# Connecticut Technical Education And Career System


## Aerospace Component Manufacturing Technology

# Curriculum Guide

**January 2026**

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# CTECS - Vision of a Graduate


**The Vision of a Graduate (VoG)** at the Connecticut Technical Education and Career System (CTECS) embodies our commitment to preparing students for success in Connecticut's workforce.

Developed in collaboration with students, parents, staff, and employers, the VoG ensures that CTECS students are not only job-ready but also equipped to lead, innovate, and adapt in a dynamic world.

As educators, we are dedicated to developing these qualities by providing a comprehensive education that empowers our students to achieve their fullest potential and make meaningful contributions to society.

## A Problem Solver

*Problem solvers tackle challenges by identifying root causes of issues, brainstorming solutions, implementing effective strategies, and demonstrating adaptability.*

- Engage students with open-ended, creative thinking tasks that require both conventional and innovative solutions.
- Facilitate group discussions and collaborative projects.
- Use real-world scenarios and hands-on activities.
- Highlight the importance of effort, persistence, and continuous learning.
- Provide regular feedback and encourage reflection.

## Work Ready

*To be work-ready includes a combination of technical expertise, soft skills, and personal qualities that ensure a graduate can effectively contribute to the workplace from day one.*

- Set high standards for punctuality, responsibility, professionalism, and task completion.
- Use project-based learning and collaborative assignments.
- Emphasize clear written and verbal communication.
- Offer practical exercises like mock interviews and resume workshops.
- Integrate technology and teach digital literacy.

## Respectful

*Graduates who embody respectfulness emphasize the importance of treating others with dignity, valuing diversity, and fostering an inclusive and positive environment, both personally and professionally.*

- Demonstrate personal, interpersonal, and professional skills.
- Show respect for diversity.
- Model respect through active listening and empathy.
- Set clear expectations for respectful interactions.
- Promote collaboration and group discussions.
- Celebrate respectful behavior.
- Address disrespect promptly and constructively.

## Skilled Socially

*Graduates who are skilled socially are equipped to navigate social environments, build relationships, and contribute positively to their communities and workplaces.*

- Show awareness of global responsibility to others and the environment.
- Participate in community involvement.
- Design cooperative group projects and team activities
- Set expectations for respect and give regular feedback.
- Facilitate discussions on inclusivity, kindness, and respect.
- Model positive interactions and recognize strong social skills.

## A Critical Thinker

*Critical thinkers approach problems systematically by analyzing, evaluating, and synthesizing information to make well-informed decisions and contribute to innovative solutions.*

- Encourage critical thinking individually and collaboratively.
- Design lessons that challenge assumptions and explore diverse viewpoints.
- Use open-ended questions, rigorous activities, and cross-curricular projects.
- Integrate project-based learning and real-world problem-solving.
- Offer reflective opportunities like journaling and discussions.
- Cultivate an environment that values curiosity and inquiry.

## An Effective Communicator

*Effective communicators convey ideas, information, and emotions accurately and persuasively, fostering understanding and collaboration.*

- Communicate effectively using oral, written, visual, artistic, and technical modes.
- Include group discussions, presentations, and peer reviews.
- Promote active listening and thoughtful responses.
- Offer clear guidelines and constructive feedback.
- Stress clear, respectful, and purposeful communication.

# CTECS Instructional Model

CTECS uses the Marzano Compendium to guide research-based instructional strategies that differentiate learning and promote access, engagement, and success for all students. Teachers apply these strategies to support diverse learners (including multilingual learners, students with disabilities, and students with varied academic or technical backgrounds) through scaffolds, modeling, guided practice, and multiple ways to participate and show understanding. This approach ensures every student can work toward proficiency in the Priority Standards and the competencies outlined in the CTECS Vision of a Graduate.

| Feedback | Content | Context |
|---|---|---|
| **Providing and Communicating Clear Learning Goals**<br>1. Providing scales and rubrics<br>2. Tracking student progress<br>3. Celebrating success<br>**Using Assessments**<br>4. Using informal assessments of the whole class<br>5. Using formal assessments of individual students | **Conducting Direct Instruction Lessons**<br>6. Chunking content<br>7. Processing content<br>8. Recording and representing content<br>**Conducting Practicing and Deepening Lessons**<br>9. Using structured practice sessions<br>10. Examining similarities and differences<br>11. Examining errors in reasoning<br>**Conducting Knowledge Application Lessons**<br>12. Engaging students in cognitively complex tasks<br>13. Providing resources and guidance<br>14. Generating and defending claims<br>**Using Strategies That Appear in All Types of Lessons**<br>15. Previewing strategies<br>16. Highlighting critical information<br>17. Reviewing content<br>18. Revising knowledge<br>19. Reflecting on learning<br>20. Assigning purposeful homework<br>21. Elaborating on information<br>22. Organizing students to interact | **Using Engagement Strategies**<br>23. Noticing and reacting when students are not engaged<br>24. Increasing response rates<br>25. Using physical movement<br>26. Maintaining a lively pace<br>27. Demonstrating intensity and enthusiasm<br>28. Presenting unusual information<br>29. Using friendly controversy<br>30. Using academic games<br>31. Providing opportunities for students to talk about themselves<br>32. Motivating and inspiring students<br>**Implementing Rules and Procedures**<br>33. Establishing rules and procedures<br>34. Organizing the physical layout of the classroom<br>35. Demonstrating withitness<br>36. Acknowledging adherence to rules and procedures<br>37. Acknowledging lack of adherence to rules and procedures<br>**Building Relationships**<br>38. Using verbal and nonverbal behaviors that indicate affection for students<br>39. Understanding students' backgrounds and interests<br>40. Displaying objectivity and control<br>**Communicating High Expectations**<br>41. Demonstrating value and respect for reluctant learners<br>42. Asking in-depth questions of reluctant learners<br>43. Probing incorrect answers with reluctant learners |

# Curriculum Introduction

This curriculum document outlines the essential learning for this trade program and provides a clear structure for planning, instruction, and assessment. It includes the components required by NEASC Standard 2.2a, along with elements that reflect the unique nature of CTECS technical programs. The curriculum is organized to show what students learn in each course, how learning progresses across grade levels, and how instruction supports both technical skill development and the CTECS Vision of a Graduate.

Teachers should use this document to:

- Understand the overall structure and expectations of the course sequence
- Reference the Course Map to see the scope and sequence of Priority Standards and the alignment to District Summative Assessments (DSAs)
- Use the Priority Standards and Units of Study to guide daily, weekly, and cycle-based planning
- Integrate Big Ideas, Essential Questions, Skills/Learning Outcomes, vocabulary, and resources during lesson design
- Identify required safety, industry, and technical content expectations
- Plan and implement formative assessments to monitor progress and guide instruction
- Prepare students for the District Summative Assessments, ensuring alignment with the Course Map
- Maintain consistency of technical and professional practice instruction across campuses while adapting to student needs and industry-based opportunities

# Curriculum Components

## Course Map

A Course Map serves as the scope and sequence for this course by outlining the progression of instructional units and the standards that guide teaching and assessment. While each campus will have individual student needs, cycle schedules, and industry-based opportunities, all instructors are expected to teach the standards outlined in the Course Map. Using the Course Map below, teachers will intentionally plan learning experiences that prepare students to meet the identified standards within the designated assessment windows.

## Priority Standards (Units of Study)

Priority Standards identify the most essential learning in the trade program. They reflect the core technical competencies, safety practices, and industry-aligned skills that require the greatest instructional focus and appear on program assessments. In CTE programs, each Priority Standard also functions as a Unit of Study, because it includes the required components such as big ideas, essential questions, content topics, and skills/learning outcomes aligned to assessments.

## Vertical Alignment

Vertical alignment shows how Priority Standards and instructional expectations progress from grade to grade within the trade program. It provides a clear pathway of skill development, increasing complexity, and technical proficiency across the four-year sequence.

## Learning Outcomes

Learning outcomes are what students will know (Concepts) and be able to do (Skills).
Concepts identify the major content topics within the Priority Standard (Unit of Study). They appear in the left column of the Learning Outcomes table and follow a similar coding structure as the Priority Standard.
Skills are learning objectives that describe the measurable actions students must be able to perform to demonstrate proficiency. They appear in the right column of the Learning Outcomes table and show the progression of learning evidence in the Priority Standard.

## Vocabulary

Essential vocabulary includes the technical and academic terms students must understand and use accurately to engage in trade-specific learning and demonstrate proficiency on assessments. Vocabulary is foundational to safety, technical precision, and industry communication, and should be a primary initial focus within each unit and taught explicitly through modeling, demonstration, and repeated application.

## Resources

Resources include the tools, equipment, texts, materials, and digital tools that support learning within each unit and reflect industry standards.

## Assessment Practices

Teachers use ongoing formative assessments—such as questioning, checks for understanding, performance demonstrations, reflections, and teacher observation—to monitor progress, guide instruction, and support all learners in mastering the Priority Standards.

Each program also includes District Summative Assessments (DSAs), which measure proficiency on the Priority Standards identified in the Course Map. DSAs provide consistent evidence of student learning across campuses and ensure alignment to industry expectations, safety requirements, and program outcomes. Teachers should reference the Course Map and Units of Study when planning instruction to ensure students have opportunities to practice and demonstrate the skills and knowledge assessed on the DSA.

# Aerospace Component Manufacturing Technology Philosophy

The philosophy of the Connecticut Technical Education and Career System's Aerospace Component Manufacturing Technology program is to provide our students with theoretical knowledge, analytical problem solving, and application skills necessary for entry-level employment in the ever-changing Aerospace manufacturing environment and preparation for post-secondary education. This philosophy is put into effect using a standard-based curriculum and comprehensive work-based learning that provides options and alternatives for learning; and is designed to accommodate varying types of gifts, talents, strengths, needs, and interests.

# Aerospace Component Manufacturing Technology – Course Map

Grade 9 – Semester 1 & 2 DSA

- Priority Standard 9.1 Shop Safety
- Priority Standard 9.2 Introduction to Automated Manufacturing
- Priority Standard 9.3 Introduction - SolidWorks®
- Priority Standard 9.4 Introduction – CAM Software - MasterCam®
- Priority Standard 9.5 Blueprint Reading
- Priority Standard 9.6 Introduction – Basic CNC Operations
- Priority Standard 9.7 Hand Tools
- Priority Standard 9.8 Measurements
- Priority Standard 9.9 Introduction Milling Machines
- Priority Standard 9.10 Introduction Lathes

Grade 10 – Semester 1 DSA

- Priority Standard 10.1 Shop Safety (OSHA 10)
- Priority Standard 10.2 Employability Skills and Work Ethic
- Priority Standard 10.3 Orthographic drawing SOLIDWORKS® 2D & 3D
- Priority Standard 10.4 Measurement, Quality and Applied Math
- Priority Standard 10.5 MasterCAM®
- Priority Standard 10.6 Dimensioning Working Drawings
- Priority Standard 10.7 Fasteners / Threaded and Non-Treaded

Grade 10 – Semester 2 DSA

- Priority Standard 10.8 Layout
- Priority Standard 10.9 Milling Machines
- Priority Standard 10.10 Conversational CNC Programming
- Priority Standard 10.11 Auxiliary and Section Views
- Priority Standard 10.12 Mechanical Working Drawings
- Priority Standard 10.13 Introduction to Additive Manufacturing

Grade 11 – Semester 1 DSA

- Priority Standard 11.1 Shop/Workplace Safety
- Priority Standard 11.2 Lathes
- Priority Standard 11.3 Welding processes
- Priority Standard 11.4 Material Composition and Heat Treatment
- Priority Standard 11.5 Tolerances
- Priority Standard 11.6 CamInstructor® & CIMCO Edit®

Grade 11 – Semester 2 DSA

- Priority Standard 11.7 CNC Programming and Operations
- Priority Standard 11.8 Working Drawings Solid Modeling
- Priority Standard 11.9 Design practices and principles
- Priority Standard 11.10 Product Data Management (PMD) / Revision control
- Priority Standard 11.11 Additive Manufacturing
- Priority Standard 11.12 Inspection Setups and Coordinate Measuring Machines (CMM)
- Priority Standard 11.13 Continuous Improvement and Lean Manufacturing Principles

Grade 12 – Semester 1 DSA

- Priority Standard 12.1 Shop/Workplace Safety
- Priority Standard 12.2 Geometric Dimensioning and Tolerancing
- Priority Standard 12.3 Milling Machines (4 and 5 Axis Machining)
- Priority Standard 12.4 MasterCAM®

Grade 12 – Semester 2 DSA

- Priority Standard 12.5 Senior Project
- Priority Standard 12.6 Specialty Machines

# 9th Grade curriculum

## Priority Standard 9.1 Shop Safety

**Big Idea(s):**

- Safety is the number one priority of the shop.
- Safety is everyone's responsibility.

**Essential Question(s):**

- What types of PPE have you used in your daily lives? Why?
- What could be a result of someone not following all safety rules?

**Learner Outcomes**

| Students will know: | As evidenced by: (oral, written, or performance) |
|---|---|
| **9.1.1** Safe Work Habits | ● Identify Personal Protective Equipment<br>● Demonstrate appropriate PPE use<br>● Explain proper shop dress code<br>● Follow shop safety rules<br>● Maintain a clean work area/shop<br>● Locate Emergency shut-offs in shop<br>● Score 100% on safety test each phase |
| **9.1.2** Fire Safety | ● Explain the fire triangle<br>● Identify classes of fires<br>● Locate fire extinguishers and blankets in shop<br>● Identify types of extinguishers<br>● Explain the process of extinguishing certain fires<br>● Score 100% on written safety test |
| **9.1.3** First Aid | ● Describe procedures for dealing with various injuries.<br>● Explain the dangers bloodborne pathogens<br>● Score 100% on written safety test |
| **9.1.4** PMT Specific Hazards | ● Identify and describe specific shop/ machine hazards:<br>○ Clearing of chips using proper tools<br>○ Lathe safety<br>○ Mill safety<br>○ Bandsaw safety<br>○ Large stock/material handling<br>○ Proper hand tool care and usage<br>○ Score 100% on safety test |

**Technical Vocabulary:**

PPE, Emergency Shut-off, Shield/Guards, Eye Wash Station, Lock-out/Tag-out

Fire triangle

| **Priority Standard 9.1 Shop Safety** |
| --- |
| |
| **Resources:**<br><br>Precision Machining Technology, second edition text:<br>Section 2 Unit 1<br><br>Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:<br><br>Basic Personal Protective Equipment for Machining Video:<br>https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&id=1840887818&snapshotId=3554665& |

## Priority Standard 9.2 Introduction to Aerospace Component Manufacturing

**Big Idea(s):**

- Every item in our daily lives was designed and built by machines and manufacturing.
- There are a variety of career paths offered to young machinists after graduating from Precision Machining Technology.

**Essential Question(s):**

- What type of job do you see yourself doing after graduation?

