Connecticut Technical Education And Career System

Precision Machining Technology

Curriculum Guide

Rev January 2026

Table of Contents

Contents

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

Precision Machining Technology Program Philosophy

The philosophy of the Connecticut Technical Education and Career System's Precision Machining 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 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.

Precision Machining Technology – Course Map

Grade 9 – Semester 1 & 2 DSA

- 9.1 Shop Safety
- 9.2 Introduction to Machining Technology
- 9.3 Hand Tools
- 9.4 Blueprint Reading
- 9.5 Measurements
- 9.6 Layout
- 9.7 Lathes
- 9.8 Milling Machines
- 9.9 Drill Press Types and Operation
- 9.10 Computer Numerical Control (CNC) and Conversational Programming

Grade 10 – Semester 1 DSA

- 10.1 Shop Safety (OSHA 10)
- 10.2 Layout & Blueprint Reading
- 10.3 Measurement and Quality
- 10.4 Material Composition and Heat Treatment
- 10.5 Maintenance, Lubrication and Cutting Fluids
- 10.6 Milling Machines

Grade 10 – Semester 2 DSA

- 10.7 Saws and Cut-off Machines
- 10.8 Lathes
- 10.9 Grinding Machines, Procedures and Techniques
- 10.10 CamInstructor® & CIMCO Edit®
- 10.11 Employability Skills and Work Ethic

Grade 11 – Semester 1 DSA

- 11.1 Shop/Workplace Safety
- 11.2 Grinding Machines
- 11.3 CNC Programming and Operations
- 11.4 Milling Machine Operations
- 11.5 Blueprint Reading and GD&T

Grade 11 – Semester 2 DSA

- 11.6 Inspection Setups and Coordinate Measuring Machines (CMM)
- 11.7 Continuous Improvement and Lean Manufacturing Principles
- 11.8 Lathe Operations
- 11.9 MasterCam®

Grade 12 – Semester 1 DSA

- 12.1 Shop/Workplace Safety
- 12.2 Continuous Improvement and Lean Manufacturing Principles
- 12.3 Milling Machines (4 and 5 Axis Machining)

Grade 12 – Semester 2 DSA

- 12.4 Additive Manufacturing
- 12.5 Destructive and Non-Destructive Quality Testing
- 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 ● Demonstrate appropriate PPE use ● Explain proper shop dress code ● Follow shop safety rules ● Maintain a clean work area/shop ● Locate Emergency shut-offs in shop ● Score 100% on safety test each phase
9.1.2 Fire Safety	● Explain the fire triangle ● Identify classes of fires ● Locate fire extinguishers and blankets in shop ● Identify types of extinguishers ● Explain the process of extinguishing certain fires ● Score 100% on written safety test
9.1.3 First Aid	● Describe procedures for dealing with various injuries. ● Explain the dangers bloodborne pathogens ● Score 100% on written safety test
9.1.4 PMT Specific Hazards	● Identify and describe specific shop/ machine hazards: ○ Clearing of chips using proper tools ○ Lathe safety ○ Mill safety ○ Bandsaw safety ○ Large stock/material handling ○ Proper hand tool care and usage

Priority Standard 9.1 Shop Safety	
	○ Score 100% on safety test
Technical Vocabulary: **9.1.1** PPE, Emergency Shut-off, Shield/Guards, Eye Wash Station, Lock-out/Tag-out **9.1.2** Fire triangle	
Resources: Precision Machining Technology, second edition text: Section 2 Unit 1 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 9.2 - Introduction to Precision Machining Technology	
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: ○ Semi-Skilled ■ Machine Operator ■ Assembler ■ Shipping ○ Skilled ■ Machinist ■ Toolmaker ■ CNC Programmer & setup ■ Inspector ■ Mold Maker ■ Machine Repair ○ Technicians ■ Inspection/QC ■ Engineering ○ Professional ■ Engineer ■ Supervisor ■ Tech Ed/trade teacher ■ Business Owner
9.2.3 Technical Skills and Concepts	● Perform trade math calculations ● Demonstrate measurement tool usage ● Perform basic part layout ● Describe basic blueprint reading terminology ● Demonstrate proper operation of manual machines

Priority Standard 9.2 - Introduction to Precision Machining Technology
Technical Vocabulary: **9.2.1** Machine Tool, Computer Numerical Control, Lathe, Milling Machine **9.2.2** Machinist, Tool Maker, Die Maker, Inspector, Programmer, Engineer, Apprenticeship, Journeyperson, OJT/WBL, Associates Degree, Baccalaureate Degree
Resources: Precision Machining Technology, second edition text: Section 1 Unit 1 Introduction to Machining Section 1 Unit 2 Careers in Machining Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition: Section 1 Unit 1: Introduction to Machining Section 1 Unit 2: Careers in Machining Connecticut Manufacturing Video: https://www.youtube.com/watch?v=IZAznZCYYuE CPTV Videos: https://cptv.org/episode/amanda/ https://cptv.org/episode/angie/ https://cptv.org/episode/millie/ https://cptv.org/episode/nasir/ https://ctcreates.org/resources/cptv-making-the-future/ Connecticut Manufacturing Company Tours and Testimonial Videos: https://ctcreates.org/virtual-fair/tours/

Priority Standard 9.3 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)**
9.3.1 Hand/Bench tools	● Identify and describe each common hand/bench tool: ○ Wrenches ○ Hacksaws ○ Files ○ Hand Reamers ○ Hand taps/dies (threading) ○ Hand Drill ○ Hammers ○ C-clamp & Parallel clamp ○ V-Block ○ Vises ○ Pliers ■ Needle nose ■ Slip joint ■ Side cutting ○ Screwdrivers ■ Flat head (Straight/Slotted) ■ Phillips ■ Torx ○ Needle nose pliers ○ Wrenches ■ Open end ■ Box end ■ Adjustable wrench ■ Spanner
9.3.2 Hand Tool Care and Safety	● Demonstrate the safe use & care of all appropriate tools ● Select appropriate hand/bench tool for a specific application

Priority Standard 9.3 Hand Tools

Technical Vocabulary:

9.3.1 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 9.4 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)**
9.4.1 Orthographic Projection	● Describe the relationship between the views of a print: ○ Front view ○ Top view ○ Right side view ○ Rear view ○ Bottom view ○ Left side view ○ Isometric view
9.4.2 Alphabet of lines	● Identify the “alphabet of lines” and explaining the characteristics/uses of each type of line: ○ Object/Visible ○ Hidden ○ Center ○ Border ○ Dimension ○ Leader ○ Extension ○ Break ○ Cutting-plane ○ Phantom ○ Section ○ Symmetry ○ Viewing-plane (Cutting-plane)
9.4.3 Title Blocks and Notes	● Identify and name the parts of a blueprint: ○ Drawing number ○ Part number ○ Revision history block ○ Sheet size

