should include

• applying material properties theory
  o predicting speeds and feeds and tooling requirements based on known properties of a material
  o responding to cutting conditions imposed by material properties
• identifying common materials and their principal properties relevant to machining tasks
• recognizing differences among ferrous and nonferrous, magnetic, and ductile materials
• explaining the changes to materials caused by heat-treating
• predicting the machinability of a part based on its appearance, its call-out value on the blueprint, and its supplied hardness value.

Process/Skill Questions

• What is the difference between ferrous and nonferrous materials?
• What happens to steel when it is heat-treated?
• How do materials affect speeds and feeds?
• What is the difference between ductile and brittle materials?
• How do different materials affect tool life?
• Why is it helpful to know the melting point when machining various materials?
Exploring CNC Machining

Task Number 70

Describe the main computer systems used across the industry.

Definition
Description should include

- computer-aided design (CAD)
- computer numerical control (CNC)
- computer-aided manufacturing (CAM)
- coordinate measuring machine (CMM)
- the Cartesian coordinate system.

Process/Skill Questions

- Why should the CMM be in a controlled environment?
- Which system will output or provide the actual machine program?
- What types of files can be uploaded into machine controls?

Task Number 71

Describe the variety of machines in the industry that are controlled by CNC programming.

Definition
Description should include

- vertical and horizontal machining centers
- turning centers
- EDM
- waterjet
- plasma
- laser
- CMM.

Process/Skill Questions

- What are the advantages of live tooling?
- What is an EDM machine?
- What are the advantages of a bar feeder?
- What are the three configurations of a machining center?
- What types of CNC machines are laser, plasma, and water jet?
Task Number 72

Write a basic G-code program.

Definition
The CNC program (milling or lathe) should be written to machine a simple part, using offline programming software on a personal computer and verified using graphic verification.

Process/Skill Questions
- What are the basic differences between mill and lathe programs?
- What are the differences between absolute and incremental programming?
- Why are trial runs important before actual program implementation?
- What is it called when one specifies programming from program zero? What is the other mode of programming called?
- What are the four types of programming formats used with a given machining center?

Task Number 73

Model a part, using CAD software.

Definition
Modeling should include
- sharing a database with CAM
- generating CNC code
- manufacturing the part, using CAM
- complying with instructor's specifications.

Process/Skill Questions
- How does one determine whether the part should be designed with CAD or with CAM?
- What does the post-process do?
- How does CAD/CAM operation affect the bottom line?
- What are the benefits of using parametric software when developing a part for manufacturing?

Task Number 74

Produce the designed part, using a 3D printer or CNC machine.

Definition
Production of the part should match the print and tolerances allowed per the instructor's specifications.

Process/Skill Questions
- Why are fixtures not used with a 3D printer?
- Why are parts first 3D-printed before they are machined on a CNC?
- What type of material is used in a 3D printer?
Task Number 75 Optional

Analyze the part design for improvements.

Definition
Analysis should include

- improvements made to the prior design or manufacture
- improvements required to increase the lifespan or efficiency of the part.

Process/Skill Questions

- Why would a part need to be improved?
- Why would a part's lifespan need to be tracked?
- How might redesigning a part affect cost?
- What effect does tolerancing have when analyzing a part?
- How can GDT be applied to improve a product?

Exploring Automation

Task Number 76

Define *automation process*.

Definition
Definition should include using computers and software to automate processes that would benefit from less human interaction. Processes typically include

- assembly options
- product inspection
- product finishing.

Process/Skill Questions

- What are the reasons for automating a process?
- How can automation make packaging safer?
- When is automation not an appropriate choice?

Task Number 77

Identify sub-assembly and complete product assembly or packaging techniques.

Definition
Identification should include

- locating packaging companies or divisions within companies that use automation
describing the types of automated processes used by a packaging company or division
analyzing the packaging process required by common products
determining the benefits of using automated packaging.