**Learning Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **9.2.1** Evolution of Machine Tools | ● Summarize the evolution of machine tools |
| **9.2.2** Occupations and Careers | ● Describe typical career paths leading to advancement for these occupations and careers:<br>○ Semi-Skilled<br>■ Machine Operator<br>■ Assembler<br>■ Shipping<br>○ Skilled<br>■ Machinist<br>■ Toolmaker<br>■ CNC Programmer & setup<br>■ Inspector<br>■ Mold Maker<br>■ Machine Repair<br>○ Technicians<br>■ Inspection/QC<br>■ Engineering<br>○ Professional<br>■ Engineer<br>■ Supervisor<br>■ Tech Ed/trade teacher<br>■ Business Owner |
| **9.2.3** Technical Skills and Concepts | ● Perform trade math calculations<br>● Demonstrate measurement tool usage<br>● Perform basic part layout<br>● Describe basic blueprint reading terminology<br>● Demonstrate proper operation of manual machines |

**Technical Vocabulary:**

Machine Tool, Computer Numerical Control, Lathe, Milling Machine

| **Priority Standard 9.2 Introduction to Aerospace Component Manufacturing** |
| --- |
| Machinist, Tool Maker, Die Maker, Inspector, Programmer, Engineer, Apprenticeship, Journeyperson, OJT/WBL, Associates Degree, Baccalaureate Degree |
| **Resources:**<br><br>Precision Machining Technology, second edition text:<br>Section 1 Unit 1 Introduction to Machining<br>Section 1 Unit 2 Careers in Machining<br><br>Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:<br>Section 1 Unit 1: Introduction to Machining<br>Section 1 Unit 2: Careers in Machining<br><br>Connecticut Manufacturing Video:<br>https://www.youtube.com/watch?v=IZAznZCYYuE<br><br>CPTV Videos:<br>https://cptv.org/episode/amanda/<br>https://cptv.org/episode/angie/<br>https://cptv.org/episode/millie/<br>https://cptv.org/episode/nasir/<br>https://ctcreates.org/resources/cptv-making-the-future/<br><br>Connecticut Manufacturing Company Tours and Testimonial Videos:<br>https://ctcreates.org/virtual-fair/tours/ |

## Priority Standard 9.3 Introduction - SolidWorks®

**Big Idea(s):**

- 3D models communicate design ideas.
- Accurate sketches create accurate models.

**Essential Question(s):**

- How do we use 3D models to communicate design ideas?
- Why is parametric modeling useful?

**Learner Outcomes**

| Students will know: | As evidenced by: (oral, written, or performance) |
|---|---|
| **9.3.1** SolidWorks® interface Components | • Navigating and identifying components<br>  ○ Component Manager<br>  ○ Feature Tree<br>  ○ Sketch environment<br>  ○ Saving drawing<br>  ○ Organizing file<br>  ▪ .SLDPRT<br>  ▪ .SLDASM<br>  ▪ .SLDDRW |
| **9.3.2** Sketching Tools – 2 Dimensional (2D) | • Creating a fully defined 2D sketch<br>  ○ Line<br>  ○ Circle<br>  ○ Rectangle<br>  ○ Arc |
| **9.3.3** Design intent – Model accuracy | • Producing a simple drawing or model that communicates the design clearly.<br>• Parametric modeling |

**Technical Vocabulary: Parametric Modeling, Parameter, Dimension, Constraint / Relation Sketch, Feature, Extrude, Cut, Fillet, Chamfer, Feature Tree, Rebuild, Part File (.SLDPRT), Assembly File (.SLDASM), Drawing File (.SLDDRW)**

**Resources:**

**SolidWorks® Tutorials – Mysolidworks training.**

**SolidWorks® YouTube Channel**

## Priority Standard 9.4 Introduction – CAM Software - MasterCam®

**Big Idea(s):**

- CAM software creates toolpaths for machines.
- Simulation helps prevent errors.

**Essential Question(s):**

- How does MasterCam® create toolpaths?
- Why is simulation important before machining?

**Learner Outcomes**

| Students will know: | As evidenced by: (oral, written, or performance) |
|---|---|
| **9.4.1** CAM software - MasterCam® - Purpose | • Explain how CAD geometry is converted into toolpaths and G-code. |
| **9.4.2** Toolpaths | • Creating and applying the following Toolpaths:<br>  ○ Contour<br>  ○ Pocket<br>  ○ Drill |
| **9.4.3** Machining Parameters | • Assign and adjust correct machining parameters within toolpath:<br>  ○ Spindle Feed<br>  ○ Feed rate<br>  ○ Depth of cut<br>  ○ Step-over. |
| **9.4.4** Tool Selection / Tool Library | • Selecting appropriate cutting tools and applying them to operations. |
| **9.4.5** Stock Setup | • Properly define:<br>  ○ Stock size<br>  ○ Origin<br>  ○ Work Coordinate system (WCS) |
| **9.4.6** Simulation - Verification | • Run a simulation and verification to identify errors such as collisions or missed materials. |

**Technical Vocabulary:** CAM (Computer Aided Manufacturing), MasterCam®, Toolpath, Contour Toolpath, Contour Toolpath, Drill Toolpath, Facing, Stock, Work Coordinate System (WCS), Geometry, Chain / Chaining, Tool Library, Spindle Speed (RPM), Climb Milling, Conventional Milling, Step-over, Simulation, Post processor, G – M Code.

**Resources:**

**Mastercam 2024 Training Guide Mill 2D**

**Mastercam University**

**Titans of CNC Academy**

**NIMS / SME**

| Priority Standard 9.4 Introduction – CAM Software - MasterCam® |
| --- |
| |

## Priority Standard 9.5 Blueprint Reading

**Big Idea(s):**

- Blueprints are like roadmaps (driving directions) to a final product.

**Essential Question(s):**

- What are some advantages and disadvantages of viewing images or models of parts and assemblies on a computer screen, tablets, and other media devices versus having paper prints?
- What are some of the consequences that a company might incur if it does not choose to create prints in a standard fashion?

**Learning Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **9.5.1** Orthographic Projection | ● Describe the relationship between the views of a print:<br>○ Front view<br>○ Top view<br>○ Right side view<br>○ Rear view<br>○ Bottom view<br>○ Left side view<br>○ Isometric view |
| **9.5.2** Alphabet of lines | ● Identify the “alphabet of lines” and explaining the characteristics/uses of each type of line:<br>○ Object/Visible<br>○ Hidden<br>○ Center<br>○ Border<br>○ Dimension<br>○ Leader<br>○ Extension<br>○ Break<br>○ Cutting-plane<br>○ Phantom<br>○ Section<br>○ Symmetry<br>○ Viewing-plane (Cutting-plane) |
| **9.5.3** Title Blocks and Notes | ● Identify and name the parts of a blueprint:<br>○ Drawing number<br>○ Part number<br>○ Revision history block<br>○ Sheet size<br>○ Title block<br>○ Tolerance block<br>○ Zones<br>○ General notes |

| **Priority Standard 9.5 Blueprint Reading** | |
|---|---|
| **9.5.4** Dimensions and Tolerance | ● Identify the types of dimensions on a blueprint:<br>○ Unilateral tolerance<br>○ Bilateral tolerance<br>○ Upper limit<br>○ Lower limit<br>○ Limit tolerance<br>● Calculate the tolerance for a given dimension |

**Technical Vocabulary:**

Blueprint, Orthographic Projection, Isometric View

Object Line, Hidden Line, Center Line, Border, Dimension Line, Leader Line, Extension Line, Break Line, Dimension Line, Cutting-plane Line, Phantom Line, Section Line, Symmetry Line, Viewing-plane (Cutting-plane) Line

Drawing number, Part number, Revision, Revision history block, Sheet size, Title block, Tolerance block, Zones, General notes

Dimension, Tolerance, Basic size, Unilateral tolerance, Bilateral tolerance, Upper limit, Lower limit, Limit tolerance

**Resources:**

Precision Machining Technology, second edition text:
Section 3 Unit 1 Understanding Drawings

Machine Trades Print Reading 6th edition:
Unit 2 Visualizing Shapes
Unit 3 Line Types
Unit 4 Title Blocks and Notes
Unit 7 Dimensions and Tolerance

Starrett Decimal Equivalent Chart:
Starrett decimal-equivalent-card.pdf

## Priority Standard 9.6 Introduction – Basic CNC Operations

**Big Idea(s):**

- CNC machines follow programmed instructions.
- Coordinates control machine movement.

**Essential Question(s):**

- How do CNC Machines follow a program?
- How do coordinates control movement?

**Learner Outcomes**

| Students will know: | As evidenced by: (oral, written, or performance) |
|---|---|
| 9.6.1 Safe Machine operation | Demonstrate proper:<br>• PPE<br>• Safe start-up<br>• Operational practices |
| 9.6.2 Purpose and Function – CMC machines | Explaining how CNC machines use programmed instructions to manufacture parts. |
| 9.6.3 Types of CNC Machines | • Identify types of CNC machines:<br>○ CNC Milling machine<br>○ Vertical machining center (VMC)<br>○ Horizontal machining center (HMC)<br>○ CNC Lathe<br>○ CNC Turning Center<br>○ Swiss-Type |
| 9.6.4 Machine Components | Identify components on a CNC machine and describe their functions:<br>• Controller<br>• Spindle<br>• Axes<br>• Tool Holder |
| 9.6.5 Coordinate system | Demonstrating correct identification and uses of axes and setting a work offset.<br>• X, Y, Z, axes<br>• Machine Zero<br>• Part Zero |
| 9.6.6 Conversational Programming | • Demonstrate how to create the following events on the milling machine MCU:<br>○ Position<br>○ Mill<br>○ Drill<br>○ Arc<br>• Demonstrate how to create the following events on the lathe MCU (If available):<br>○ Position<br>○ Turn<br>○ Drill<br>○ Arc |

| Priority Standard 9.6 Introduction – Basic CNC Operations | |
|---|---|
| 9.6.7 G and M Codes | Interpreting and executing simple CNC programs using common G and M codes<br>• G00<br>• G01<br>• G02<br>• G20<br>• G40, G41, G42<br>• G54<br>• G90<br>• M00<br>• M03<br>• M06<br>• M30 |
| 9.6.8 Machine Setup | Complete a basic machine setup including:<br>• Part Zero<br>• Tool setup<br>• Work holding |
| 9.6.9 Program Verification | Running a program safely using:<br>• Dry run<br>• Single block<br>• Simulation |
| **Technical Vocabulary: CNC (Computer Numerical Control), Program, G-Code, M-Code, Axis (X,Y,Z), Absolute positioning, Incremental, Home position, Work offset, Part zero, Tool offset, Tool number, Spindle, Feed rate, Spindle Speed (RPM), Linear, Circular Interpolation, Workholding, setup, Dry run, Single block, cycle start, Emergency stop** | |
| **Resources:**<br><br>**National Institute for Metalworking skills**<br><br>**CamInstructor**<br><br>**Haas Automation**<br><br>**Haas Tip of the Day** | |

## Priority Standard 9.7 Hand Tools

**Big Idea(s):**

- Using the right tool to complete a job safely, quickly, and efficiently.
- Hand tools can be just as dangerous as the machines in the shop.

**Essential Question(s):**

- What do you feel is the importance of hand tools in today's manufacturing world?
- Why do people take everyday hand tools for granted, and forget to follow simple precautions for safety?
- What are possible repercussions of using the wrong tool for a job and using a tool incorrectly?

**Learning Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **9.7.1** Hand/Bench tools | ● Identify and describe each common hand/bench tool:<br>○ Wrenches<br>○ Hacksaws<br>○ Files<br>○ Hand Reamers<br>○ Hand taps/dies (threading)<br>○ Hand Drill<br>○ Hammers<br>○ C-clamp & Parallel clamp<br>○ V-Block<br>○ Vises<br>○ Pliers<br>■ Needle nose<br>■ Slip joint<br>■ Side cutting<br>○ Screwdrivers<br>■ Flat head (Straight/Slotted)<br>■ Phillips<br>■ Torx<br>○ Needle nose pliers<br>○ Wrenches<br>■ Open end<br>■ Box end<br>■ Adjustable wrench<br>■ Spanner |
| **9.7.2** Hand Tool Care and Safety | ● Demonstrate the safe use & care of all appropriate tools<br>● Select appropriate hand/bench tool for a specific application |

| **Priority Standard 9.7 Hand Tools** | |
|---|---|
| | |

**Technical Vocabulary:**

Adjustable Wrench, Dead Blow Hammer/Mallet, File, File Card, Hex Key/Allen Wrench, Pliers, Hack Saw, Vise, Taps, Dies, Draw filing, Loading, Needle nose pliers, Open end wrench, Pinning, Side cutting pliers, Spanner wrench, Straight filing, Deburring, Box end wrench

**Resources:**

Precision Machining Technology, second edition text:
Section 3 Unit 3 Hand Tools

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
Section 3 Unit 3: Hand Tools

Hacksaw Use Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&id=1840887834&snapshotId=3554665&

File Use Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887835&

Hand Tapping Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887840&

Hand Threading with a Die Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887841&

## Priority Standard 9.8 Measurements

**Big Idea(s):**

- Without accurate measurement, modern industry could not exist.
- Precision measurement is a science known as metrology.

**Essential Question(s):**

- How is measurement incorporated into our everyday lives?

**Learning Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **9.8.1** Machine Technology Math | ● Demonstrate and understanding of fractional and decimal math<br>● Demonstrate an understanding of conversions between decimals and fractions<br>● Reduce fractions to their lowest terms<br>● Use machinist lingo to properly pronounce 3-place decimal figures in *thousandths of an inch* terms |
| **9.8.2** Semi-Precision Instruments | ● Read a steel rule down to 1/64” graduation<br>● Measure an angle with a protractor<br>● Measure a radius with a radius gage |
| **9.8.3** Precision Instruments | ● Read a micrometer to 3 decimal places<br>● Measure an outer diameter with a micrometer<br>● Read a dial caliper<br>● Measure a length and shoulder with a dial caliper<br>● Measure a height using a height gage<br>● Measure perpendicularity with a solid square |

**Technical Vocabulary:**

Numerator, Denominator

Steel Rule, Graduations, Protractor, Fixed Gages, Semi-Precision Instrument

Micrometer, Dial Caliper, Precision Instrument, Solid square

**Resources:**

Precision Machining Technology, second edition text:
Section 2 Unit 2 Measurement Systems and Machine Tool Math Overview
Section 2 Unit 3 Semi-Precision Measurement
Section 2 Unit 4 Precision Measurement

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:

**Priority Standard 9.8 Measurements**

Measuring with a Dial Caliper Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&id=1840887824&snapshotId=3554665&

Machine Trades Print Reading 6th edition:
Unit 5 Applied Math
Unit 6 Measurement

Micrometer Simulator:
https://www.stefanelli.eng.br/en/virtual-micrometer-thousandth-inch-simulator/

Starrett Decimal Equivalent Chart:
Starrett decimal-equivalent-card.pdf

## Priority Standard 9.9 Introduction Milling Machines

**Big Idea(s):**

- Milling machines can create almost any shape imagined.

**Essential Question(s):**

- What are some items you can think of that were made by a milling machine?
- How many different operations can be performed by a milling machine?

**Learning Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **9.9.1** Milling Machine Safety | ● Identify all safety devices and explaining their function(s)<br>○ Emergency stop<br>○ Chip shields<br>○ Safety glasses<br>○ Safety shoes<br>○ Jewelry (as it relates to moving parts)<br>○ Long hair (as it relates to moving parts)<br>○ Loose clothes (as it relates to moving parts)<br>○ Medication<br>○ Chips<br>● Explain how these personal items can become safety hazards<br>● Identify and analyze the moving parts of a milling machine that can cause injury |
| **9.9.2** Milling machine operations | ● Perform the milling operations:<br>○ Mill block to size<br>○ Drill holes<br>○ Tapping holes |

**Technical Vocabulary:**

Vertical Milling Machine, Bridgeport, Endmill

**Resources:**

Precision Machining Technology, second edition text:
Section 6 Unit 2 Tools, Toolholding, and Workholding for the Vertical Milling Machine

## Priority Standard 9.10 Introduction Lathes

**Big Idea(s):**

- Most parts that are round, at some point in time, were impacted by a lathe.
- Lathes can be dangerous machines; They are only as safe as the operator using them.