<table>
<tr><th colspan="2">Priority Standard 9.4 Blueprint Reading</th></tr>
<tr><td></td><td>○ Title block
○ Tolerance block
○ Zones
○ General notes</td></tr>
<tr><td>9.4.4 Dimensions and Tolerance</td><td>● Identify the types of dimensions on a blueprint:
○ Unilateral tolerance
○ Bilateral tolerance
○ Upper limit
○ Lower limit
○ Limit tolerance
● Calculate the tolerance for a given dimension</td></tr>
<tr><td colspan="2">Technical Vocabulary:

9.4.1 Blueprint, Orthographic Projection, Isometric View

9.4.2 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

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

9.4.4 Dimension, Tolerance, Basic size, Unilateral tolerance, Bilateral tolerance, Upper limit, Lower limit, Limit tolerance</td></tr>
<tr><td colspan="2">Resources:

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

Tooling University:
Blueprint Reading 131

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</td></tr>
</table>

Priority Standard 9.5 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)
9.5.1 Machine Technology Math	● Demonstrate and understanding of fractional and decimal math ● Demonstrate an understanding of conversions between decimals and fractions ● Reduce fractions to their lowest terms ● Use machinist lingo to properly pronounce 3-place decimal figures in *thousandths of an inch* terms
9.5.2 Semi-Precision Instruments	● Read a steel rule down to 1/64” graduation ● Measure an angle with a protractor ● Measure a radius with a radius gage
9.5.3 Precision Instruments	● Read a micrometer to 3 decimal places ● Measure an outer diameter with a micrometer ● Read a dial caliper ● Measure a length and shoulder with a dial caliper ● Measure a height using a height gage ● Measure perpendicularity with a solid square

Technical Vocabulary:

9.5.1 Numerator, Denominator

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

9.5.3 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

Priority Standard 9.5 Measurements
Section 2 Unit 4 Precision Measurement Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition: 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 Tooling University: Math: Fractions and Decimals 111 Micrometer Simulator: https://www.stefanelli.eng.br/en/virtual-micrometer-thousandth-inch-simulator/ Starrett Decimal Equivalent Chart: Starrett decimal-equivalent-card.pdf

Priority Standard 9.6 Layout

Big Idea(s):

- Layout is the process of marking 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)
9.6.1 Layout Tools	• Demonstrate the use of: ○ Decimal chart conversions ○ Angle plate ○ Center head ○ Center punch ○ Divider ○ Height gage ○ Hermaphrodite caliper ○ Layout dye (Dykem®) ○ Prick punch ○ Steel rule ○ Scriber ○ Steel square (Solid square) ○ Combination square ○ Surface plate ○ Surface gage ○ Protractor ○ Trammel ○ V-block

Technical Vocabulary:

9.6.1 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

Resources:

Precision Machining Technology, second edition text:
Section 3 Unit 2 Layout

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

Height Gage Use Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887822&

Priority Standard 9.6 Layout

Using the Combination Set for Layout Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887831&

Arc Layout with a Trammel and Divider Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887832&

Surface Gage Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887833&

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

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

Priority Standard 9.7 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)
9.7.1 Lathe Safety	● Identify all safety devices and explain their function(s) ○ Emergency stop ○ Chip shields ○ Spindle brake ○ Chuck key removal ○ Safety glasses ○ Safety shoes ○ Jewelry (as it relates to moving parts) ○ Long hair (as it relates to moving parts) ○ Loose clothes (as it relates to moving parts) ○ Medication ○ Chips ● Explain how personal items can become safety hazards ● Identify and analyze the moving parts of a lathe that can cause injury ● Determine and use all required personal safety equipment when operating a lathe
9.7.3 Lathe Operations	● Perform these lathe operations: ○ Facing ○ Turning ○ Shouldering ○ Chamfers ○ Knurling ○ Filing/polishing ○ Grooving/cutoff ○ Drilling

Priority Standard 9.7 Lathes

Technical Vocabulary:

9.7.1 Emergency stop, Entanglement, Impairment

9.7.2 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&

Priority Standard 9.8 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)
9.8.1 Milling Machine Safety	● Identify all safety devices and explaining their function(s) ○ Emergency stop ○ Chip shields ○ Safety glasses ○ Safety shoes ○ Jewelry (as it relates to moving parts) ○ Long hair (as it relates to moving parts) ○ Loose clothes (as it relates to moving parts) ○ Medication ○ Chips ● Explain how these personal items can become safety hazards ● Identify and analyze the moving parts of a milling machine that can cause injury
9.8.2 Milling machine operations	● Perform the milling operations: ○ Mill block to size ○ Drill holes ○ Tapping holes

Technical Vocabulary:

9.8.2 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 9.9 Drill Press Types and Operation	
Big Idea(s): ● Drill presses are machines used to perform hole making operations. ● Drill presses come in a variety of sizes.	
Essential Question(s): ● Why would you use a drill press over a milling machine?	
Learning Outcomes	
Students will know	**As evidenced by: (oral, written, or performance)**
9.9.1 Drill Press Safety	● Identify all safety devices and explaining their function(s) ○ Chip shields ○ Safety glasses ○ Safety shoes ○ Jewelry (as it relates to moving parts) ○ Long hair (as it relates to moving parts) ○ Loose clothes (as it relates to moving parts) ○ Medication ○ Chips ● Explain how chuck keys can be a hazard ● Explain the importance of moving parts the could cause injury ● Explain the importance of securing working hold devices
9.9.2 Drill Presses	● Identify the following types of drill presses: ○ Micro drill press ○ gang style drill press ○ Radial-arm drill press ○ Upright drill press
9.9.3 Tools, Toolholding, and Workholding	● Identify the parts of a twist drill ● List the 4 drill size classifications: ○ Letter ○ Number ○ Fractional ○ Metric ● Explain how to sharpen a twist drill ● Explain how to properly ream holes ○ Speeds ○ Feeds

<table>
<tr><th colspan="2">Priority Standard 9.9 Drill Press Types and Operation</th></tr>
<tr><td></td><td>

How much material to leave for reaming based on hole size

Explain the difference between a center drill and a spot drill
Explain how to use a Morse taper with drift key
Explain the difference between a counterbore and a countersink
Identify a countersink tool
Identify a counterbore tool
Explain the difference between a Jacobs-type drill chuck and a keyless drill chuck
Identify and demonstrate the proper and safe usage of:

Angle plate
Drill chuck
V-Block
Vise

Setup hold-down clamps

</td></tr>
<tr><td>9.9.4 Drill Press Operations</td><td>

Calculate drill press speeds

CS
RPM

Explain how to change the speed on a drill press
Calculate drill press feeds

IPR
FPR

Explain how to locate holes

Center finder
Edge finder

Explain how to set the depth for a blind hole
Setup a drill press for tapping

</td></tr>
<tr><td colspan="2">Technical Vocabulary:

9.9.2 Gang drill press, Micro drill press, Radial-arm drill press, Upright drill press, Feed, Spindle

9.9.3 Angle plate, Dead center, Drill body, Drill chuck, Drill drift, Drill point, Flutes, Helix angle, Lips, Margin, Morse taper, Pilot, Pin vise, Shank, T-nut, V-block, Web, Twist drill, Center drill, Spot drill, Countersink, Counterbore

9.9.4 Blind hole, Edge finder (Center finder), Cutting speed, FPR, IPR, Pilot hole, RPM, Pecking, Spotting, SFPM, Tapping head, Through hole</td></tr>
<tr><td colspan="2">Resources:

<u>Precision Machining Technology, second edition text:</u></td></tr>
</table>

Priority Standard 9.9 Drill Press Types and Operation
Section 3 unit 6 Drilling, Threading, Tapping, and Reaming Section 4 unit 1 Introduction to the Drill Press Section 4 unit 2 Tools, Toolholding, and Workholding for the Drill Press Section 4 unit 3 Drill Press Operations Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition: Section 4 unit 1: Introduction to the Drill Press Section 4 unit 2: Tools, Toolholding, and Workholding for the Drill Press Section 4 unit 3: Drill Press Operations Tooling University: NIMS Core Drill Press Skills 241 Starrett Decimal Equivalent Chart: Starrett decimal-equivalent-card.pdf NIMS Drill Press Links: Performance Standards Drill Press NIMS Machining Level I Preparation Guide Drill Press

Priority Standard 9.10 Conversational Programming and Computer Numerical Control (CNC)

Big Idea(s):

- CNC programs are a list of actions that you need a machine to complete.
- A CNC machine replaces a human operator with computers and servo motors.

Essential Question(s):

- What is the difference between conversational programming and G & M code programming?

Learning Outcomes

Students will know	As evidenced by: (oral, written, or performance)
9.10.1 Conversational Programming	● Demonstrate how to create the following events on the milling machine MCU: ○ Position ○ Mill ○ Drill ○ Arc ● Demonstrate how to create the following events on the lathe MCU (If available): ○ Position ○ Turn ○ Drill ○ Arc
9.10.2 Types of CNC Machines	● Identify types of CNC machines: ○ CNC Milling machine ○ Vertical machining center (VMC) ○ Horizontal machining center (HMC) ○ CNC Lathe ○ CNC Turning Center ○ Swiss-Type
9.10.3 Purpose of CNC Machining	● Compare and contrast the advantages and disadvantages of CNC machining over conventional machining

Technical Vocabulary:

9.10.1 Conversational Programming, MCU

9.10.2 CNC, Machining center, Turning center

Resources:

Priority Standard 9.10 Conversational Programming and Computer Numerical Control (CNC)
Precision Machining Technology, second edition text: Section 8 Unit 1 CNC Basics

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 ● Demonstrate appropriate PPE use ● Explain proper shop dress code ● Follow shop safety rules ● Maintain a clean work area/shop ● Locate Emergency shut-offs in shop ● Score 100% on safety test
10.1.2 Fire Safety	● Explain the fire triangle ● Identify classes of fire ● Locate fire extinguishers and blankets in shop ● Identify types of extinguishers ● Explain the process of extinguishing certain fires ● Score 100% on written safety test
10.1.3 First Aid	● Describe procedures for dealing with various injuries. ● Explain the dangers bloodborne pathogens ● Score 100% on written safety test
10.1.4 Machining Hazards	● Identify and describe specific shop/ machine hazards: ○ Clearing of chips using proper tools ○ Lathe safety ○ Mill safety ○ Bandsaw safety ○ Grinding safety ○ Large stock/material handling ○ Proper hand tool care and usage ○ Heavy lifting technique

Priority Standard 10.1 Shop Safety (OSHA 10)	
	○ Compressed air safety ○ Lockout/tagout ○ Score 100% on safety test
10.1.5 Safety Data Sheet (i.e. M.S.D.S.)	● Identify chemical safety using S.D.S. ● Identify HMIS ● 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/

Tooling University:
NIMS Core Measurement and Materials Skills 211

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

Priority Standard 10.2 Layout & Blueprint Reading

Big Idea(s):

- Understanding and reading blueprints is an essential skill for a successful career in machining.
- A blueprint is a system of views, lines, symbols, and notations.
- Understanding tolerances for a given dimension is a critical part of job planning.

Essential Question(s):

- How can reading a blueprint increase productivity?
- Why is it an important first step to fully review a blueprint before machining?

Learning Outcomes

Students will know	As evidenced by: (oral, written, or performance)
10.2.1 Layout	• Study a blueprint and determine a process plan of steps and tools to perform a layout • Identify reference edges(baselines and datums) • Perform a layout

10.2.2 BPR Symbols and Notations	• Identify the following blueprint symbols:
	  ○ Diameter
	  ○ Depth
	  ○ Counterbore (Spotface)
	  ○ Countersink
	  ○ Surface finish
	• Identify the following blueprint notations:
	  ○ R or RAD
	  ○ UOS
	  ○ TYP
	  ○ DIA.
	  ○ D.P.
	  ○ C'sink
	  ○ C'bore
	  ○ S'face or SF
	  ○ THRU
	  ○ #X (to indicate number of holes or features)

10.2.3 Dimensions and Tolerance	• Identify the types of dimensions on a blueprint:
	  ○ Dimension types
	  ■ Inches
	  ■ Fraction
	  ■ Metric
	  ■ Angular

<table>
<tr><th colspan="2">Priority Standard 10.2 Layout & Blueprint Reading</th></tr>
<tr><td></td><td>

Calculate the tolerance for a given dimension
Convert between inches to metric
Understand the division of a circle:

Degrees
Minutes
Seconds

</td></tr>
<tr><td>10.2.4 Classes of Fit</td><td>

Research the following classifications of fit in Machinery's Handbook and determine the allowance for a given size:

RC
LC
LT
LN
FN

Explain the difference between a positive allowance and a negative allowance with mating parts

</td></tr>
<tr><td colspan="2">Technical Vocabulary:

10.2.1 Baseline, Datum

10.2.2 Diameter, Radius, Depth, Counterbore, Countersink, Spotface, Blind hole

10.2.3 Inches, Metric, Degrees, Minutes, Seconds

10.2.4 Allowance</td></tr>
<tr><td colspan="2">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

Tooling University:
Basics of Tolerance 121
Benchwork and Layout Operations 241
NIMS Core Job Planning Skills 221

Machine Trades Print Reading 6th edition:
Unit 9 Holes

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

Machinery’s Handbook:
Machinerys Handbook 29th Edition.pdf</td></tr>
</table>

Priority Standard 10.2 Layout & Blueprint Reading

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

Priority Standard 10.3 Measurement and Quality

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)

10.3.1 Semi-precision Measuring Tools	• Explain the difference between semi-precision and precision instruments.
	• Identify and explain the use of:
	  ○ Rule/Scale (Steel rule)
	  ○ Caliper
	  ○ Adjustable/Combination square
	  ○ Protractor
	• Identify and explain the use of the following semi-precision fixed gages:
	  ○ Radius gage
	  ○ Angle gage
	  ○ Screw Pitch Gage
	• Select the correct measuring instrument(s) based on feature and tolerance.

Priority Standard 10.3 Measurement and Quality	
10.3.2 Precision Measuring Tools	● Explain the difference between semi-precision and precision instruments ● Identify and explain the use of the following precision fixed gages: ○ Feeler gage ○ Pin/Plug gage ○ Go/No-Go gage ○ Thread Go/No-Go gage ○ Ring gage ○ Thread Go/No-Go gage ○ Snap gage ● Read a vernier scale on a caliper and height gage ● Identify and explain the use of: ○ Inside Micrometer ○ Depth Micrometer ○ Thread Pitch Micrometer ○ Blade Micrometer ● Read a micrometer to the fourth decimal place (Tenths position) ● Identify the parts of a micrometer ● Read a metric micrometer ● Read a metric dial caliper ● Identify and explain the use of a dial bore gage ● Identify and explain the use of the following transfer or helper-type measuring tools: ○ Hole gages ○ Telescoping gages ○ Dial bore gage ○ Adjustable parallels ● Select the proper measuring instrument(s) based on feature and tolerance. ● Define and explain the importance of calibration ● Define and explain the following surface finish measuring tools: ○ Profilometer ○ Surface finish comparator ● Identify various surface finish symbols
10.3.3 Indicators	● Identify and explain the common uses of dial and digital indicators

Priority Standard 10.3 Measurement and Quality	
	● Identify the graduations on a variety of dial indicators (3 and 4 place decimal) ● Explain the difference between a balance and a continuous dial indicator ● Set-up and demonstrate the use of a the following indicators: ○ Plunger-type ○ Test-type
10.3.4 Gage Pins	● Explain the common uses of gage pins on an inspection plan ● Measure a hole +/- .001” utilizing gage pins ● Calculate and build a Go/No-Go plug gage for a given hole size ● Explain the classes of gage pins
10.3.5 Algebraic Functions	● Demonstrate the ability to solve algebraic formulas: ○ Order of Operations ■ PEMDAS ○ Solving for a variable
10.3.6 Trigonometry	● Identify the sides of a triangle ○ Adjacent, Opposite, Hypotenuse ● Use the Pythagorean Theorem to calculate the an unknown side of a right triangle ● Demonstrate the ability to solve right triangles using sine, cosine, and tangent trigonometric functions
10.3.7 Gage Blocks	● Explain the common uses of gage blocks and gage pins on an inspection plan ● Explain the grades of gage pins ● Identify the different size sets of gage blocks from the Machinery's Handbook ● Measure a height +/- .001” utilizing gage blocks with an indicator ● Explain the purpose of sine tools ● Explain how to wring gage blocks ● Calculate a gage block build, using the fewest number of blocks, from a given angle ○ h=sine(θ)*l

Priority Standard 10.3 Measurement and Quality	
	● Set up a gage block build and measure a given angle
10.3.8 Optical Comparators	● Demonstrate the use of an optical comparator: ○ Measure a radius on an optical comparator to within +/- 1 degree. ○ Measure a hole location to within +/- .002" in X &Y axis. ○ Utilize fiber optics feature (if available) ○ measure a blind hole for +/-.002” dia.
10.3.9 Quality	● Define Quality Assurance ● Explain the importance of a process plan (also called a job traveler, work order, job card, router, lot traveler, or Standard Operating Procedure [SOP]) ● List the information found in a Process Plan: ○ Material Selection ○ Machines to be used ○ Workholding ○ Tooling ○ Speed and Feed calculations ○ Miscellaneous Information ● Create a process plan from a given job ● Explain the importance of Quality Control ● Explain the purpose of a sampling plan ● List the steps to set up an inspection plan: ○ Critical dimensions identification ○ Measuring tools to be used ○ Procedures for set up and inspection ● Create an inspection plan from a given job ● Explain the control charts found in a Statistical Process Control (SPC) ○ X-bar charts ○ R-charts

Priority Standard 10.3 Measurement and Quality

Technical Vocabulary:

10.3.1 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 Gag**e**

10.3.2 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

10.3.3 Dial indicator

10.3.4 Gage pins

10.3.5 Order of Operations

10.3.6 Pythagorean theorem, Adjacent side, Complementary angle, Hypotenuse, Opposite side, SIne, Cosine, Tangent, Trigonometry

10.3.7 Gage blocks, Sine tools (Bar and plate), wringing

10.3.8 Optical comparator (Shadowgraph), Mylar

10.3.9 Inspection plan, Process plan, Quality Assurance (QA), Quality control (QC), R-Chart, Sampling plan, Statistical Control Process (SPC), X-bar chart, Mean, Range

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
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&

Priority Standard 10.3 Measurement and Quality

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:
Machinerys 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 10.4 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)**
10.4.1 Manufacturing Materials	● Identify common manufacturing materials and explain their applications: ○ Iron ■ Cast ● Gray ● Malleable ● Ductile ■ Wrought ○ Plain carbon steel ○ Alloy steel ○ Tool steel ○ Stainless steel ■ Austenitic ■ Ferritic ■ Martensitic ○ Aluminum alloys ○ Magnesium alloys ○ Copper alloys ■ Bronze ■ Brass ○ Titanium alloys ○ Super alloys
10.4.2 Metal Characteristics	● Analyze common metal characteristics and describe how these characteristics affect a metal's purpose: ○ Ductility ○ Hardness ○ Malleability ○ Brittleness ○ Toughness ○ Elasticity