**Process/Skill Questions**

- What is sub-assembly?
- Why is automated packaging used? What are the benefits?
- Which industries produce sub-assembly operations?
- What are the applications of Flexible Manufacturing Systems (FMS) in automation?
- How are the basic components of FMS employed in automated systems?

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**Task Number 78**

**Compare a variety of final finishes and their effects.**

**Definition**
Comparison should include the applications for

- plating
- anodizing
- powder coating.

**Process/Skill Questions**

- What is powder coating?
- What kind of materials can be anodized?
- How does zinc plating affect welding?
- How is robotics contributing to metal/material finishing?
- How are finishes used in the final part of the construction or manufacturing process?

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**Task Number 79**

**Describe the advantages of automation.**

**Definition**
Description should include

- identifying industry examples in which automation is used
- identifying the benefits automation.

**Process/Skill Questions**

- How does an automated welder interface with a computer?
- How many axes does a typical automated welder have?
- Which industries employ automatic welders?
- What are the eight benefits of automation, and how do they affect the automated manufacturing processes?

**SOL Correlations by Task**

<table>
<thead>
<tr>
<th>Task</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>39</td>
<td>11.5, 12.5</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>
| 40 | Identify personal protective equipment (PPE) requirements. | History: Govt 7, 8, 9, 15  
Science: CH.1  
English: 11.5, 12.5 |
| 41 | Identify emergency first-aid procedures. | Science: CH.1  
English: 11.5, 12.5 |
| 42 | Identify the types of fires and the methods used to extinguish them. | Science: CH.1  
English: 11.5, 12.5 |
| 43 | Inspect course-specific hand and power tools to visually identify defects. | English: 11.5, 12.5 |
| 44 | Demonstrate lifting and carrying techniques. |   |
| 45 | Report personal injuries and environmental and equipment safety violations to the appropriate authority. | English: 11.5, 11.6, 11.7, 12.5, 12.6, 12.7 |
| 46 | Pass a safety exam for lab/site safety and the use of tools and equipment specific to the manufacturing industry. | English: 11.5, 12.5  
Science: CH.1 |
| 47 | Demonstrate safe workplace practices. | English: 11.5, 11.6, 11.7, 12.5, 12.6, 12.7 |
| 48 | Handle hazardous materials as assigned. | English: 11.5, 111.6, 11.7, 12.5, 12.6, 12.7  
History: Govt 7, 8, 9, 15 |
| 49 | Describe the importance of Occupational Safety and Health Administration (OSHA) standards and Environmental Protection Agency (EPA) regulations. | English: 11.5, 12.5  
History: Govt 7, 8, 9, 15 |
| 50 | Apply the properties of various nonmetals to cutting conditions and problems. | English: 11.5, 12.5 |
| 51 | Describe the importance of quality assurance, process planning, and quality control. | English: 11.5, 11.6, 11.7, 12.5, 12.6, 12.7  
Mathematics: PS.1*, PS.2*, PS.4* |
| 52 | Apply surface plate instruments. | English: 11.5, 12.5 |
| 53 | Convert measurements. | English: 11.5, 12.5  
Mathematics: AII.3 |
| 54 | Inspect samples for the required data, according to a sampling plan. | English: 11.1, 11.5, 12.1, 12.5  
Science: CH.1, PH.1  
Mathematics: PS.8*, PS.10*, AFDA.8 |
<p>| 55 | Develop a process plan for a part requiring milling, drilling, turning, and/or grinding. | English: 11.5, 12.5 |
| 56 | Write instructions for producing a part. | English: 11.6, 11.7 |
| 57 | Make process adjustments or improvements to the production of a single part. | English: 11.5, 12.5 |
| 58 | Perform routine power feed milling, using power feeds. | English: 11.1, 11.5, 12.1, 12.5 |
| 59 | Perform routine surface grinding, using manual surface grinders with a wheel 10 inches or smaller in diameter. | English: 11.1, 11.5, 12.1, 12.5 |</p>
<table>
<thead>
<tr>
<th></th>
<th>Explain the functions and operations of various CNC machines.</th>
<th>English: 11.5, 11.6, 12.5, 12.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>61</td>
<td>Write programs for a CNC machine using a machine control unit and a personal computer.</td>
<td>English: 11.2, 11.5, 12.2, 12.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mathematics: COM.1, COM.7, COM.17</td>
</tr>
<tr>
<td>62</td>
<td>Perform general machine maintenance.</td>
<td>English: 11.5, 12.5</td>
</tr>
<tr>
<td>63</td>
<td>Manage the CNC tooling library.</td>
<td>English: 11.5, 12.5</td>
</tr>
<tr>
<td>64</td>
<td>Set tool offsets on a machine.</td>
<td>English: 11.5, 11.6, 11.7, 12.5, 12.6, 12.7</td>
</tr>
<tr>
<td>65</td>
<td>Interpret geometric dimensioning and tolerancing (GDT) from orthographic blueprints.</td>
<td>English: 11.5, 12.5</td>
</tr>
<tr>
<td>66</td>
<td>Interpret engineering drawings with multiple auxiliary views.</td>
<td>English: 11.5, 12.5</td>
</tr>
<tr>
<td>67</td>
<td>Interpret GDT drawings with multiple datums.</td>
<td>English: 11.1, 11.5, 12.1, 12.5</td>
</tr>
<tr>
<td>68</td>
<td>Create specialized fixtures.</td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>Machine a variety of materials.</td>
<td>English: 11.5, 12.5</td>
</tr>
<tr>
<td>70</td>
<td>Describe the main computer systems used across the industry.</td>
<td>English: 11.5, 12.5</td>
</tr>
<tr>
<td>71</td>
<td>Describe the variety of machines in the industry that are controlled by CNC programming.</td>
<td>English: 11.2, 11.5, 12.2, 12.5</td>
</tr>
<tr>
<td>72</td>
<td>Write a basic G-code program.</td>
<td>English: 11.2, 12.2</td>
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<tr>
<td>76</td>
<td>Define automation process.</td>
<td>English: 11.3, 12.3</td>
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<td>77</td>
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<td>Describe the advantages of automation.</td>
<td>English: 11.5, 12.5</td>
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</tbody>
</table>
Appendix: Credentials, Course Sequences, and Career Cluster Information