**Essential Question(s):**

- How have lathes affected the machining industry?
- What are some safety guidelines that you need to be aware of in order to operate a lathe?

**Learning Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **9.10.1** Lathe Safety | ● Identify all safety devices and explain their function(s)<br>○ Emergency stop<br>○ Chip shields<br>○ Spindle brake<br>○ Chuck key removal<br>○ Safety glasses<br>○ Safety shoes<br>○ Jewelry (as it relates to moving parts)<br>○ Long hair (as it relates to moving parts)<br>○ Loose clothes (as it relates to moving parts)<br>○ Medication<br>○ Chips<br>● Explain how personal items can become safety hazards<br>● Identify and analyze the moving parts of a lathe that can cause injury<br>● Determine and use all required personal safety equipment when operating a lathe |
| **9.10.2** Lathe Operations | ● Perform these lathe operations:<br>○ Facing<br>○ Turning<br>○ Shouldering<br>○ Chamfers<br>○ Knurling<br>○ Filing/polishing<br>○ Grooving/cutoff<br>○ Drilling |

| **Priority Standard 9.10 Introduction Lathes** | |
|---|---|
| | |

**Technical Vocabulary:**

Emergency stop, Entanglement, Impairment

Facing, Turning, Shouldering, Knurling, Grooving, Chamfer

**Resources:**

Precision Machining Technology, second edition text:
Section 5 Unit 1 Introduction to the Lathe
Section 5 Unit 3 Machining Operations on the Lathe

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:

Facing and Turning on the Lathe Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887861&

Square Shouldering on the Lathe Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887862&

Filing and Polishing on the Lathe Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887864&

Knurling on the Lathe Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887868&

# 10th Grade Curriculum

## Priority Standard 10.1 Shop Safety (OSHA 10)

**Big Idea(s):**

- Safety is the number one priority of the shop
- Safety is everyone's responsibility

**Essential Question(s):**

- Is there a difference between school and work safety?
- Why would someone ignore safety protocols?
- What are the dangers to someone ignoring safety protocols or taking shortcuts?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **10.1.1** Safe Work Habits | ● Identify Personal Protective Equipment<br>● Demonstrate appropriate PPE use<br>● Explain proper shop dress code<br>● Follow shop safety rules<br>● Maintain a clean work area/shop<br>● Locate Emergency shut-offs in shop<br>● Score 100% on safety test |
| **10.1.2** Fire Safety | ● Explain the fire triangle<br>● Identify classes of fire<br>● Locate fire extinguishers and blankets in shop<br>● Identify types of extinguishers<br>● Explain the process of extinguishing certain fires<br>● Score 100% on written safety test |
| **10.1.3** First Aid | ● Describe procedures for dealing with various injuries.<br>● Explain the dangers bloodborne pathogens<br>● Score 100% on written safety test |
| **10.1.4** Machining Hazards | ● Identify and describe specific shop/ machine hazards:<br>○ Clearing of chips using proper tools<br>○ Lathe safety<br>○ Mill safety<br>○ Bandsaw safety<br>○ Grinding safety<br>○ Large stock/material handling<br>○ Proper hand tool care and usage<br>○ Heavy lifting technique<br>○ Compressed air safety<br>○ Lockout/tagout<br>○ Score 100% on safety test |

| **Priority Standard 10.1 Shop Safety (OSHA 10)** | |
|---|---|
| **10.1.5** Safety Data Sheet (Previous, M.S.D.S.) | • Identify chemical safety using S.D.S.<br>• Identify HMIS<br>• Identify NFPA |
| **10.1.6** OSHA 10 | • Certify with the OSHA 10 credential |

**Technical Vocabulary:**

**10.1.1** PPE, Emergency Shut-off, Shield/Guards, Eye Wash Station, Lock-out/Tag-out

**10.1.2** Class A fire extinguisher, Class B fire extinguisher, Class C fire extinguisher, Class D fire extinguisher, Multipurpose fire extinguisher, UEL, UFL, Flash point, LEL, LFL, EPA, NIOSH, OSHA

**10.1.5** SDS (MSDS), HMIS, NFPA, PPM, PPB, PPT, PEL, STEL, TLV, TWA

**Resources:**

Precision Machining Technology, second edition text:
Section 2 Unit 1 Introduction to Safety

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
Section 1 Unit 1: Introduction to Safety

https://www.careersafeonline.com/

NIMS Materials, Measurement, and Safety Links:
Measurement, Materials, & Safety
MMS 2020 Prep Guide V1.pdf (nims-skills.org)

## Priority Standard 10.2 Employability Skills and Work Ethic

**Big Idea(s):**

- Most employers seek workers with employability skills and work ethic over trade skills.
- Many of these skills and habits are important in more places than only work or school.

**Essential Question(s):**

- What role does employability / interpersonal skills have in a manufacturing environment?

**Learning Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **10.2.1** Employability Skills | ● Explain the importance of interpersonal skills related to work ethic and key characteristics which are important for success in the workplace:<br>○ Attendance (Punctuality)<br>○ Character<br>○ Teamwork<br>○ Attitude<br>○ Productivity<br>○ Organizational Skills<br>○ Communication<br>○ Cooperation<br>○ Respect |
| **10.2.2** Interpersonal Skills | ● Explain the role of interpersonal skills as an aspect of work ethic:<br>○ Habits<br>○ Attitude<br>○ Manners<br>○ Appearance<br>○ Behaviors<br>● Develop and implement strategies for improving interpersonal skills in and out of the shop and classroom |
| **10.2.3** Initiative | ● Explain initiative as a part of work ethic as it relates to work ethic and utilization in appropriate and productive ways<br>● Evaluate one's own initiative, and demonstrating an increased initiative in appropriate and productive ways |

| **Priority Standard 10.2 Employability Skills and Work Ethic** | |
|---|---|
| **10.2.4** Dependability | ● Explain the importance of being dependable and identify areas for improving personal dependability on a written and/or oral assessment<br>● Employ characteristics that will improve personal dependability in and out of the shop and classroom |
| **Technical Vocabulary:**<br>Attendance (Punctuality), Character, Teamwork, Attitude, Productivity, Organizational Skills, Communication, Cooperation, Respect<br>Interpersonal skills<br>Initiative<br>Dependability | |
| **Resources:**<br>Precision Machining Technology, second edition text:<br>Section 1 Unit 3 Workplace Skills<br><br>Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:<br>Section 1 Unit 3: Workplace Skills<br><br>Employability Skills: 10 Examples of Skills Companies Value \| Indeed.com<br><br>Employability Skills<br><br>Soft skills vs hard skills. \| Linkedin Top 5 Soft skills for 2020 | |

## Priority Standard 10.3 Orthographic drawing SOLIDWORKS® 2D & 3D

**Big Idea(s):**

- The number of views needed to describe an object completely depends on its shape and characteristics.
- Orthographic projection uses either a first angle projection or third angle projection method.

**Essential Question(s):**

- Why is there a “standard” orthographic method?
- What is the difference between first and third angle projection?
- How do you locate views on a drawing using accepted principals of drafting?

**Learning Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **10.3.1** Multiview drawing | ● Identify the three normal views.<br>● Explain why visualization is important.<br>● List the 6 views of an object.<br>● Describe the “proper view selection” for a given object. |
| **10.3.2** Angles of Projection | ● Explain the difference between first angle and third angle projection.<br>● Sketch and label the symbol for first and third angle projection. |
| **10.3.3** Glass box | ● Explain the theory of projecting all sides using the “glass box” method.<br>● List, sketch, and properly label the six views of an object. |
| **10.3.4** Drawing the views | ● Determine the number of views for drawing sample parts.<br>● Describe the proper placement of views.<br>● Layout views for assigned problems |
| **10.3.5** CAD Methods – SOLIDWORKS® | ● Explain how to create views independently using CAD.<br>● Demonstrate creating a Multiview drawing using 3D solid modeling.<br>● Outline how a 3D model can help create 2D views. |
| **10.3.6** Principle Dimensions | ● Identify the 3 principle dimensions in Multiview drawing:<br>○ Height<br>○ Width<br>○ Depth<br>● Label the three on a drawing assessment. |
| **10.3.7** Laying out views using CAD -SOLIDWORKS® | ● Demonstrate how to offset lines.<br>● Explain what a solid model is and its purpose. |

| Priority Standard 10.3 Orthographic drawing SOLIDWORKS® 2D & 3D | |
|---|---|
| | ● Illustrate how to create a wireframe model. |
| **10.3.8** Conventional representation of manufacturing features. | ● Identify the conventional representation of these features on a drawing.<br>• Fillets/Rounds<br>• Slots<br>• Grooves/Necks<br>• Counterbore<br>• Countersink<br>• Spot face<br>• Blind/Through holes<br>● Label the symbols for the features on a drawing. |
| **Technical Vocabulary:**<br><br>Baseline, Datum<br><br>Diameter, Radius, Depth, Counterbore, Countersink, Spot face, Blind hole<br><br>Inches, Metric, Degrees, Minutes, Seconds<br><br>Allowance | |
| **Resources:**<br><br>Precision Machining Technology, second edition text:<br>Section 2 Unit 2 Measurement Systems and Machine Tool Math Overview<br>Section 3 Unit 1 Understanding Drawings<br>Section 3 Unit 2 Layout<br><br>Starrett Decimal Equivalent Chart:<br>Starrett decimal-equivalent-card.pdf<br><br>Machinery's Handbook:<br>Machinerys Handbook 29th Edition.pdf | |

## Priority Standard 10.4 Measurement, Quality and Applied Math

**Big Idea(s):**

- Without accurate measurement, modern industry could not exist.
- Precision measurement is a science known as metrology.
- Becoming familiar with the use and care of measuring tools is an important step in creating a strong foundation of machining skills.
- Your work is only as good as the instruments you are using.
- Process planning, QA, QC, and SPC are critical tools to ensure part consistency, accuracy, and customer satisfaction.

**Essential Question(s):**

- Where can we find triangles in the world around us? What purpose do they serve?
- How is accuracy affected by calibration?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **10.4.1** Semi-precision Measuring Tools | • Explain the difference between semi-precision and precision instruments.<br>• Identify and explain the use of:<br>  ○ Rule/Scale (Steel rule)<br>  ○ Caliper<br>  ○ Adjustable/Combination square<br>  ○ Protractor<br>• Identify and explain the use of the following semi-precision fixed gages:<br>  ○ Radius gage<br>  ○ Angle gage<br>  ○ Screw Pitch Gage<br>• Select the correct measuring instrument(s) based on feature and tolerance. |
| **10.4.2** Precision Measuring Tools | • Explain the difference between semi-precision and precision instruments<br>• Identify and explain the use of the following precision fixed gages:<br>  ○ Feeler gage<br>  ○ Pin/Plug gage<br>  ○ Go/No-Go gage<br>  ○ Thread Go/No-Go gage<br>  ○ Ring gage<br>  ○ Thread Go/No-Go gage<br>  ○ Snap gage |

| **Priority Standard 10.4 Measurement, Quality and Applied Math** | |
|---|---|
| | ● Read a vernier scale on a caliper and height gage<br>● Identify and explain the use of:<br>○ Inside Micrometer<br>○ Depth Micrometer<br>○ Thread Pitch Micrometer<br>○ Blade Micrometer<br>● Read a micrometer to the fourth decimal place (Tenths position)<br>● Identify the parts of a micrometer<br>● Read a metric micrometer<br>● Read a metric dial caliper<br>● Identify and explain the use of a dial bore gage<br>● Identify and explain the use of the following transfer or helper-type measuring tools:<br>○ Hole gages<br>○ Telescoping gages<br>○ Dial bore gage<br>○ Adjustable parallels<br>● Select the proper measuring instrument(s) based on feature and tolerance.<br>● Define and explain the importance of calibration<br>● Define and explain the following surface finish measuring tools:<br>○ Profilometer<br>○ Surface finish comparator<br>● Identify various surface finish symbols |
| **10.4.3** Indicators | ● Identify and explain the common uses of dial and digital indicators<br>● Identify the graduations on a variety of dial indicators (3 and 4 place decimal)<br>● Explain the difference between a balance and a continuous dial indicator<br>● Set-up and demonstrate the use of a the following indicators:<br>○ Plunger-type<br>○ Test-type |
| **10.4.4** Gage Pins | ● Explain the common uses of gage pins on an inspection plan<br>● Measure a hole +/- .001” utilizing gage pins<br>● Calculate and build a Go/No-Go plug gage for a given hole size<br>● Explain the classes of gage pins |

| **Priority Standard 10.4 Measurement, Quality and Applied Math** | |
|---|---|
| **10.4.5** Algebraic Functions | ● Demonstrate the ability to solve algebraic formulas:<br>○ Order of Operations<br>■ PEMDAS<br>○ Solving for a variable |
| **10.4.6** Trigonometry | ● Identify the sides of a triangle<br>○ Adjacent, Opposite, Hypotenuse<br>● Use the Pythagorean Theorem to calculate an unknown side of a right triangle<br>● Demonstrate the ability to solve right triangles using sine, cosine, and tangent trigonometric functions |
| **10.4.7** Gage Blocks | ● Explain the common uses of gage blocks and gage pins on an inspection plan<br>● Explain the grades of gage pins<br>● Identify the different size sets of gage blocks from the Machinery's Handbook<br>● Measure a height +/- .001” utilizing gage blocks with an indicator<br>● Explain the purpose of sine tools<br>● Explain how to wring gage blocks<br>● Calculate a gage block build, using the fewest number of blocks, from a given angle<br>○ h=sine($\theta$)*l<br>● Set up a gage block build and measure a given angle |
| **10.4.8** Optical Comparators | ● Demonstrate the use of an optical comparator:<br>○ Measure a radius on an optical comparator to within +/- 1 degree.<br>○ Measure a hole location to within +/- .002" in X &Y axis.<br>○ Utilize fiber optics feature (if available)<br>○ measure a blind hole for +/-.002” dia. |
| **10.4.9** Quality | ● Define Quality Assurance<br>● Explain the importance of a process plan (also called a job traveler, work order, job card, router, lot traveler, or Standard Operating Procedure [SOP])<br>● List the information found in a Process Plan:<br>○ Material Selection |

| Priority Standard 10.4 Measurement, Quality and Applied Math | |
|---|---|
| | ○ Machines to be used<br>○ Workholding<br>○ Tooling<br>○ Speed and Feed calculations<br>○ Miscellaneous Information<br>● Create a process plan from a given job<br>● Explain the importance of Quality Control<br>● Explain the purpose of a sampling plan<br>● List the steps to set up an inspection plan:<br>○ Critical dimensions identification<br>○ Measuring tools to be used<br>○ Procedures for set up and inspection<br>● Create an inspection plan from a given job<br>● Explain the control charts found in a Statistical Process Control (SPC)<br>○ X-bar charts<br>○ R-charts |
| **Technical Vocabulary:**<br><br>Semi-precision measurement, Rule/Scale (Steel rule), Caliper, Adjustable/Combination square, Protractor, Transfer or helper type measuring tool, Fixed gage, Radius gage, Angle gage, Screw Pitch Gage<br><br>Feeler gage, Pin/Plug gage, Go/No-Go gage, Thread Go/No-Go gage, Ring gage, Thread Go/No-Go gage, Snap gage, Solid square, Gage blocks, Vernier, Calibration, Inside micrometer, Depth micrometer, Thread Pitch Micrometer, Blade micrometer, Hole gage, Telescoping gage, Adjustable parallel, Calibration, Profilometer, Surface finish comparator, Microinches, Dial bore gage, Height gage, Straight edge, Transfer/Helper type measuring tool, Vernier, Small hole gage<br><br>Dial indicator<br><br>Gage pins<br><br>Order of Operations<br><br>Pythagorean theorem, Adjacent side, Complementary angle, Hypotenuse, Opposite side, SIne, Cosine, Tangent, Trigonometry<br><br>Gage blocks, Sine tools (Bar and plate), wringing<br><br>Optical comparator (Shadowgraph), Mylar<br><br>Inspection plan, Process plan, Quality Assurance (QA), Quality control (QC), R-Chart, Sampling plan, Statistical Control Process (SPC), X-bar chart, Mean, Range | |
| **Resources:**<br><br><u>Precision Machining Technology, second edition text:</u><br>Section 2 Unit 2 Measurement Systems and Machine Tool Math Overview | |