Priority Standard 10.4 Material Composition and Heat Treatment	
10.4.3 Standard Coding Systems	● Determine the physical characteristics of metals using standard coding systems: ○ AISI ○ SAE ○ UNS ○ AA ○ IADS ○ ASTM
10.4.4 Heat Treatment	● Describe the methods and purposes of: ○ Direct hardening ○ Surface hardening ○ Flame hardening ○ Induction hardening ○ Case hardening ○ Carburizing ○ Cyaniding ○ Nitriding ○ Tempering ○ Annealing ○ Quenching ○ Normalizing ○ Precipitation heat treatment ● Identify various heat-treating furnaces: ○ Box ○ Specialty ○ Atmospheric ● Describe the hardness scales and cross reference chart: ○ Brinell ○ Rockwell

Technical Vocabulary:

10.4.1 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

10.4.2 Ductility, Hardness, Malleability, Brittleness, Toughness, Elasticity

10.4.3 AISI, SAE, UNS, AA, IADS, ASTM

10.4.4 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

Priority Standard 10.4 Material Composition and Heat Treatment

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:
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 10.5 Maintenance, Lubrication and Cutting Fluids	
Big Idea(s): ● Machine maintenance is critical to maintaining machine accuracy, and ultimately workpiece quality. ● Cutting fluids and coolants are designed to increase cutting speeds and quality while reducing tool wear and costs.	
Essential Question(s): ● How does regular machine maintenance affect a machine's accuracy? ● Why is it important to select the correct cutting fluids for a job?	
Learning Outcomes	
Students will know	**As evidenced by: (oral, written, or performance)**
10.5.1 Maintenance Procedures	● Identify common maintenance tasks on: ○ Manual mills ○ Manual lathes ○ Drill presses ○ Saws ○ Grinders ● Explain how to adjust the gibs on a manual lathe and manual mill
10.5.2 Machine Lubricants	● Identify how to check the waylube levels on: ○ Manual lathe carriage ○ Manual mill "one-shot" ● Demonstrate how to add oil to: ○ Oil cups ○ Ball oilers ○ Manual mill spindle bearings ○ Manual lathe headstocks ○ Manual lathe carriage ● Identify grease zerks and demonstrate how to use a grease gun
10.5.3 Cutting Fluids	● Explain why cutting fluids are important ● Identify correct cutting fluids for: ○ threading on a lathe ○ tapping (sulfurized) ○ turning ○ milling ● Identify coolant types required for: ○ ferrous metals ○ non-ferrous metals ● Demonstrate how to mix water based coolant to a specified concentration

<table>
<tr><th colspan="2">Priority Standard 10.5 Maintenance, Lubrication and Cutting Fluids</th></tr>
<tr><td></td><td>Demonstrate how to check coolant percentage using a refractometer
Explain the different methods of coolant application:
Manual
Flood
Mist</td></tr>
<tr><td colspan="2">Technical Vocabulary:

10.5.1 Gib

10.5.2 Ball oiler, Oil cup, Zerk fittings

10.5.3 Flood system, Mist system, Oil-based cutting fluid, Refractometer, Semi-synthetic, Soluble oil, Straight oil, Synthetic, Solid and semi-solid cutting compounds</td></tr>
<tr><td colspan="2">Resources:

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

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

Machine Gib Adjustment Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&id=1840887829&snapshotId=3554665&

<u>NIMS Materials, Measurement, and Safety Links:</u>
Measurement, Materials, & Safety
MMS 2020 Prep Guide V1.pdf (nims-skills.org)</td></tr>
</table>

Priority Standard 10.6 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.
- Familiarity with the components, capabilities, and functions of a milling machine is the first step in becoming skilled in its' use.
- There is a vast selection of cutting tools that can be used on a milling machine.
- Each milling operation must be performed using appropriate speeds and feeds to ensure safety and to prevent damage to the workpiece and equipment.

Essential Question(s):

- How many different ways can a workpiece be held in a milling machine?
- What are the benefits of knowing about various types of workholding attachments?
- What shapes can be machined on a milling machine?

Learning Outcomes

Students will know	As evidenced by: (oral, written, or performance)
10.6.1 Milling Machine Safety	● Identify all safety devices and explaining their function(s) ○ Emergency stop ○ Chip shields ○ Safety glasses ○ Safety shoes ○ Jewelry (as it relates to moving parts) ○ Long hair (as it relates to moving parts) ○ Loose clothes (as it relates to moving parts) ○ Medication ○ Chips ● Explain how these personal items can become safety hazards ● Identify and analyze the moving parts of a milling machine that can cause injury
10.6.2 Milling Machines Types	● Distinguish and explain different types of milling machines: ○ Vertical spindle (knee mill)

Priority Standard 10.6 Milling Machines	
	○ Horizontal spindle (plain & universal) ○ CNC vertical milling center ○ CNC vertical machining center
10.6.3 Vertical Milling Machine Components	● Identify the major components of a vertical milling machine: ○ Knee ○ Table ○ Head ○ Base ○ Saddle ○ Drawbar ○ Quill ○ Ram ○ Turret ○ Leadscrew ● Identify what parts of the machine provide motion to the 3 axes: ○ X-axis ○ Y-axis ○ Z-axis (Knee and the quill)
10.6.4 Mill Cutters	● Identify common milling cutters: ○ End cutter ○ Fly cutter ○ Shell endmill ○ Roughing endmill ○ Ballnose endmill ○ Radius endmill (Bullnose) ○ Corner-rounding ○ Chamfer ○ Tapered ○ Specialty milling cutters ■ Dovetail ■ Woodruff keyseat cutter ■ Slitting saw ■ T-slot cutter ■ Form cutter ○ Insert tool cutter ■ Drills ■ Endmill ■ Face mill ● Explain the advantages of replaceable insert tooling
10.6.5 Tool Holding Attachments	● Identify common tool holding attachments, explain their characteristics, and successfully demonstrate the use of: ○ R-8 Tapers ○ R-8 Collets

Priority Standard 10.6 Milling Machines	
	○ Endmill tool holder ○ Drill Chucks ○ Stub arbor
10.6.6 Work-holding Attachments	● Identify these work-holding attachments: ○ Vises ○ 3 and 4 jaw chuck ○ Collet fixtures (Collet blocks) ○ Fixtures ○ Milling Jacks ○ Clamp sets ○ Magnetic and vacuum ○ Adhesives-Based
10.6.7 Speeds and Feeds	● Identify factors that determine milling machine cutting speeds and feeds ○ Cutting tool ○ Cutting tool material ○ Material being cut ○ Machine capability ● Use charts, tables, and algebraic formulas to calculate inch-based speeds and feeds based on job requirements: ○ RPM = CS X 3.82/D ○ IPM = FPT X N X RPM
10.6.8 Milling Operations:	● Tram a vertical milling machine head with a dial indicator to within +/- .003" ● Indicate the milling machine vise, with dial indicator, to within +/- .002" ● Explain the procedures used to perform these operations: ○ Mill block to size ○ Climb / Conventional milling ○ Square Block ○ Indicating/Edge finding ○ Drill holes to specification ○ Tapping holes ○ Angle cuts ○ Spot face ○ Reaming ○ Counter boring ○ Countersinking ○ Hole / slot center (Dial Indicator) ○ Steps, slots, and key sets ● Use the milling machine in a responsible and safe manner to perform these operations: ○ Mill block square and parallel to within +/- .003".