Industry Credentials (Only apply to 36-week courses)

- CNC Milling and Turning Examination
- College and Work Readiness Assessment (CWRA+)
- Customer Service Examination
- Customer Service Specialist (CSS) Examination
- Machining-Level I Examinations
- Manufacturing Specialist Certification Examination
- Manufacturing Technician Level I Certification Examination
- National Career Readiness Certificate Assessment
- Pre-Manufacturing Technician I (PreMT1) Examination
- Precision Machining Assessment
- Professional Communications Certification Examination
- Workplace Readiness Skills for the Commonwealth Examination

Concentration sequences: A combination of this course and those below, equivalent to two 36-week courses, is a concentration sequence. Students wishing to complete a specialization may take additional courses based on their career pathways. A program completer is a student who has met the requirements for a CTE concentration sequence and all other requirements for high school graduation or an approved alternative education program.

- Precision Machining Technology I (8539/36 weeks, 140 hours)

Career Cluster: Manufacturing

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Occupations</th>
</tr>
</thead>
<tbody>
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<td>Maintenance, Installation, and Repair</td>
<td>Millwright</td>
</tr>
<tr>
<td>Manufacturing Production Process Development</td>
<td>Precision Inspector, Tester, or Grader Production Manager</td>
</tr>
<tr>
<td>Production</td>
<td>Extruding and Drawing Machine Operator Tool and Die Maker</td>
</tr>
<tr>
<td>Quality Assurance</td>
<td>Quality Control Technician</td>
</tr>
</tbody>
</table>