## Priority Standard 10.4 Measurement, Quality and Applied Math

Section 2 Unit 3 Semi-Precision Measurement
Section 2 Unit 4 Precision Measurement
Section 2 Unit 5 Quality Assurance, Process Planning, and Quality Control

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
Section 2 Unit 2: Measurement Systems and Machine Tool Math Overview
Section 2 Unit 3: Semi-Precision Measurement
Section 2 Unit 4: Precision Measurement
Section 2 Unit 5: Quality Assurance, Process Planning, and Quality Control

Using the Combination Set for Measurement Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&id=1840887819&snapshotId=3554665&

Creating a Gage Block Build Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&id=1840887821&snapshotId=3554665&

Calibrating a Micrometer Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887823&

Indicator Contact Angle Setup Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887825&

Sine Tools Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887826&

Tooling University:
Basic Measurement 101
Surface Texture and Inspection 201
NIMS Core Measurement and Materials Skills 211
Trigonometry: The Pythagorean Theorem 201
Trigonometry: Sine, Cosine, Tangent 211
Shop Trig Overview 210
Trigonometry: Sine Bar Applications 221
Hole Standards and Inspection 141

Micrometer Simulator:
https://www.stefanelli.eng.br/en/virtual-micrometer-thousandth-inch-simulator/

Machinery's Handbook:
Machinery's Handbook 29th Edition.pdf

Starrett Decimal Equivalent Chart:
Starrett decimal-equivalent-card.pdf

NIMS Materials, Measurement, and Safety Links:
Measurement, Materials, & Safety
MMS 2020 Prep Guide V1.pdf (nims-skills.org)

## Priority Standard 10.5 MasterCAM®

**Big Idea(s):**

- CAD/CAM software have revolutionized the way modern parts are machined as they can quickly and accurately create 3D models and machine toolpaths.

**Essential Question(s):**

- What are the advantages / disadvantages for using CAD/CAM software?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **10.5.1** Features of MasterCam® | ● Explain the major components and features:<br>○ User coordinate system<br>○ Menus and icons<br>○ Basic Commands |
| **10.5.2** File Types | ● Explain the functions of file types used with CAD/CAM systems:<br>○ CAD- .dwg, .prt<br>○ CAM- .mcam, .nci, .nc<br>● Demonstrate the process of importing or exporting files from a variety of file sources outside the CAD/CAM system<br>● Understand how to convert files from one format to another within the CAD/CAM system |
| **10.5.3** Two-dimensional Part Geometry | ● Demonstrate the construction of 2D part geometry using:<br>○ Line, line parallel, line perpendicular<br>○ Circle, arc, filet<br>○ Rectangle<br>○ Trim, break, divide, extend, join |
| **10.5.4** Tool Motion Parameters | ● Demonstrate the procedures to create tool motions based on necessary part geometry and product finish:<br>○ Define part boundaries<br>○ Drill, contour, or pocket routines<br>○ Multi-passes<br>○ Lead-in & lead-out<br>○ Depth of cut<br>○ Cutter compensation<br>○ Speed & feed calculations |
| **10.5.5** Tool Motion | ● Demonstrate the procedures to verify tool motion using:<br>○ Verify<br>○ Backplot<br>○ Simulation |
| **10.5.6** Post-processors | ● Demonstrate the post-processor procedures necessary to translate files into M&G Code |

| **Priority Standard 10.5 MasterCAM®** | |
|---|---|
| | • Identify how to select and modify parameters of a post |

**Technical Vocabulary:**

User coordinate system

File types

Trim, Break, Divide, Extend, Join, Filet

Multi-passes, Lead-in, Lead-out

Verify, Back plot, Simulation

Post processing, Post

Extrude, Surface, Power surface

**Resources:**

Precision Machining Technology, second edition text:
Section 8 Unit 3 CNC Turning: Programming
Section 8 Unit 6 CNC Milling: Programming
Section 8 Unit 8 Computer-Aided Design and Computer-Aided Manufacturing

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
Section 8 Unit 3: CNC Turning: Programming
Section 8 Unit 6: CNC Milling: Programming
Section 8 Unit 8: Computer-Aided Design and Computer-Aided Manufacturing

CamInstructor® :
https://caminstructor.com/
Mastercam 2022 Lathe Course
Mastercam 2023 Lathe Course
Mastercam 2022 Mill 3D Course
Mastercam 2023 Mill 3D Course

CNC Programming: Principles and Applications; Michael Mattson

Tooling University:
NIMS Core Mill Programming and Setup Skills 231
NIMS Core Lathe Programming and Setup Skills 232

## Priority Standard 10.6 Dimensioning Working Drawings

**Big Idea(s):**

- A complete engineering drawing contains all necessary dimensions to accurately describe the part and its features so that it can be manufactured.
- Notes and symbols give information about the type of finish and materials needed to make an object.
- Size dimensions define the size of each piece, location dimensions give the size of each piece as well as its position in relation to the other pieces.
- Technical drawings include geometric dimensions and tolerancing to define allowable differences in parts to be manufacturer.

**Essential Question(s):**

- Why are drafting standards used in industry?
- What is the purpose of geometric tolerancing and dimensioning?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **10.6.1** Basic dimensioning practices | • Identify the lines and symbols used for dimensioning.<br>• List the two basic types of dimensions.<br>  ○ Aligned<br>  ○ Unidirectional<br>• Define the difference between aligned and unidirectional dimensioning. |
| **10.6.2** Dimensioning in different types of drawings | • Define a Detail Drawing.<br>• Explain why the dimensions are added in the final step on a Detail Drawing.<br>• Define an Assembly Drawing.<br>• Describe how dimensioning differs on an assembly drawing. |
| **10.6.3** Line types and symbols | • Define the following lines:<br>  ○ Extension<br>  ○ Center<br>  ○ Leader<br>  ○ Object<br>  ○ Hidden<br>  ○ Dimension<br>• Identify the symbol for:<br>  ○ Chamfer<br>  ○ Taper<br>  ○ Diameter<br>  ○ Radius<br>  ○ Counterbore<br>  ○ Countersink<br>  ○ Spot face<br>  ○ Depth |

| Priority Standard 10.6 Dimensioning Working Drawings | |
|---|---|
| | ○ Degrees |
| **10.6.4** Dimensioning Techniques | ● Describe two ways CAD streamlines the dimensioning process.<br>● List the steps in creating a CAD drawing.<br>● Specify how to set the dimension style on a CAD drawing.<br>● Indicate how accuracy and precision affect the production processes.<br>● Define Limit dimensions. |
| **10.6.5** Tolerance | ● Name and explain the two tolerance systems.<br>● Define the term “tolerance”.<br>● Explain the difference between unilateral and bilateral tolerance systems.<br>● Give an example of a limit system. |
| **10.6.6** Dimensioning for Fits | ● Describe the basic shaft system.<br>● Explain how to determine the limits for fits.<br>● Identify a basic shaft method tolerance.<br>● Identify a basic hole system tolerance. |
| **10.6.7** Geometric Dimensioning and Tolerancing (GD&T) | ● Cite the purpose of GD&T.<br>● Explain how datums are used.<br>● Label a chart of the (14) ASME standard geometric conditions.<br>● List the three tolerance zones.<br>● Differentiate between the following:<br>○ Flatness and Parallelism<br>○ Cylindricity and Total runout<br>○ Perpendicularity and Angularity |
| **10.6.8** Standard dimensioning methods | ● Identify the following terms:<br>○ Unilateral<br>○ Aligned<br>○ Baseline<br>○ Chain<br>○ Tabular<br>○ Coordinate<br>○ Dual |
| **Technical Vocabulary:**<br>Accumulate, Actual size, Aligned system, Allowance, Basic shaft system, Basic hole system, Basic size, Bilateral, Clearance, Datums, Dimension line, Finish mark, Geometric dimensioning and tolerancing, Limits, Nominal Size, Processes, Symbols, Tolerance, Unidirectional system, Unilateral. | |
| **Resources:**<br><br>Hardening and Tempering Video:<br>https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887827&<br><br>Rockwell Hardness Testing Video:<br>https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887828& | |

## Priority Standard 10.6 Dimensioning Working Drawings

Tooling University:
Introduction to Metals 121
Introducción de los materiales 100 (Spanish)
Propiedades mecánicas de los metales 120 (Spanish)
Ferrous Metals 231
Nonferrous Metals 241
Classification of Steel 201
Hardness Testing 221
Essentials of Heat Treatment of Steel 211

NIMS Materials, Measurement, and Safety Links:
Measurement, Materials, & Safety
MMS 2020 Prep Guide V1.pdf (nims-skills.org)

Machinery's Handbook:
Machinerys Handbook 29th Edition.pdf

## Priority Standard 10.7 Fasteners / Threaded and Non-Treaded

**Big Idea(s):**

- Fasteners are essential mechanical components used to join parts securely while allowing for assembly, disassembly, or permanent connections.
- Threaded fasteners rely on helical threads to create clamping force, while non-threaded fasteners use deformation, friction, or interference to hold components together.
- Incorrect fastener type, size, or installation can lead to mechanical failure, safety risks, and reduced product performance.

**Essential Question(s):**

- How do threads create clamping force in a fastener?
- When is a permanent fastener more appropriate than a removable one?
- How does fastener selection impact safety and performance in manufacturing and assembly?

**Learning Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **10.7.1** Identification of threads and fasteners | • Label different types of threads on a sketch.<br>• Define common screw thread terms. Identify non threaded fasteners. |
| **10.7.2** Thread terminology | • Identify the following on a drawing of a thread:<br>  • Crest<br>  • Root<br>  • Pitch<br>  • Axis<br>  • Major / minor diameter<br>  • Thread angle<br>  • lead<br>• Calculate pitch for given threads. |
| **10.7.3** Thread forms and applications | • Identify the following threads and sketch a sample of each:<br>  • Unifies<br>  • ACME<br>  • Tapered Pipe<br>  • Metric<br>  • Buttress<br>  • Knuckle<br>  • Sharp V<br>  • American National<br>  • Whitworth,<br>  • Square |
| **10.7.4** Thread Specifications | • Breakdown thread callouts on a drawing.<br>• Using tables and charts determine thread conventions from a thread note. |

| Priority Standard 10.7 Fasteners / Threaded and Non-Treaded | |
|---|---|
| **10.7.5** Thread Representations | • Identify and sketch the three types of thread representations.<br>• Explain when each one is used. |
| **10.7.6** Threaded fastener application | • Identify the following threaded fasteners:<br>  ○ Nuts<br>  ○ Bolts<br>  ○ Cap screw<br>  ○ Machine screw<br>  ○ Setscrew<br>  ○ Studs<br>  ○ ANSI<br>  ○ Metric |
| **10.7.7** Non-Threaded fastener application | • Identify and explain the application for the following non-threaded fasteners:<br>  • Keys<br>  • Rings<br>  • Pins<br>  • Washers<br>• Match keys to appropriate sketches.<br>• Explain the difference between a keyseat and a keyway |

**Technical Vocabulary:**

ACME thread, American national, Attribute, Bolts, Block, Buttress, Crest, External, Helix, Internal, Keyseat, Keyway, Keys, Knuckle, Lead,
Left-hand thread, Major diameter, Metric, Minor diameter, Nut, Pin, Pitch, Rivets, Right-hand thread, ring, Schematic thread representation, Screws, Setscrew, Sharp “V”, Simplified thread representation, Square, Stud, Symbol library, Tapered, Threads per inch, Tolerance, Tolerance class, Unified, Unified national course, Unified national extra fine, Unified national fine, Washers, Whitworth, Wood screws.

**Resources:**

Precision Machining Technology, second edition text:
Section 2 Unit 2 Measurement Systems and Machine Tool Math Overview
Section 3 Unit 1 Understanding Drawings
Section 3 Unit 2 Layout

Starrett Decimal Equivalent Chart:
Starrett decimal-equivalent-card.pdf

Machinery’s Handbook:
Machinerys Handbook 29th Edition.pdf

## Priority Standard 10.8 Layout

**Big Idea(s):**

- Layout is the process of making a piece of material to provide a visual guide while cutting or machining.

**Essential Question(s):**

- How can layout prevent costly errors and improve accuracy?

**Learning Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **10.8.1** Layout Tools | ● Demonstrate the use of:<br>○ Decimal chart conversions<br>○ Angle plate<br>○ Center head<br>○ Divider<br>○ Height gage<br>○ Hermaphrodite caliper<br>○ Layout dye (Dykem®)<br>○ Prick Punch Steel rule<br>○ Scriber<br>○ Sold square<br>○ Combination square<br>○ Surface plate<br>○ Surface gage<br>○ Protractor<br>○ Trammel<br>○ V-block |
| **10.8.2** Layout | ● Study a part print and determine a process plan of steps and tools to perform a layout.<br>● Identify reference edges (baselines and datums)<br>● Perform a layout. |

**Technical Vocabulary:** Angle plate, Center head, Center punch, Divider, Height gage, Hermaphrodite caliper, Prick punch, Steel rule, Scriber, Steel square (Solid square), Combination square, Surface plate, Surface gage, Protractor, Trammel, V-block

## Priority Standard 10.8 Layout

**Resources:**

Precision Machining Technology, second edition text:
Section 2 Unit 8 Maintenance, Lubrication, and Cutting Fluid Overview

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
Section 2 Unit 8: Maintenance, Lubrication, and Cutting Fluid Overview

NIMS Materials, Measurement, and Safety Links:
Measurement, Materials, & Safety
MMS 2020 Prep Guide V1.pdf (nims-skills.org)

## Priority Standard 10.9 Milling Machines

**Big Idea(s):**

- Milling machines can create almost any shape imagined and are available in several variations.
- On a vertical milling machine, the head and workpiece can be strategically positioned to perform a wide variety of machining operations.
- Setup and alignment affect accuracy and safety.

**Essential Question(s):**

- How does a vertical milling machine create a part?
- How do tools and machine movement shape materials?
- How do speeds and feeds affect machining results?