Priority Standard 10.6 Milling Machines	
	○ "Edge find" a piece to within +/- .003" using manual dials and/or DRO. ○ Mill a 1/2" min. depth step to within +/- .002". ○ Drill hole to a location to within +/- .005" and +/- 1/8" depth. ○ Drill and tap a blind hole using proper starting chamfer, tap alignment, and bottom tap depth. ○ Mill an angled surface to within +/- 1 deg. ○ Ream a 1/4" dia. or larger hole to within +/- .0005. ○ Counterbore a hole for a standard cap screw.
10.6.9 Mill Maintenance	● Implement an acceptable "checkout procedure" for proper mill maintenance: ○ Cleaning ○ Lubrication ○ Adjustment

Technical Vocabulary:

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

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

10.6.5 R-8 collet, Drill chuck, Arbor

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

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

10.6.8 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&

Priority Standard 10.6 Milling Machines

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

Tooling University:
Manual Mill Basics 201
Chucks, Collets, and Vises 141
Speed and Feed for the Mill 311
Manual Mill Setup 221
Manual Mill Operation 251

Priority Standard 10.7 Saws and Cut-off Machines

Big Idea(s):

- Power bandsaws allow machinists to cut material quickly and accurately, saving time and effort.
- The different types of power saws have many different options for blades and speeds that give the operator a large range of uses and functions.

Essential Question(s):

- Without a bandsaw, how much time would you lose if you had to cut all your stock with a hacksaw?
- What is the importance of selecting the correct blade for a given material?

Learning Outcomes

Students will know	As evidenced by: (oral, written, or performance)
10.7.1 Saw Safety	● Identify all safety devices and explaining their function(s) ○ Emergency stop ○ Chip shields ○ Safety glasses ○ Safety shoes ○ Jewelry (as it relates to moving parts) ○ Long hair (as it relates to moving parts) ○ Loose clothes (as it relates to moving parts) ○ Medication ○ Chips ● Explain how these personal items can become safety hazards ● Identify and analyze the moving parts of a saw that can cause injury ● Explain and demonstrate the use of pusher bars/sticks when feeding material
10.7.2 Saw Operations	● Identify the differences and uses for: ○ Horizontal band saw ○ Power hacksaw ○ Vertical band saw

<table>
<tr><th colspan="2">Priority Standard 10.7 Saws and Cut-off Machines</th></tr>
<tr><td></td><td>

Using the appropriate saw or cut off machine in a safe manner to perform these operations:

Cut raw material to length within +/- 1/8" with a hacksaw.
Cut raw material to length within +/ 1/16" on a horizontal power saw

</td></tr>
<tr><td>10.7.2 Care and Maintenance</td><td>

Cut and weld bandsaw blades (if available)
Select/set speeds and feeds (if available)
Select and apply cutting fluids
List and explain the procedures for the care and maintenance of power saws
Select/replace blades

</td></tr>
<tr><td>10.7.3 Blade Terminology</td><td>

Describe the following:

Tooth patterns
Blade sets
Kerf
Teeth per inch

Identify various hand and power saw blade types
Explain the characteristics of each blade type

</td></tr>
<tr><td colspan="2">Technical Vocabulary:

10.7.2 Horizontal band saw, Power hacksaw, Vertical band saw

10.7.3 Kerf, Bimetal, Carbide tooth, Pitch (of blade teeth), Teeth Per Inch (TPI)</td></tr>
<tr><td colspan="2">Resources:

Precision Machining Technology, second edition text:
Section 3 Unit 4 Saws and Cutoff Machines

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
Section 3 Unit 4: Saws and Cutoff Machines

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

Band Saw Blade Welding Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887836&</td></tr>
</table>

Priority Standard 10.7 Saws and Cut-off Machines
Band Saw Blade Mounting and Guide Adjustment Video: https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887837&

Priority Standard 10.8 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.
- Multiple factors affect the selection of tools and toolholding devices: Cost, Material, Time, Quantity, Accuracy.
- Each lathe operation must be performed using appropriate speeds and feeds to ensure safety and to prevent damage to the workpiece and equipment.
- Familiarity with formulas and math calculations is important to understanding taper specifications and machining methods.

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)
10.8.1 Lathe Safety	● Identify all safety devices and explaining their function(s) ○ Emergency stop ○ Chip shields ○ Spindle brake ○ Chuck key removal ○ Safety glasses ○ Safety shoes ○ Jewelry (as it relates to moving parts) ○ Long hair (as it relates to moving parts) ○ Loose clothes (as it relates to moving parts) ○ Medication ○ Chips ● Explain how personal items can become safety hazards ● Identify and analyze the moving parts of a lathe that can cause injury ● Determine and use all required personal safety equipment when operating a lathe

Priority Standard 10.8 Lathes	
10.8.2 Lathe Components	● Identify the major parts of a lathe and explain their purpose: ○ Apron ○ Bed ○ Carriage ○ Compound rest ○ Cross slide ○ Half nut ○ Head stock ○ Lead screw ○ Saddle ○ Spindle ○ Spindle nose ○ Swing ○ Tailstock ○ Ways
10.8.3 Work Holding Devices	● Identify and explain the use of these work-holding devices: ○ Three-Jaw Chuck ○ 5C Collet ● Demonstrate the use of these common work-holding devices
10.8.4 Tool Holding Attachments	● Identify common tool holding attachments and explain their characteristics: ○ Rocker-type Tool holder ○ Quick-change Tool holder ○ Drill chuck ○ Taper-shank ○ Indexable tool post ● Demonstrate the correct use of the common tool holding attachments
10.8.5 Cutting Tools	● Identify common cutting tools used in turning and explain their application ○ Boring ○ Facing & Turning ○ HSS tool bit ○ Knurling ○ Roughing ○ Finishing ○ Grooving & Cutoff (Parting) ○ Brazed carbide ○ Insert tool cutter
10.8.6 Speeds and Feeds	● Identify factors that determine lathe cutting feeds and speeds.