**Learning Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **10.9.1** Milling Machine Safety | • Identify all safety devices and explaining their function(s)<br>  ○ Emergency stops<br>  ○ Chip shields<br>  ○ Safety glasses<br>  ○ Safety shoes<br>  ○ Jewelry (as it relates to moving parts)<br>  ○ Long hair (as it relates to moving parts)<br>  ○ Loose clothes (as it relates to moving parts)<br>  ○ Medication<br>  ○ Chips<br>• Explain how these personal items can become safety hazards<br>• Identify and analyze the moving parts of a milling machine that can cause injury |
| **10.9.2** Milling Machines Types | • Distinguish and explain different types of milling machines:<br>  ○ Vertical spindle (knee mill)<br>  ○ Horizontal spindle (plain & universal)<br>  ○ CNC vertical milling center<br>  ○ CNC vertical machining center |
| **10.9.3** Vertical Milling Machine Components | • Identify the major components of a vertical milling machine:<br>  ○ Knee<br>  ○ Table<br>  ○ Head<br>  ○ Base<br>  ○ Saddle |

| **Priority Standard 10.9 Milling Machines** | |
|---|---|
| | ○ Drawbar<br>○ Quill<br>○ Ram<br>○ Turret<br>○ Leadscrew<br>● Identify what parts of the machine provide motion to the 3 axes:<br>○ X-axis<br>○ Y-axis<br>○ Z-axis (Knee and the quill) |
| **10.9.4** Mill Cutters | ● Identify common milling cutters:<br>○ End cutter<br>○ Fly cutter<br>○ Shell endmill<br>○ Roughing endmill<br>○ Ballnose endmill<br>○ Radius endmill (Bullnose)<br>○ Corner-rounding<br>○ Chamfer<br>○ Tapered<br>○ Specialty milling cutters<br>■ Dovetail<br>■ Woodruff keyseat cutter<br>■ Slitting saw<br>■ T-slot cutter<br>■ Form cutter<br>○ Insert tool cutter<br>■ Drills<br>■ Endmill<br>■ Face mill<br>● Explain the advantages of replaceable insert tooling |
| **10.9.5** Tool Holding Attachments | ● Identify common tool holding attachments, explain their characteristics, and successfully demonstrate the use of:<br>○ R-8 Tapers<br>○ R-8 Collets<br>○ Endmill tool holder<br>○ Drill Chucks<br>○ Stub arbor |
| **10.9.6** Work-holding Attachments | ● Identify these work-holding attachments:<br>○ Vises<br>○ 3 and 4 jaw chuck<br>○ Collet fixtures (Collet blocks)<br>○ Fixtures<br>○ Milling Jacks<br>○ Clamp sets<br>○ Magnetic and vacuum<br>○ Adhesives-Based |
| **10.9.7** Speeds and Feeds | ● Identify factors that determine milling machine cutting speeds and feeds<br>○ Cutting tool |

| **Priority Standard 10.9 Milling Machines** | |
|---|---|
| | ○ Cutting tool material<br>○ Material being cut<br>○ Machine capability<br>● Use charts, tables, and algebraic formulas to calculate inch-based speeds and feeds based on job requirements:<br>○ RPM = CS X 3.82/D<br>○ IPM = FPT X N X RPM |
| **10.9.8** Milling Operations: | ● Tram a vertical milling machine head with a dial indicator to within +/- .003"<br>● Indicate the milling machine vise, with dial indicator, to within +/- .002"<br>● Explain the procedures used to perform these operations:<br>○ Mill block to size<br>○ Climb / Conventional milling<br>○ Square Block<br>○ Indicating/Edge finding<br>○ Drill holes to specification<br>○ Tapping holes<br>○ Angle cuts<br>○ Spot face<br>○ Reaming<br>○ Counter boring<br>○ Countersinking<br>○ Hole / slot center (Dial Indicator)<br>○ Steps, slots, and key sets<br>● Use the milling machine in a responsible and safe manner to perform these operations:<br>○ Mill block square and parallel to within +/- .003".<br>○ “Edge find” a piece to within +/- .003" using manual dials and/or DRO.<br>○ Mill a 1/2" min. depth step to within +/- .002".<br>○ Drill hole to a location to within +/- .005" and +/- 1/8" depth.<br>○ Drill and tap a blind hole using proper starting chamfer, tap alignment, and bottom tap depth.<br>○ Mill an angled surface to within +/- 1 deg.<br>○ Ream a 1/4" dia. or larger hole to within +/- .0005.<br>○ Counterbore a hole for a standard cap screw. |
| **10.9.9** Mill Maintenance | ● Implement an acceptable "checkout procedure" for proper mill maintenance:<br>○ Cleaning<br>○ Lubrication<br>○ Adjustment |

## Priority Standard 10.9 Milling Machines

**Technical Vocabulary:**

Knee, Table, Head, Base, Saddle, Drawbar, Quill, Ram, Turret, Leadscrew, X-axis, Y-axis, Z-axis

Endmill, Fly cutter, Face mill, Shell mill, Ballnose endmill

R-8 collet, Drill chuck, Arbor

Vise, 3-jaw chuck, 4-jaw chuck, Clamp sets, Collet fixtures

RPM, CS, D, IPM, FP, Chip load

Climb milling, Conventional milling, Edge finder, Face milling, Peripheral milling (Side milling)

**Resources:**

Precision Machining Technology, second edition text:
Section 6 Unit 1 Introduction to the Vertical Milling Machine
Section 6 Unit 2 Tools, Toolholding, and Workholding for the Vertical Milling Machine
Section 6 Unit 3 Vertical Milling Machine Operations

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
Section 6 Unit 1: Introduction to the Vertical Milling Machine
Section 6 Unit 2: Tools, Toolholding, and Workholding for the Vertical Milling Machine

Movements of the Vertical Milling Machine Head Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&id=1840887874&snapshotId=3554665&

R-8 Holding, Mounting and Removal Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887875&

Conventional and Climb Milling Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887881&

Tramming the Head of the Vertical Milling Machine Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887876&

Vise Workholding Alignment on the Milling Machine Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887877&

Edge Finding on the Milling Machine Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887878&

Machine Trades Print Reading 6th edition:
Unit 10 Angles
Unit 12 Machining Details

| **Priority Standard 10.9 Milling Machines** |
| --- |
| Tooling University:<br>Manual Mill Basics 201<br>Chucks, Collets, and Vises 141<br>Speed and Feed for the Mill 311<br>Manual Mill Setup 221<br>Manual Mill Operation 251 |

## Priority Standard 10.10 Conversational CNC Programming

**Big Idea(s):**

- Conversational CNC milling simplifies programming by guiding machinists through prompts and events that convert part geometry directly into machine operations without writing G-code.
- Accurate part geometry, tool selection, and work coordinate setup are essential to producing precise and repeatable CNC milled parts.

**Essential Question(s):**

- How does conversational programming on a ProtoTRAK mill translate part geometry into machine movements?
- How can planning, sequencing, and program verification improve machining accuracy, safety, and efficiency?

**Learning Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **10.10.1** Conversational CNC concepts | • Identify conversation programming VS G-Code. |
| **10.10.2** CNC Controller Interface | • Navigate controller<br>  ○ Screens<br>  ○ Prompts<br>  ○ Inputs<br>  ○ Geometry |
| **10.10.2** Operations / events | • Input machining parameters<br>  ○ Facing<br>  ○ Drilling<br>  ○ Pocketing<br>  ○ Profiling |
| **10.10.3** Tooling and Work Offsets | • Select proper tools and offsets.<br>• Set part zero.<br>• Select tooling<br>• Calculate Feeds / Speeds. |

| Priority Standard 10.10 Conversational CNC Programming | |
|---|---|
| 10.10.4 Program Verification | ● Simulate and verify program.<br>● Demonstrate safe operation. |
| **Technical Vocabulary:**<br>**Conversational programming, CNC Controller, Event / Operation, Toolpath, Datum / Part zero, Work offset, Tool offset, Spindle Speed, Pocket, Profile, Drill cycle, Simulation, Verification.** | |
| **Resources:**<br><u>Precision Machining Technology, second edition text:</u><br>Section 8 Unit 1 CNC Basics<br><br><u>Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:</u><br>Section 8 Unit 1: CNC Basics<br><br>TRAK Machine Tools Online Resources.<br><br>ACU-RITE Solutions Online Resources. | |

## Priority Standard 10.11 Auxiliary and Section Views

**Big Idea(s):**

- Auxiliary views reveal the true size and shape of inclined or oblique surfaces that cannot be accurately represented in standard orthographic views.
- Section views expose internal features of a part, improving clarity and reducing the need for hidden lines in technical drawings.
- Effective use of auxiliary and section views enhances communication, accuracy, and manufacturability in engineering and machining.

**Essential Question(s):**

- Why are standard orthographic views sometimes insufficient to fully describe a part?
- When is a section view necessary instead of using hidden lines?
- How do section and auxiliary views improve communication between designers and machinists?

**Learning Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **10.11.1** Auxiliary views(s)<br>○ Primary<br>○ Secondary | ● Demonstrate when an auxiliary view is required on a drawing.<br>● Identify when a secondary auxiliary view is needed. |
| **10.11.2** Auxiliary view projection | ● Lists the steps to create an auxiliary view.<br>● Sketch an auxiliary view from an assigned problem.<br>● Explain how to draw curves on an auxiliary view.<br>● Identify the angle of an auxiliary view. |
| **10.11.3** Primary auxiliary views | ● Explain how to draw a front auxiliary view of an asymmetrical object using a vertical reference plane.<br>● Describe the situations in which a partial auxiliary view can be drawn. |
| **10.11.4** Secondary auxiliary views | ● Identify the purpose of a secondary auxiliary view.<br>● Explain why it is important to understand the development of a primary auxiliary view before you can draw a secondary one. |

| **Priority Standard 10.11 Auxiliary and Section Views** | |
|---|---|
| **10.11.5** Types of Sectional Views<br>● Full<br>● Half<br>● Revolved<br>● Removed<br>● Broken-out<br>● Offset<br>● Aligned | ● Describe the two ASME forms of a cutting plane line.<br>● Identify the difference types of sectional views.<br>● List the two most common types of section views. |
| **10.11.6** Cutting Plane | ● Draw the two ASME forms of a cutting plane line.<br>● Identify the most commonly used CPL<br>● List section views that do not use a CPL. |
| **10.11.7** Section Line / Cross hatching | ● Sketch the section lines for general use.<br>● Identify what section lines are called in CAD.<br>● Identify symbols used in sectioning. |
| **10.11.8** Feature Construction | ● Explain when shafts, bolts, screws, rivets, and similar parts are usually not sectioned.<br>● Identify features that are not sectioned.<br>● Describe when some features are rotated to show true shape. |
| **Technical Vocabulary:**<br><br>Aligned Section, Associative hatching, Auxiliary Section, Broken-out Section, Conventional Break, Cross hatching, Cutting-plane line, Full Section, Half Section, Hidden line, Material specification, Offset Section, Outline sectioning, Phantom Section, Removed Section, Revolved Section, Rib, Section lining, Sectional View, Spoke, Symmetrical, Web, Auxiliary view, Auxiliary plane, Axis of rotation, Edge view, Front auxiliary view, Inclined surface, Oblique Plane, Oblique surface, Partial auxiliary, Primary auxiliary, Projected, Reference plane, Revolution, Right-side auxiliary view, Section auxiliary, Secondary Auxiliary, True length, Top Auxiliary view. | |
| **Resources:**<br><br><u>Precision Machining Technology, second edition text:</u><br>Section 3 Unit 1 Understanding Drawings | |

## Priority Standard 10.12 Mechanical Working Drawings

**Big Idea(s):**

- Mechanical working drawings communicate all information required to manufacture a part, including geometry, dimensions, tolerances, and notes.
- Standardized drawing practices (symbols, line types, views, and conventions) enable effective communication across the manufacturing industry.
- Working drawings serve as the bridge between design intent and physical production.

**Essential Question(s):**

- What information must a mechanical working drawing include to ensure a part can be manufactured correctly?
- How do working drawings communicate design intent to machinists and manufacturers?

**Learning Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **10.12.1** Standard Working Drawing | ● Outline the purpose of working drawings.<br>● Explain the setup for working drawings:<br>○ Choosing views<br>○ Scale<br>○ Grouping<br>○ Title Block<br>○ Bill of Materials<br>○ Notes<br>● Types<br>○ Detail<br>○ Assembly<br>○ Combination |
| **10.12.2** Bill of Materials (BOM) | ● Identify the name used by ASME for BOM<br>● Describe why it is important that part numbers be unique to each part<br>● List the parts of a BOM. |
| **10.12.3** Assembly Drawing supplemental Components. | ● List the components for an assembly drawing:<br>○ Parts list<br>○ Assembly procedure<br>○ Item balloons<br>○ Dimensions<br>○ Manufacturing notes |
| **10.12.4** Working drawing formatting | ● Specify the importance of a title block.<br>● Demonstrate the setup for the following:<br>○ Single sheet grouping<br>○ Multiple sheet set |
| **10.12.5** Engineering Drawing Revision | ● Specify the importance of proper drawing revisions.<br>● Demonstrate recording a revision on a working drawing. |

**Technical Vocabulary:**

## Priority Standard 10.12 Mechanical Working Drawings

Architect's scale, Assembly, Assembly sections, Balloons, Bill of Materials, Blueprints, Border, Combination drawings, Construction drawing, Cover sheet, Design/layout assembly, Detail drawing, Detail sections, Engineer's scale, Engineering change number (EC), Engineering Change Order, Exploded assembly drawing, General assembly, Installation assembly, Item number, Landscape, Layout drawing, Main assembly, Metric scale, Outline assembly drawing, Part, Part name, Part number, Parts list, Portrait, Profile views, Reference Assembly drawing, Reference dimensions, Revision block, Sheet size, Specifications, Sub-assemblies, Tabulated Drawing, Title block, Working assembly, Working drawing.

**Resources:**

Precision Machining Technology, second edition text:
Section 3 Unit 1 Understanding Drawings

## Priority Standard 10.13 Introduction to Additive Manufacturing

**Big Idea(s):**

- 3D printers build parts layer by layer.
- Plastic prototypes reduce cost before making metal parts.