Priority Standard 10.8 Lathes	
	● Use algebraic formulas and conversion tables to calculate speeds and feeds based on job requirements **Time in minutes = $\frac{\text{L (length of cut)}}{\text{RPM *feed rate}}$** **rpm = $\frac{\text{CS X 3.82}}{\text{D}}$**
10.8.7 Lathe Operations	● Explaining the procedures used to perform these lathe operations: ○ Knurling ○ Filing/polishing ○ Grooving/cutoff ○ Drilling ○ Boring ○ Angles ● Identify the attachments and tools needed for boring a hole on a lathe and explaining their function on a written and/or oral assessment. ● Produce a medium to large diamond knurl with complete diamond hatch pattern. ● Drill a hole to within +/- 1/8" depth. ● Turn a taper(Angle) with compound rest to within +/- 2 deg. ● Cut threads with Stock & Die using proper chamfer, die alignment, and chip break. ● Tap hole using chamfer, tap alignment, and chip break. ● Grind a square 5/16" HSS lathe turning bit for right hand and left hand turning to within acceptable industry standards. ● Grind 60-deg. HSS lathe threading tool bit manually, to conform to standard center gage. ● Turn an outside diameter to within +/- .001" and +/- .002" shoulder. ● Demonstrate the procedure to bore a hole to within +/- .002" at a given depth +/-.003" dia.

Priority Standard 10.8 Lathes	
10.8.8 Lathe Maintenance	● Implement an acceptable "checkout procedure" for proper lathe maintenance including: ○ Cleaning ○ Lubrication ○ Adjustment
10.8.9 Angles and Tapers	● Identify methods and accessories utilized in taper turning and explaining the advantages and disadvantages of each ○ Tool bit ○ Compound Rest ○ Offset tailstock ○ Taper attachment ○ Reamer ● Demonstrate the set-up procedure for cutting angles or tapers on a lathe ● Turn a taper with the compound rest to within +/- 1 degree ● Select algebraic formulas and use conversion tables to calculate and cut angles and tapers: ○ TPI = (D-d)/l ○ TPF = (D-d/l) X12 ○ TPF = 24 (Tan X) ○ TPF = 12 (Tan X) ○ Center line angle = Arc tan(TPF/24) ○ Included angle = Arc tan(TPF/12) ○ Set over = (L X TPI) / 2
Technical Vocabulary: **10.8.2** Apron, Bed, Carriage, Compound rest, Cross slide, Half nut, Head stock, Lead screw, Saddle, Spindle, Spindle nose, Swing, Tailstock, Ways **10.8.3** Three-Jaw Chuck, 5C Collet **10.8.4** Rocker-type Tool holder, Tool Post, Quick-change Tool holder, Drill chuck, Taper-shank, Indexable tool post **10.8.5** Boring bar, Facing & Turning tools, HSS tool bit, Knurling tool, Roughing tool, Finishing tool, Grooving & Cutoff (Parting) tool, Brazed carbide, Insert tool cutter **10.8.9** Offset tailstock method, Taper attachment, Tailstock offset, TPF, TPI, Tool bit method	
Resources: <u>Precision Machining Technology, second edition text:</u> Section 5 Unit 1 Introduction to the Lathe	

Priority Standard 10.8 Lathes

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:
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:

Priority Standard 10.8 Lathes
Performance Standards Benchwork NIMS Machining Level I Preparation Guide Job Planning, Benchwork, and Layout

Priority Standard 10.9 Grinding Machines, Procedures and Techniques	
Big Idea(s): ● Grinding Machines are capable of removing small amounts of material for a high degree of accuracy.	
Essential Question(s): ● When you consider the entire machining process, what part of that process does “grinding” perform?	
Learning Outcomes	
Students will know	**As evidenced by: (oral, written, or performance)**
10.9.1 Grinding Machines Safety	● Identify safety topics to avoid injury during the operation of grinding machines: ○ Safety guards ○ Tool rest (1/16” gap) ○ Spark breaker (1/16” gap) ○ Safe clothing ○ Ring Test ○ Correct wheel selection ○ Proper mounting of wheel ○ Safe work holding measures ○ Safe work area
10.9.2 Grinding Machines	● Identify different types of grinding machines and explaining their functions: ○ Surface Grinder ○ Bench / Offhand / Pedestal Grinder
10.9.3 Surface Grinder Parts	● Identify and describing the basic parts of a Surface Grinder: ○ Spindle ○ Magnetic Chuck ○ Base ○ Column ○ Ways ○ Longitude feed handwheel ○ Cross feed handwheel ○ Down feed handwheel ○ Lubrication System
10.9.4 Grinding Wheel Inspection	● Demonstrate a visual inspection of a Grinding Wheel before mounting including: ○ Inspect wheel for damage ○ Insure wheel has blotters on both sides ○ Perform a Ring test on wheel

Priority Standard 10.9 Grinding Machines, Procedures and Techniques	
10.9.5 Grinding Wheel Install	● Demonstrate mounting and balancing of a grinding wheel on: ○ Surface Grinder ○ Pedestal/bench grinder ● Demonstrate wheel dressing by: ○ Selection of the dressing tool ○ Set-up of the dressing tool ○ Dressing tool usage: ■ Dress the side of a grinding wheel with a 0.025 recess leaving a 1/8" lip. ■ Dress a radius greater than 1/8" on the corner of the grinding wheel.
10.9.6 Accessories and Work-holding Devices:	● Explain the use of common accessories and work-holding attachments: ○ Magnetic Chucks ○ C-Clamp ○ Parallel Clamps ○ Collet Blocks ○ Vise ● Explain the procedure and techniques for grinding a chuck ● Demonstrate the safe and use of these common accessories and work-holding attachments to: ○ Magnetic chuck grinding. (i.e. making chuck flat.) ○ Back rail grinding. (i.e. square to chuck surface.)
10.9.7 Grinding Operations	● Demonstrate the use of a grinding machine to: ○ Dress a grinding wheel using a diamond dresser ○ Grind a 1" or larger block square to within +/-.002". ○ Surface grind an angle greater than 10 deg. but less than 30 deg. with a sine plate to within +/- 1/2deg.
10.9.8 Grinding Machine Maintenance	● Implement an acceptable “checkout procedure” for grinding machine maintenance including: ○ Cleaning ○ Lubrication
Technical Vocabulary:	