**Essential Question(s):**

- How do 3D printers create parts?
- How does 3D printing save cost before machining metal parts?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **10.13.1** Safety | Demonstrate safe operation including:<br>● Proper P.P.E.<br>● Handling Hot Components<br>● Proper plastic cutting. |
| **10.13.2 3D printing – Additive MFG.** | Explain how parts are created:<br>● Layer by Layer |
| **10.13.3 Materials** | ● PLA<br>● ABS<br>● PETG |
| **10.13.4** Printer Components | ● Nozzle<br>● Bed<br>● Extruder<br>● Build Plate |
| **10.13.5 Supports** | Choosing correct:<br>● Part orientation<br>● Support structure |

**Technical Vocabulary: Additive Manufacturing, 3D printing, CAD Model, STL file, Slicer, Layer Height, Infill, Nozzle, Extruder, Bed, Adhesion, Support material, Filament, PLA, ABS, PETG, Prototype**

**Resources:**

**Stratasys – 3D printing guide**
**Print Lab**

# 11th Grade Curriculum

| **Priority Standard 11.1 Shop/Workplace Safety** | |
|---|---|
| **Big Idea(s):**<br>● Safety is the number one priority of the shop.<br>● Safety is everyone's responsibility. | |
| **Essential Question(s):**<br>● Are there any differences between school and workplace safety?<br>● What could be a result of someone not following all safety rules at school? At work? | |
| **Learner Outcomes** | |
| **Students will know** | **As evidenced by: (oral, written, or performance)** |
| **11.1.1** Safe Work Habits | ● Identify Personal Protective Equipment<br>● Demonstrate appropriate PPE use<br>● Explain proper shop dress code<br>● Follow shop safety rules<br>● Maintain a clean work area/shop<br>● Locate Emergency shut-offs in shop<br>● Score 100% on safety test |
| **11.1.2** Fire Safety | ● Identify classes of fires<br>● Locate fire extinguishers and blankets in shop<br>● Identify types of extinguishers<br>● Explain the process of extinguishing certain fires<br>● Score 100% on safety test |
| **11.1.3** First Aid | ● Describe procedures for dealing with various injuries.<br>● Explain the dangers bloodborne pathogens<br>● Score 100% on safety test |
| **11.1.4** Machining Hazards | ● Identify and describe specific shop/ machine hazards:<br>○ Clearing of chips using proper tools<br>○ Lathe safety<br>○ Mill safety<br>○ Bandsaw safety<br>○ Grinding safety<br>○ Large stock/material handling<br>○ Hand tool care and usage<br>○ Score 100% on safety test |
| **11.1.5** Safety Data Sheet (i.e. M.S.D.S.) | ● Identify chemical safety using S.D.S.<br>● Identify HMIS |

| **Priority Standard 11.1 Shop/Workplace Safety** | |
|---|---|
| | • Identify NFPA |

**Technical Vocabulary:**

**11.1.3** Bloodborne pathogens

**Resources:**

Precision Machining Technology, second edition text:
Section 2 Unit 1

Tooling University:
Safety for Metal Cutting 101
CDC Workplace Infection Safety and Prevention 135
Hand and Power Tool Safety 201

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition

Basic Personal Protective Equipment for Machining Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&id=1840887818&snapshotId=3554665&

## Priority Standard 11.2 Lathes

**Big Idea(s):**

- It is important for a machinist to know the parts of a lathe and understand how they work.
- Selecting the proper workholding device is critical for safety, accuracy, and efficiency.

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**Essential Question(s):**

- How does each component of a lathe affect its capabilities and accuracy?
- What are the benefits of knowing about various types of workholding attachments?
- Why is it important to calculate speeds and feeds?

**Learning Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **11.2.1** Lathe Safety | ● Identify all safety devices and explaining their function(s)<br>○ Emergency stop<br>○ Chip shields<br>○ Spindle brake<br>○ Chuck key removal<br>○ Safety glasses<br>○ Safety shoes<br>○ Jewelry (as it relates to moving parts)<br>○ Long hair (as it relates to moving parts)<br>○ Loose clothes (as it relates to moving parts)<br>○ Medication<br>○ Chips<br>● Explain how personal items can become safety hazards<br>● Identify and analyze the moving parts of a lathe that can cause injury<br>● Determine and use all required personal safety equipment when operating a lathe |

| **Priority Standard 11.2 Lathes** | |
|---|---|
| **11.2.2** Lathe Components | ● Identify the major parts of a lathe and explain their purpose:<br>○ Apron<br>○ Bed<br>○ Carriage<br>○ Compound rest<br>○ Cross slide<br>○ Half nut<br>○ Head stock<br>○ Lead screw<br>○ Saddle<br>○ Spindle<br>○ Spindle nose<br>○ Swing<br>○ Tailstock<br>○ Ways |
| **11.2.3** Work Holding Devices | ● Identify and explain the use of these work-holding devices:<br>○ Three-Jaw Chuck<br>○ 5C Collet<br>● Demonstrate the use of these common work-holding devices |
| **11.2.4** Tool Holding Attachments | ● Identify common tool holding attachments and explain their characteristics:<br>○ Rocker-type Tool holder<br>○ Quick-change Tool holder<br>○ Drill chuck<br>○ Taper-shank<br>○ Indexable tool post<br>● Demonstrate the correct use of the common tool holding attachments |
| **11.2.5** Cutting Tools | ● Identify common cutting tools used in turning and explain their application<br>○ Boring<br>○ Facing & Turning<br>○ HSS tool bit<br>○ Knurling<br>○ Roughing<br>○ Finishing<br>○ Grooving & Cutoff (Parting)<br>○ Brazed carbide<br>○ Insert tool cutter |
| **11.2.6** Speeds and Feeds | ● Identify factors that determine lathe cutting feeds and speeds.<br>● Use algebraic formulas and conversion tables to calculate speeds and feeds based on job requirements<br><br>**Time in minutes = <u>L (length of cut)</u>** |

| **Priority Standard 11.2 Lathes** | |
|---|---|
| | **RPM *feed rate**<br><br>**rpm = $\frac{CS \times 3.82}{D}$** |
| **11.2.7** Lathe Operations | ● Explaining the procedures used to perform these lathe operations:<br>○ Knurling<br>○ Filing/polishing<br>○ Grooving/cutoff<br>○ Drilling<br>○ Boring<br>○ Angles<br>● Identify the attachments and tools needed for boring a hole on a lathe and explaining their function on a written and/or oral assessment.<br>● Produce a medium to large diamond knurl with complete diamond hatch pattern.<br>● Drill a hole to within +/- 1/8" depth.<br>● Turn a taper(Angle) with compound rest to within +/- 2 deg.<br>● Cut threads with Stock & Die using proper chamfer, die alignment, and chip break.<br>● Tap hole using chamfer, tap alignment, and chip break.<br>● Grind a square 5/16" HSS lathe turning bit for right hand and left hand turning to within acceptable industry standards.<br>● Grind 60-deg. HSS lathe threading tool bit manually, to conform to standard center gage.<br>● Turn an outside diameter to within +/- .001" and +/- .002" shoulder.<br>● Demonstrate the procedure to bore a hole to within +/- .002" at a given depth +/-.003" dia. |
| **11.2.8** Lathe Maintenance | ● Implement an acceptable “checkout procedure” for proper lathe maintenance including:<br>○ Cleaning<br>○ Lubrication<br>○ Adjustment |
| **11.2.9** Angles and Tapers | ● Identify methods and accessories utilized in taper turning and explaining the advantages and disadvantages of each<br>○ Tool bit<br>○ Compound Rest |

| Priority Standard 11.2 Lathes | |
|---|---|
| | ○ Offset tailstock<br>○ Taper attachment<br>○ Reamer<br>● Demonstrate the set-up procedure for cutting angles or tapers on a lathe<br>● Turn a taper with the compound rest to within +/- 1 degree<br>● Select algebraic formulas and use conversion tables to calculate and cut angles and tapers:<br>○ TPI = (D-d)/l<br>○ TPF = (D-d/l) X12<br>○ TPF = 24 (Tan X)<br>○ TPF = 12 (Tan X)<br>○ Center line angle = Arc tan(TPF/24)<br>○ Included angle = Arc tan(TPF/12)<br>○ Set over = (L X TPI) / 2 |

**Technical Vocabulary:**

Apron, Bed, Carriage, Compound rest, Cross slide, Half nut, Head stock, Lead screw, Saddle, Spindle, Spindle nose, Swing, Tailstock, Ways

Three-Jaw Chuck, 5C Collet

Rocker-type Tool holder, Tool Post, Quick-change Tool holder, Drill chuck, Taper-shank, Indexable tool post

Boring bar, Facing & Turning tools, HSS tool bit, Knurling tool, Roughing tool, Finishing tool, Grooving & Cutoff (Parting) tool, Brazed carbide, Insert tool cutter

Offset tailstock method, Taper attachment, Tailstock offset, TPF, TPI, Tool bit method

**Resources:**

Precision Machining Technology, second edition text:
Section 5 Unit 1 Introduction to the Lathe
Section 5 Unit 2 Workholding and Toolholding Devices for the Lathe
Section 5 Unit 3 Machining Operations on the Lathe
Section 5 Unit 5 Taper Turning

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
Section 5 Unit 1: Introduction to the Lathe
Section 5 Unit 3: Machining Operations on the Lathe
Section 5 Unit 5: Taper Turning

Holding work with a Three-Jaw Universal Lathe Chuck Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887854&

Holding work with Lathe Collets Video:

**Priority Standard 11.2 Lathes**

https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887856&

Lathe Tailstock Alignment Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887858&

Boring on the Lathe Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887866&

Grooving and Cutoff on the Lathe Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887867&

Cutting a Taper with a Tool Bit and with the Compound Rest Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887871&

Cutting a Taper with a Taper Attachment Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887872&

Tooling University:
Engine Lathe Basics 211
Engine Lathe Setup 231
Engine Lathe Operation 261
Speed and Feed for the Lathe 301
Taper Turning on the Engine Lathe 311
Lathe Tool Geometry 351

NIMS Job Planning, Benchwork, and Layout Links:
Performance Standards Benchwork
NIMS Machining Level I Preparation Guide Job Planning, Benchwork, and Layout

## Priority Standard 11.3 Welding processes

**Big Idea(s):**

- Safety is critical for welding.
- Welding joins materials together.

**Essential Question(s):**

- How does welding, join materials?
- How do we choose the correct welding process?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **11.3.1 Basic welding safety** | Demonstrate:<br>• Proper PPE<br>• Correct equipment setup<br>• Ventilation<br>• Fire Prevention |
| **11.3.2 Welding Processes** | • SMAW<br>• GMAW / MIG<br>• GTAW / TIG |
| **11.3.3 Welding Equipment** | Identify equipment and describe the function:<br>• Power Source<br>• Electrode<br>• Torch<br>• Shielding gas |
| **11.3.4 Weld Types** | Identify and produce basic weld types:<br>• Bead<br>• Fillet weld<br>• Groove weld |
| **11.3.5 Welding Parameters** | Adjust welder settings:<br>• Amperage<br>• Voltage<br>• Wire speed |
| **11.3.6 Weld defects** | Identify defects and explain possible causes and corrections.<br>• Porosity<br>• Undercut<br>• Lack of Fusion |

**Technical Vocabulary:**

**Welding, Base metal, Filler metal, Weld Bead, Joint, Butt Joint, Lap joint, Corner joint, Fillet weld, Stick Welding (SMAW), Tig Welding (GTAW), Electrode, Shielding Gas, Arc, Amperage, Voltage, Travel Speed, Penetration, (HAZ) Heat Affected Zone, Porosity, Slag, Spatter**

**Resources:**
American Welding Society
Lincoln Electric Welding School
Weld.com

## Priority Standard 11.4 Material Composition and Heat Treatment

**Big Idea(s):**

- Metal Compositions is an art and science that improves the quality, strength, and capabilities of many materials and alloys.
- Heat and chemical treatments have a large impact on the strength of materials.

**Essential Question(s):**

- Why is it important to know the properties of common materials found in the industry?
- Why does a machinist need to know the meanings of various heat treatment methods?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **11.4.1** Manufacturing Materials | ● Identify common manufacturing materials and explain their applications:<br>○ Iron<br>■ Cast<br>● Gray<br>● Malleable<br>● Ductile<br>■ Wrought<br>○ Plain carbon steel<br>○ Alloy steel<br>○ Tool steel<br>○ Stainless steel<br>■ Austenitic<br>■ Ferritic<br>■ Martensitic<br>○ Aluminum alloys<br>○ Magnesium alloys<br>○ Copper alloys<br>■ Bronze<br>■ Brass<br>○ Titanium alloys<br>○ Super alloys |
| **11.4.2** Metal Characteristics | ● Analyze common metal characteristics and describe how these characteristics affect a metal's purpose:<br>○ Ductility<br>○ Hardness<br>○ Malleability<br>○ Brittleness<br>○ Toughness<br>○ Elasticity |
| **11.4.3** Standard Coding Systems | ● Determine the physical characteristics of metals using standard coding systems:<br>○ AISI |

| Priority Standard 11.4 Material Composition and Heat Treatment | |
|---|---|
| | ○ SAE<br>○ UNS<br>○ AA<br>○ IADS<br>○ ASTM |
| **11.4.4** Heat Treatment | ● Describe the methods and purposes of:<br>○ Direct hardening<br>○ Surface hardening<br>○ Flame hardening<br>○ Induction hardening<br>○ Case hardening<br>○ Carburizing<br>○ Cyaniding<br>○ Nitriding<br>○ Tempering<br>○ Annealing<br>○ Quenching<br>○ Normalizing<br>○ Precipitation heat treatment<br>● Identify various heat-treating furnaces:<br>○ Box<br>○ Specialty<br>○ Atmospheric<br>● Describe the hardness scales and cross reference chart:<br>○ Brinell<br>○ Rockwell |

**Technical Vocabulary:**

Alloy, Alloy steel, Aluminum alloy, Bronze, Brass, Cast iron, Copper alloy, Ferrous, Non-ferrous, Iron, Magnesium, Plain carbon steel, Stainless steel, Superalloy, Titanium alloy, Tool steel, Wrought iron

Ductility, Hardness, Malleability, Brittleness, Toughness, Elasticity

AISI, SAE, UNS, AA, IADS, ASTM

Annealing, Brinell, Carburizing, Case hardening, Cyaniding, Direct hardening, Flame hardening, Heat-treatment, Induction hardening, Nitriding, Normalizing, Precipitation heat treatment, Quenching, Rockwell, Surface hardening, Tempering (Drawing)

**Resources:**

Precision Machining Technology, second edition text:
Section 2 Unit 6 Metal Composition and Classification
Section 2 Unit 7 Heat Treatment of Metals

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
Section 2 Unit 6: Metal Composition and Classification
Section 2 Unit 7: Heat Treatment of Metals

Hardening and Tempering Video:

## Priority Standard 11.4 Material Composition and Heat Treatment

https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887827&

Rockwell Hardness Testing Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887828&

Tooling University:
Introduction to Metals 121
Introducción de los materiales 100 (Spanish)
Propiedades mecánicas de los metales 120 (Spanish)
Ferrous Metals 231
Nonferrous Metals 241
Classification of Steel 201
Hardness Testing 221
Essentials of Heat Treatment of Steel 211

NIMS Materials, Measurement, and Safety Links:
Measurement, Materials, & Safety
MMS 2020 Prep Guide V1.pdf (nims-skills.org)

Machinery's Handbook:
Machinerys Handbook 29th Edition.pdf

## Priority Standard 11.5 Tolerances

**Big Idea(s):**

- Grinding wheels are made of abrasive particles held together by a bonding agent.
- Grinding wheels can be purchased in a multitude of sizes and shapes.
- There are a variety of grinding machines available, depending on specific tasks.

**Essential Question(s):**

- What are the repercussions of not selecting the correct type or size/shape of wheel for a job?
- If grinding machines were not available, what other processes would be used to replace grinding?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **11.5.1** Tolerancing and Machined surfaces. | • Define the following:<br>  ○ ANSI Y14.5<br>  ○ Unilateral<br>  ○ Bilateral<br>  ○ Limits<br>  ○ Deviation<br>  ○ Clearance<br>  ○ Allowance<br>  ○ Nominal<br>  ○ Basic Size<br>  ○ Fits<br>  ■ RC<br>  ■ LC<br>  ■ LN<br>  ■ LT<br>  ■ FN<br>  ○ General Tolerances |
| **11.5.2** Standard Tolerances and Fits | • List the three types of fit.<br>• Calculate tolerances for given problems.<br>• Explain why tolerances and fits are important. |

**Technical Vocabulary:**

Allowance, ASME-ANSI Y14.5, Baseline dimensioning, Basic size, Bilateral, Chain dimensioning, Clearance, Limits, Datum, Datum reference frame, Deviation, Feature control frame, Fits, Forced Fits, General Tolerance, Interchangeable manufacturing, Interference, Locational Clearance, Locational Interference, Locational Transition, Maximum material condition, Unilateral, Running Clearance, Statistical Process Control (SPC), Statistical tolerancing.

**Resources:**

Introduction to Abrasives 101
Grinding Processes 201

## Priority Standard 11.6 CamInstructor® & CIMCO Edit®

**Big Idea(s):**

- CAD/CAM software has revolutionized the way modern parts are machined as they can quickly and accurately create 3D models and machine toolpaths.

**Essential Question(s):**

- To become a successful CNC programmer, what knowledge will you need?

**Learning Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **11.6.1** Absolute and Incremental Positioning | ● Describe the difference between the two positioning systems<br>● Demonstrate the ability to plot points using both systems |
| **11.6.2** CNC Programming | ● Identify commonly used preparatory G-codes and M-codes<br>● Create a program safety block<br>● Demonstrate how to move to machine zero - G28 and G53<br>● Identify machine interpolations<br>○ Rapid (G00)<br>○ Linear (G01)<br>○ Clockwise (G02)<br>○ Counter-clockwise (G03) |
| **11.6.3** CIMCO Edit® | ● Create a basic milling toolpath including<br>○ Spindle commands<br>○ Tool change<br>○ Rapid, linear, and arc interpolation<br>● Define tool shape and size<br>● Simulate a successful operation |

**Technical Vocabulary:**

Absolute programming, Incremental programming

Rapid, Linear interpolation, Modal, Origin, Clockwise, Counter clockwise, Machine zero, G-code, M-code, Safety block, Cartesian Coordinate system, End of block

CAD, CAM, Geometry, Solid model, Toolpath, Wireframe

**Resources:**

Precision Machining Technology, second edition text:
Section 8 Unit 1 CNC Basics
Section 8 Unit 8 Computer-Aided Design and Computer-Aided Manufacturing

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:

## Priority Standard 11.6 CamInstructor® & CIMCO Edit®

Section 8 Unit 1: CNC Basics

CamInstructor® **:**
http://www.caminstructor.com/login
CNC Programming - Lathe Online Course
CNC Programming - Mill Online Course

Gene HAAS:
https://learn.haascnc.com/
HAAS Basic Mill Operator
HAAS Basic Mill Operator

Tip of The Day: 9 Lines of Code Every CNC Machinist Needs to Know! Video:
https://youtu.be/hJM8pnUazpk

Tooling University:
Introduction to CNC Machines 201
History and Definition of CNC 202
Basics of G Code Programming 231

## Priority Standard 11.7 CNC Programming and Operations

**Big Idea(s):**

- CNC machines are capable of achieving greater accuracy, and more complex geometries than manual machines.
- CNC machines, when programmed correctly, can create repeatable parts in a cost effective manner.

**Essential Question(s):**

- Why is it crucial to calculate the correct speeds and feeds for a given job?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **11.7.1** CNC Speeds and Feeds | • Calculate speeds for the lathe:<br>  ○ G97<br>  ○ G96 CSS<br>  ○ RPM=(CSS X 3.82) / Dia.<br>• Calculate feeds for the lathe:<br>  ○ Feed for lathes in IPR<br>  ■ Roughing feeds .005” - .015” per rev.<br>  ■ Finishing feeds .001” - .003” per rev.<br>• Calculate speeds for the mill:<br>  ○ RPM=(CSS X 3.82) / Dia.<br>• Calculate feeds for the mill:<br>  ○ Used with M3/M4/M5<br>  ○ G94 IPM<br>  ○ Feed = N x IPT x RPM<br>  ■ N = # of Cutting edges/flutes<br>  ■ IPT = Inch per tooth (Chip load)<br>  ○ Tapping on mill either Inch Per Revolution or Inch Per Minute and a slower RPM. (400 – 800)<br>  ■ IPM= RPM X Thread Pitch<br>  ■ G98 IPM command |

| Priority Standard 11.7 CNC Programming and Operations | |
|---|---|
| **11.7.2** Canned Cycles | • Demonstrate an understanding of lathe canned cycles<br>  ○ Drill canned cycle G74<br>  ○ Tapping canned cycle<br>  ■ G99 for IPR<br>  ■ Feed for tapping on lathe:<br>  ● IPR = 1/TPI<br>  ■ Floating tap holder G32<br>  ■ Rigid tap holder G84<br>  ● Use with M29 S<br>  ○ Rough/finish turning canned cycle G71/G70<br>  ■ U, R<br>  ■ P, Q, U, W, F<br>  ○ Threading canned cycle G76<br>  ■ X, Z, P, Q, R, F<br>• Demonstrate an understanding of mill canned cycles<br>  ○ Peck drill canned cycle<br>  ■ G73<br>  ● Q, R<br>  ■ G83 (deep holes)<br>  ● Q, R<br>  ● I, J, K<br>  ○ Tapping canned cycle<br>  ■ G84 RH threads , G74 LH threads<br>  ■ R, Z, F<br>  ■ Feed for tapping on mill:<br>  ● IPR = 1/TPI<br>  ● IPM = IPR / RPM<br>  ■ Rigid tap holder G84 M29 S |
| **11.7.3** CNC Programming | • Demonstrate and understanding of modal codes<br><br>• Demonstrate an understanding of lathe codes:<br>  ○ M-codes<br>  ○ Tool change<br>  ○ Program stop<br>  ○ Coolant<br>• Demonstrate an understanding of the principle of Tool Nose Radius Compensation (TNRC) on the lathe<br><br>• Demonstrate an understanding of mill codes:<br>  ○ M-codes<br>  ○ Tool change<br>  ○ Program stop<br>  ○ Coolant<br>  ○ Work offsets (G54-G59) |

| Priority Standard 11.7 CNC Programming and Operations | |
|---|---|
| | ○ Tool height offset (G43 and H)<br>○ Dwell (G82)<br>● Demonstrate an understanding of Cutter Radius Compensation (G41 & G42) |
| **11.7.4** CNC Milling and Turning Operations | ● Demonstrate how to startup a machine:<br>○ Main breaker on<br>○ Power on<br>○ Clear alarms<br>○ Powerup-restart/machine home<br>● Demonstrate how to manually move machine using:<br>○ Handle jog<br>○ Jog keys<br>○ MDI<br>○ ATC<br>● Perform a tool change<br>● Load a program into the machines memory<br>● Set tool length offsets using<br>○ Shim/touch-off<br>○ Probe<br>● Set work coordinate systems using<br>○ Edge finder<br>○ Probe<br>● Tool geometry offsets<br>● Wear offsets |
| **Technical Vocabulary:**<br><br>CSS, IPR, IPM, IPT, Chip load<br><br>Canned Cycle, Rigid tapping<br><br>Modal, M-Codes, TNRC, Work offset, Tool height offset, Cutter radius compensation<br><br>MDI, ATC, Probe, Handle jog, Power up-restart, Geometry offset, Wear offset | |

## Priority Standard 11.7 CNC Programming and Operations

**Resources:**

Precision Machining Technology, second edition text:
Section 8 Unit 2 Introduction to CNC Turning
Section 8 Unit 3 CNC Turning: Programming
Section 8 Unit 4 CNC Turning: Setup and Operation
Section 8 Unit 5 Introduction to CNC Milling
Section 8 Unit 6 CNC Milling: Programming
Section 8 Unit 7 CNC Milling: Setup and Operation
Section 8 Unit 8 Computer-Aided Design and Computer-Aided Manufacturing

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
Section 8 Unit 2: Introduction to CNC Turning
Section 8 Unit 3: CNC Turning: Programming
Section 8 Unit 4: CNC Turning: Setup and Operation
Section 8 Unit 5: Introduction to CNC Milling
Section 8 Unit 6: CNC Milling: Programming
Section 8 Unit 7: CNC Milling: Setup and Operation
Section 8 Unit 8: Computer-Aided Design and Computer-Aided Manufacturing

CamInstructor® :
https://caminstructor.com/
Mastercam 2022 Lathe Course
Mastercam 2023 Lathe Course
Mastercam 2022 Mill 3D Course
Mastercam 2023 Mill 3D Course

CNC Programming: Principles and Applications; Michael Mattson

Tooling University:
NIMS Core CNC Milling Skills 141
NIMS Core CNC Turning Skills 142
NIMS Core Advanced Machining Skills 151
NIMS Core Mill Programming and Setup Skills 231
NIMS Core Lathe Programming and Setup Skills 232

Haas Tip of The Day:
How To Calculate Speeds and Feeds (Inch Version) - Haas Automation Tip of the Day - YouTube
Tool Offsets Explained – Haas Automation Tip of the Day - YouTube
How Canned Cycles Work with G98 & G99 - Haas Automation Tip of the Day - YouTube
Master the G71 Roughing Cycle! - Haas Automation Tip of the Day - YouTube
Troubleshoot your lathe G71 and G72 roughing cycles quickly – Haas Automation Tip of the Day - YouTube
Don't Waste Cycle Time; Peck Drilling Essentials - Haas Automation Tip of the Day - YouTube
Simple Peck Tapping Using a G84 Tapping Cycle – Haas Automation Tip of the Day - YouTube

NIMS CNC Lathe and Mill Operator Links:
Credentialing Achievement Record CNC Lathe Operator
CNC Lathe Operations
Credentialing Achievement Record CNC Mill Operator
CNC Mill Operations

| **Priority Standard 11.7 CNC Programming and Operations** |
| --- |
| NIMS Programming, Setup and Operations Links:<br>Performance Standards CNC Turning<br>CNC Lathe Programming Setup & Operations<br><br>Performance Standards CNC Milling<br>CNC Milling: Programming Setup & Operations |

## Priority Standard 11.8 Working Drawings Solid Modeling

**Big Idea(s):**

- Solid models digitally represent parts in three dimensions, allowing designers and machinists to visualize, analyze, and refine designs before production.
- The integration of solid modeling and working drawings improves accuracy, efficiency, and consistency in the design-to-manufacturing process.

**Essential Question(s):**

- How are solid models translated into working drawings for production?
- Why is it critical that solid models and working drawings accurately match?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **11.8.1 Software Interface** | ● Explain the purpose of the following Tool Bars<br>○ Menu Bar<br>○ Command Manager<br>○ Feature manager design tree<br>○ Configuration manager<br>○ Property manager<br>○ Graphics area<br>● Complete a tutorial on the user interface of the 3D software. |
| **11.8.2 2D CAD sketching** | ● Describe why you should constrain a 2D sketch.<br>● Identify a weakness to 2D CAD systems.<br>● Define common terms related to 2D sketching.<br>• Constraints<br>• Origins<br>• Planes<br>• Axis<br>• Coordinate system |
| **11.8.3 Constrained 3D solid modeling** | ● Identify and explain common terms related to 3D modeling:<br>• Sketch<br>• Materials<br>• Extrude<br>• Extrude cut<br>• Revolve<br>• Revolve cut<br>• Loft |

| Priority Standard 11.8 Working Drawings Solid Modeling | |
|---|---|
| | • Ribs<br>• Swept<br>• Surfacing<br>• Threads<br>• Fillets<br>• Chamfers<br>• Shell<br>• Holes<br>• Patterning<br>• Mirroring<br>• Draft<br>• Configurations<br>• Sheet metal<br>• Weldments<br>• Assemblies |
| **11.8.4 Detail and assembly drawings** | ● Name and describe three types of assembly constraints.<br>● Complete a tutorial on assemblies.<br>● Create a detail and assembly drawing.<br>● Identify relationships that are made when an assembly model is established. |
| **11.8.5 Assembly strategies** | ● List the primary difference between top-down design and bottom-up design.<br>● Define common terms associated with assembly drawings. |
| **11.8.6 Assembly animation** | ● Demonstrate how to animate assembly components using proper constraint methods.<br>● List two benefits of animating an assembly. |
| **11.8.7 Parametric design** | ● Create a parametric design and modify using a spreadsheet. |
| **Technical Vocabulary:**<br>Base feature, Blend, Blind extrusion, Chamfers, Constraints, Constructive solid geometry, Cut, Database, Datum geometries, Datum planes, Design table, Design tree, Dimensional constraints, Driven dimension, Extrusion, Features, Fillets, Geometric constraints, History tree, Holes, Mirrored feature, Model tree, Parameters, Parametric solid modeling, Path, Primitives, Profile, Revolved section, Ribs, Rounds, Shelling, Sketches, Sketching plane, Solid model, Splines, suppressed, Surface model, Swept feature, Trajectory, Unsuppressed, Vertex, Webs, Wireframe. | |

| **Priority Standard 11.8 Working Drawings Solid Modeling** |
| --- |
| Assembly constraints, Associativity, Base instance, Bill of materials, Bottom up modeling, Clearances, Components, Exploded configuration, Hierarchy, Instances, Interference, Subassembly, Top down modeling. |
| **Resources:** |

## Priority Standard 11.9 Design practices and principles

**Big Idea(s):**

- The engineering design process is a universal approach used across all industries to develop effective solutions.
- The design process is iterative, requiring repeated refinement and continuous improvement to achieve optimal solutions.

**Essential Question(s):**

- What is meant by concurrent engineering?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **11.9.1** Stages of design | ● List in sequential order the 7 stages of the design process.<br>● Test and evaluate a given prototype. |
| **11.9.2** Design process | ● Identify routine and non-routine problems that may occur during the design process.<br>● Identify which stage you would share your final design with others.<br>● Determine which stage you would learn from your mistakes and make your design better. |

**Technical Vocabulary:**

Brainstorming, Concept mapping, Conceptual design, Design analysts, Design documentation, Design Process, Engineering design, Finite element analysis, green engineering, Life cycle, Mass properties analysis, Model builders, Morphological chart, Problem identification, Prototype, Sustainable design, Visual thinking, Weighted decision table.

**Resources:**

## Priority Standard 11.10 Product Data Management (PMD) / Revision control

**Big Idea(s):**

- Design revision is an integral element of the design process.
- Standardized procedures efficiently control engineering document.

**Essential Question(s):**

- What is the purpose of an Engineering Change Order?
- How does a PDM facilitate document control?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **11.10.1** Engineering change notice | ● Explain the process and purpose of an engineering change order.<br>● Define the difference between ECO and ECN.<br>● Apply an ECO to an engineering working document.<br>● Create an ECO documenting changes to an engineering working drawing. |

**Technical Vocabulary:**
Engineering change order, Record of revision, Working drawing.

**Resources:**

## Priority Standard 11.11 Additive Manufacturing

**Big Idea(s):**

- Additive manufacturing is redefining the way many companies manufacture components.
- There are many practical applications for additive manufacturing in tooling, fixturing, work-holding, designing, prototyping and manufacturing items.

**Essential Question(s):**

- What makes an item produced with additive manufacturing attractive to manufacturers and their customers?
- What are some downfalls of components that were produced additively as opposed to subtractive?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **11.11.1** Additive Manufacturing Safety | ● Describe different types of personal protective equipment<br>● Describe mechanical hazards and how to protect against them<br>● Describe electrical hazards and how to protect against them<br>● Describe thermal hazards and how to protect against them<br>● Describe radiation hazards and how to protect against them<br>● Describe airborne hazards and how to protect against them<br>● Describe proper cleanup and disposal of materials |
| **11.11.2** Additive Manufacturing | ● Describe the advantages and disadvantages<br>● Describe the use of AM as a secondary process<br>● Describe the types of materials<br>● Describe the types machines<br>● Describe CAD software and its use<br>● Describe the use of STL and related files<br>● Describe STL files and how to convert CAD files to STL files<br>● Describe how to convert STL files to build files<br>● Describe G code and its use in additive manufacturing<br>● Describe the future of additive manufacturing. |

## Priority Standard 11.11 Additive Manufacturing

**Technical Vocabulary:**

STL file, Print layers, Nozzle diameter, ABS, PLA

**Resources:**

Tooling University:
Additive Manufacturing Safety 121
Introduction to Additive Manufacturing 111
The Basic Additive Manufacturing Process 131
Additive Manufacturing Methods and Materials 141
Nondestructive Testing for Additive Manufacturing 241

## Priority Standard 11.12 Inspection Setups and Coordinate Measuring Machines (CMM)

**Big Idea(s):**

- Inspection is a critical aspect of manufacturing.
- Coordinate Measuring Machines combine and simplify many inspection processes into one machine.

**Essential Question(s):**

- How does inspection add value to a workpiece?
- What inspection processes can a CMM complete faster and easier? (indicators, comparators, and go/no-go gages, etc.)

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **11.12.1** Indicators | ● Setup a drop indicator<br>● Setup test indicators with a stand<br>● Set an indicator using gage blocks or a master gage<br>● Measure runout, total runout, and concentricity of round stock using a v-block |
| **11.12.2** Optical Comparators | ● Measure a radius<br>● Measure an angle<br>● Measure hole locations |
| **11.12.3** Go/No-Go Gages | ● Explain the differences between plug gages and external gages<br>● Calculate Go/No-Go setup for both plug and external gages |
| **11.12.4** Coordinate Measuring Machine (CMM) | ● Explain the use of a coordinate measuring machine (CMM) by:<br>○ Qualify the CMM with a maximum of .0002” form error<br>○ Demonstrate the ability to set datums and origins<br>○ Demonstrate the use of the CMM by measuring a part to a NIMS inspection plan |

**Technical Vocabulary:**

Drop indicator, Test indicator

Optical comparator (Shadow graph) Go/No-Go gage, Plug gage, External gage CMM, Form error

**Resources:**

Precision Machining Technology, second edition text:
Section 2 Unit 4 Precision Measurement

## Priority Standard 11.13 Continuous Improvement and Lean Manufacturing Principles

**Big Idea(s):**

- Continuous improvement creates safer work environments, improves manufacturing process efficiency, and saves money.
- Lean manufacturing creates a cultural shift that promotes the improvement in workplaces that benefits everyone.

**Essential Question(s):**

- How can 5S and lean principles be applied in the shop?
- What are the consequences a manufacturer might face if they don't implement lean principles?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **11.13.1** Lean Manufacturing | ● Define lean manufacturing<br>● DOWNTIME<br>○ Defects<br>○ Overproduction<br>○ Waiting<br>○ Non-utilized talent<br>○ Transportation<br>○ Inventory<br>○ Motion<br>○ Extra-processing<br>● Define waste in terms of lean manufacturing<br>● Identify common types of waste<br>● Describe the importance of continuous improvement |
| **11.13.2** Five S | ● Define Five S<br>● List the activities of the Five S approach<br>● Describe the challenges to implementing a 5S program<br>● Describe the advantages to implementing a 5S program |

**Technical Vocabulary:**

Lean manufacturing, Waste, Continuous improvement

Five S

**Resources:**

Tooling University:
Lean Manufacturing Overview 101
Developing a Lean Culture 135 5S - What are The Five S's of Lean? | ASQ
5S Overview 151
Mejora continua de procesos: Gestión de flujo 124 (Spanish)
Mejora continua de procesos: Identificación y eliminación de desperdicio 125 (Spanish)

| Priority Standard 11.13 Continuous Improvement and Lean Manufacturing Principles |
| --- |
| What is Lean? Lean Manufacturing & Lean Enterprise \| ASQ<br><br>5S - What are The Five S's of Lean? \| ASQ<br><br>Who Moved My Cheese [Original] - Spencer Johnson |

# 12th Grade Curriculum

## Priority Standard 12.1 Shop/Workplace Safety

**Big Idea(s):**

- Safety is the number one priority of the shop.
- Safety is everyone's responsibility.

**Essential Question(s):**

- What could be a result of someone not following all safety rules?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **12.1.1** Safe Work Habits | ● Identify Personal Protective Equipment<br>● Demonstrate appropriate PPE use<br>● Explain proper shop dress code<br>● Follow shop safety rules<br>● Maintain a clean work area/shop<br>● Locate Emergency shut-offs in shop<br>● Score 100% on safety test |
| **12.1.2** Fire Safety | ● Identify classes of fires<br>● Locate fire extinguishers and blankets in shop<br>● Identify types of extinguishers<br>● Explain the process of extinguishing certain fires<br>● Score 100% on safety test |
| **12.1.3** First Aid | ● Describe procedures for dealing with various injuries.<br>● Explain the dangers bloodborne pathogens<br>● Score 100% on safety test |
| **12.1.4** Machining Hazards | ● Identify and describe specific shop/ machine hazards:<br>○ Clearing of chips using proper tools<br>○ Lathe safety<br>○ Mill safety<br>○ Bandsaw safety<br>○ Grinding safety<br>○ Large stock/material handling<br>○ Proper hand tool care and usage<br>○ Score 100% on safety test |
| **12.1.5** Safety Data Sheet (i.e. M.S.D.S.) | ● Identify chemical safety using S.D.S.<br>● Identify HMIS<br>● Identify NFPA |

**Technical Vocabulary:**

**12.1.1** PPE, Emergency Shut-off, Shield/Guards, Eye Wash Station, Lock-out/Tag-out

**Resources:**

## Priority Standard 12.1 Shop/Workplace Safety

Precision Machining Technology, second edition text:
Section 2 Unit 1

Tooling University:
Safety for Metal Cutting 101
CDC Workplace Infection Safety and Prevention 135
Hand and Power Tool Safety 201

## Priority Standard 12.2 Geometric Dimensioning and Tolerancing

**Big Idea(s):**

- If you are unable to read technical blueprints, you will be unable to machine parts to the correct size.
- Geometric Dimensioning and Tolerancing standardizes how features are supposed to be checked, ensuring consistency and accuracy across the industry.

**Essential Question(s):**

- What are some key elements found on a Blueprint?
- What would it be like to machine a workpiece if all four people spoke a different language? How does GD&T help this situation?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **12.2.2** Geometric Dimensioning and Tolerancing | ● Explain how GD&T ensures:<br>○ Fit<br>○ Form<br>○ Function |
| **12.2.3 GD&T symbols** | ● Flatness<br>● Parallelism<br>● Perpendicularity<br>● Position |
| **12.2.4 Feature Control frame** | ● Reading a feature control frame correctly. |
| **12.2.5 Datums** | ● Identify the Datums on a part and explain their role in measurement and setup |
| **12.2.5 Tolerance** | ● Explain how tolerance affects part acceptance and manufacturing limits |
| **12.2.6 Fit / Function** | ● Evaluate whether parts will assemble correctly based on tolerances. |

**Technical Vocabulary:**

Datum, Circular runout, Circularity, Cylindricity, Feature control frame, Flatness, Form tolerance, GD&T, Limit tolerance, Location tolerance, Orientation tolerance, Parallelism, Perpendicularity, Position tolerance, Profile tolerance, Runout tolerance, Straightness, Total runout, True position

Material condition modifiers, MMC, LMC

**Resources:**

Precision Machining Technology, second edition text:
Section 3 Unit 1 Understanding Drawings

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
Section 3 Unit 1: Understanding Drawings

Machine Trades Print Reading 6th edition:
Unit 13 Sectional Views
Unit 14 Auxiliary Views
Unit 15 GD&T
Unit 17 Assembly Drawings

Tooling University:
Introduction to GD&T 301
Major Rules of GD&T 311
GD&T Applications 312
Introducción al dimensionamiento y las tolerancias geométricas 205 (2009) (Spanish)
Interpretación de dimensionamiento y tolerancias geométricas (GD&T) 315 (2009) (Spanish)
Introducción a GD&T 200 (Spanish)
Interpretación del GD&T 310 (Spanish)

## Priority Standard 12.3 Milling Machines (4 and 5 Axis Machining)

**Big Idea(s):**

- Multi-axis machining allows machinists to create infinitely unique and intricate parts that otherwise would be impossible to machine.
- Multi-axis machining is a high-skilled and high-paying specialized area of manufacturing.

**Essential Question(s):**

- How has multi-axis machining changed manufacturing processes and what is possible to machine?
- How does multi-axis machining affect the skill requirements of a machinist?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **12.3.1** Multi-Axis Concepts | • Describe the major axes on a multi-axis CNC machine<br>• Describe common orientations of rotational axes on 5-axis CNC machines<br>• Describe multi-axis CNC machine operations<br>• Explain the benefits of a multi-axis machining center |
| **12.3.2** 4th Axis Programming | • Identify how to establish a WCS in a CAM software for a 4th-axis toolpath<br>• Demonstrate how to change between varying views and WCS<br>• Create and simulate a toolpath using 4th axis motion |

**Technical Vocabulary:**

**12.3.1** Multi-axis, 4th axis, 5th axis, Common core toolpath

**12.3.2** Work-coordinate system

**Resources:**

Tooling University:
Introduction to Multi-Axis CNC Machines 217
Multi-Axis CNC Operations 218
Workholding for Multi-Axis CNC Machines 219

Machine Trades Print Reading 6th edition:
Unit 18 Print Reading Review

CamInstructor® :
http://www.caminstructor.com/login

| **Priority Standard 12.3 Milling Machines (4 and 5 Axis Machining)** |
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| Setup & Operate - CNC 4 Axis Mill<br>Setup & Operate - CNC 5 Axis Mill<br><br>CNC Programming: Principles and Applications; Michael Mattson |

## Priority Standard 12.4 MasterCAM®

**Big Idea(s):**

- Advanced toolpaths improve efficiency and quality.
- Setup and programming impact production success.

**Essential Question(s):**

- How do advanced toolpaths improve machining?
- Why is simulation important for complex programs?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **12.4.1** Advanced Toolpath - MasterCam® | Create and apply the following:<br>• Dynamic milling<br>• Contouring<br>• Multi-pass operations |
| **12.4.2** Toolpath<br>○ Linking<br>○ Sequencing | Modifying toolpath transitions:<br>• Entry/exit moves<br>• Lead-ins / Lead-outs |
| **12.4.3** Stock models / Rest machining | Using stock awareness to remove material efficiently. |
| **12.4.4** Tool libraries and Tool management | Select and organize tools for efficient machining operations. |
| **12.4.5** Tool Motion | • Demonstrate the procedures to verify tool motion using:<br>○ Verify<br>○ Backplot<br>○ Simulation |
| **12.4.6** Post-processors | • Demonstrate the post-processor procedures necessary to translate files into M&G Code<br>• Identify how to select and modify parameters of a post |
| **12.4.7** Three-dimensional Part Geometry | • Demonstrate the procedures to construct 3D part geometry from 2D wireframe:<br>○ Extrude<br>○ Surface<br>○ Power Surface |

**Technical Vocabulary:**

Dynamic milling, High-speed machining, Toolpath, Step over, Step down, Multi pass machining, Rest machining, Linking parameters,

Multi-passes, Lead-in, Lead-out

## Priority Standard 12.4 MasterCAM®

Verify, Backplot, Simulation

Post processing, Post

Extrude, Surface, Power surface

**Resources:**

Precision Machining Technology, second edition text:
Section 8 Unit 3 CNC Turning: Programming
Section 8 Unit 6 CNC Milling: Programming
Section 8 Unit 8 Computer-Aided Design and Computer-Aided Manufacturing

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
Section 8 Unit 3: CNC Turning: Programming
Section 8 Unit 6: CNC Milling: Programming
Section 8 Unit 8: Computer-Aided Design and Computer-Aided Manufacturing

CamInstructor® :
https://caminstructor.com/
Mastercam 2022 Lathe Course
Mastercam 2023 Lathe Course
Mastercam 2022 Mill 3D Course
Mastercam 2023 Mill 3D Course

CNC Programming: Principles and Applications; Michael Mattson

Tooling University:
NIMS Core Mill Programming and Setup Skills 231
NIMS Core Lathe Programming and Setup Skills 232

## Priority Standard 12.5 Senior Project

**Big Idea(s):**

- Design and manufacturing processes are connected.
- Planning and problem-solving drive successful production.

**Essential Question(s):**

- How are design and manufacturing connected?
- How do digital models become real parts?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **12.5.1** Engineering Design Process. | Designing and producing a complete from concept to finished product<br>• Design<br>• Prototype<br>• Manufacture<br>• Evaluate. |
| **12.5.2** 3d CAD modeling | |
| **12.5.3** Stock models / Rest machining | |
| **12.5.4** Tool libraries and Tool management | |
| **12.5.5** Tool Motion | |
| **12.5.6** Post-processors | |
| **12.5.7** Three-dimensional Part Geometry | |

**Technical Vocabulary:**

**Resources:**

Precision Machining Technology, second edition text:
Section 8 Unit 3 CNC Turning: Programming
Section 8 Unit 6 CNC Milling: Programming
Section 8 Unit 8 Computer-Aided Design and Computer-Aided Manufacturing

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
Section 8 Unit 3: CNC Turning: Programming
Section 8 Unit 6: CNC Milling: Programming
Section 8 Unit 8: Computer-Aided Design and Computer-Aided Manufacturing

CamInstructor® :
https://caminstructor.com/

| **Priority Standard 12.5 Senior Project** |
| --- |
| Mastercam 2022 Lathe Course<br>Mastercam 2023 Lathe Course<br>Mastercam 2022 Mill 3D Course<br>Mastercam 2023 Mill 3D Course<br><br>CNC Programming: Principles and Applications; Michael Mattson |

## Priority Standard 12.6 Specialty Machines

**Big Idea(s):**

- There are many different types of specialty machines and their accompanying careers within the trade.

**Essential Question(s):**

- Without specialty machines, what alternative methods would be used to create the same parts?

**Learner Outcomes**

| Students will know | As evidenced by: (oral, written, or performance) |
|---|---|
| **12.6.1** Swiss Machines | ● Identify the types of screw machines<br>● Describe the use of a CNC Swiss-type lathe<br>● Describe the characteristics and benefits of the guide bushing<br>● Describe live tooling on the CNC Swiss-type lathe<br>● Describe the possible axes associated with the CNC Swiss-type lathe |
| **12.6.2** EDM | ● Define EDM<br>● Describe the following machines:<br>○ Wire<br>○ Sinker<br>○ Hole-making<br>● Describe the function of dielectric fluids |
| **12.6.3** Laser Cutting | ● Describe common laser cutting equipment:<br>○ CO2<br>○ Solid-state<br>○ Fiber |
| **12.6.4** Plasma Cutters | ● Describe plasma cutting machines |

**Technical Vocabulary:**

Swiss machines

EDM, Wire EDM, Sinker EDM

Laser cutters

Plasma cutters

**Resources:**

Tooling University:
Intro to Screw Machining 160
Basics of the CNC Swiss-Type Lathe 215
Intro to EDM 100
Introducción al EDM 100 (Spanish)
Laser Cutting Overview 261
Plasma Cutting 283