Priority Standard 10.9 Grinding Machines, Procedures and Techniques
10.9.1 Aluminum oxide, Blotter, Silicon Carbide, Spark breaker, Loading, Glazing, Grit, Grade, Ring test, Tool rest, Wheel dresser, Wheel flange **10.9.2** Surface Grinder, Bench / Offhand / Pedestal Grinder **10.9.3** Spindle, Magnetic Chuck, Base, Column, Ways, Longitude feed handwheel, Cross feed handwheel, Down feed handwheel, Lubrication System **10.9.7** Diamond dresser, Dressing sticks, Magnetic chuck
Resources: Precision Machining Technology, second edition text: Section 3 Unit 5 Offhand Grinding Section 7 Unit 1 Introduction to Precision Grinding Machines Section 7 Unit 2 Grinding Wheels for Precision Grinding Section 7 Unit 3 Surface Grinding Operations Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition: Section 3 Unit 5: Offhand Grinding Section 7 Unit 1: Introduction to Precision Grinding Machines Section 7 Unit 3: Surface Grinding Operations Pedestal Grinder Wheel Mounting Video: https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887838& Mounting a Wheel on the Surface Grinder Video: https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887883& Dressing a Wheel on the Surface Grinder Video: https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887884&

Priority Standard 10.10 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)
10.10.1 Absolute and Incremental Positioning	● Describe the difference between the two positioning systems ● Demonstrate the ability to plot points using both systems
10.10.2 CNC Programming	● Identify commonly used preparatory G-codes and M-codes ● Create a program safety block ● Demonstrate how to move to machine zero - G28 and G53 ● Identify machine interpolations ○ Rapid (G00) ○ Linear (G01) ○ Clockwise (G02) ○ Counter-clockwise (G03)
10.10.3 CIMCO Edit®	● Create a basic milling toolpath including ○ Spindle commands ○ Tool change ○ Rapid, linear, and arc interpolation ● Define tool shape and size ● Simulate a successful operation

Technical Vocabulary:

10.10.1 Absolute programming, Incremental programming

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

10.10.3 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

Priority Standard 10.10 CamInstructor® & CIMCO Edit®

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
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 10.11 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)
10.11.1 Employability Skills	● Explain the importance of interpersonal skills related to work ethic and key characteristics which are important for success in the workplace: ○ Attendance (Punctuality) ○ Character ○ Teamwork ○ Attitude ○ Productivity ○ Organizational Skills ○ Communication ○ Cooperation ○ Respect
10.11.2 Interpersonal Skills	● Explain the role of interpersonal skills as an aspect of work ethic: ○ Habits ○ Attitude ○ Manners ○ Appearance ○ Behaviors ● Develop and implement strategies for improving interpersonal skills in and out of the shop and classroom
10.11.3 Initiative	● Explain initiative as a part of work ethic as it relates to work ethic and utilization in appropriate and productive ways ● Evaluate one's own initiative, and demonstrating an increased initiative in appropriate and productive ways

Priority Standard 10.11 Employability Skills and Work Ethic	
10.11.4 Dependability	• Explain the importance of being dependable and identify areas for improving personal dependability on a written and/or oral assessment • Employ characteristics that will improve personal dependability in and out of the shop and classroom

Technical Vocabulary:

10.11.1 Attendance (Punctuality), Character, Teamwork, Attitude, Productivity, Organizational Skills, Communication, Cooperation, Respect

10.11.2 Interpersonal skills

10.11.3 Initiative

10.11.4 Dependability

Resources:

Precision Machining Technology, second edition text:
Section 1 Unit 3 Workplace Skills

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

Employability Skills: 10 Examples of Skills Companies Value | Indeed.com

Employability Skills

Soft skills vs hard skills. | Linkedin Top 5 Soft skills for 2020

11th Grade Curriculum

Priority Standard 11.1 Shop/Workplace Safety

Big Idea(s):

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

Essential Question(s):

- Are there any differences between school and workplace safety?
- 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 ● Demonstrate appropriate PPE use ● Explain proper shop dress code ● Follow shop safety rules ● Maintain a clean work area/shop ● Locate Emergency shut-offs in shop ● Score 100% on safety test
11.1.2 Fire Safety	● Identify classes of fires ● Locate fire extinguishers and blankets in shop ● Identify types of extinguishers ● Explain the process of extinguishing certain fires ● Score 100% on safety test
11.1.3 First Aid	● Describe procedures for dealing with various injuries. ● Explain the dangers bloodborne pathogens ● Score 100% on safety test
11.1.4 Machining Hazards	● Identify and describe specific shop/ machine hazards: ○ Clearing of chips using proper tools ○ Lathe safety ○ Mill safety ○ Bandsaw safety ○ Grinding safety ○ Large stock/material handling ○ Hand tool care and usage ○ Score 100% on safety test
11.1.5 Safety Data Sheet (i.e. M.S.D.S.)	● Identify chemical safety using S.D.S. ● 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 Grinding Machines

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)
11.2.1 Safety on Grinding Machines	Identify safety topics to avoid injury during the operation of grinding machines: ● Safety guards ● Safe clothing ● Correct wheel selection ● Proper mounting of wheel ● Safe work holding measures ● Safe work area
11.2.2 Grinding Wheels	● Identify and differentiate terms associated with the design, structure, and material composition of grinding wheels: ○ Abrasive type ○ Grade ○ Structure ○ Bond ○ Grain Size ● Identify and describe the usage of the following wheel shapes ○ Cylindrical ○ Straight Cup ○ Dish ○ Flared Cup ● Use standard charts to select the appropriate grinding wheel with regards to machine type, task, and part material (ferrous or non-ferrous)
11.2.3 Cylindrical Grinders (ID & OD)	● Identify the basic parts of the machine ● Understand the basic operation

Priority Standard 11.2 Grinding Machines	
11.2.4 Jig Grinder	• Identify the basic parts of the machine • Understand the basic operation
11.2.5 Vertical Grinder (Blanchard)	• Identify the basic parts of the machine • Understand the basic operation
11.2.6 Centerless Grinder	• Identify the basic parts of the machine • Understand the basic operation

Technical Vocabulary:

11.2.2 Abrasive type, Grade, Structure, Bond, Grain size

11.2.3 Cylindrical grinder

11.2.4 Jig grinder

11.2.5 Vertical grinder

11.2.6 Centerless grinder

Resources:

Precision Machining Technology, second edition text:
Section 3 Unit 5 Offhand Grinding
Section 7 Unit 1 Introduction to Precision Grinding Machines
Section 7 Unit 2 Grinding Wheels for Precision Grinding
Section 7 Unit 3 Surface Grinding Operations

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
Section 7 Unit 2: Grinding Wheels for Precision Grinding

Tooling University:
Grinding Safety 211
Introduction to Abrasives 101
Grinding Processes 201
Basics of the Cylindrical Grinder 232
Basics of the Centerless Grinder 233
Grinding Wheel Materials 331
NIMS Core Grinding Skills 251

NIMS Grinding Links:
NIMS Machining Level I Preparation Guide Grinding
Microsoft Word - Machining 1 Performance Guide.doc (nims-skills.org)

Priority Standard 11.3 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)
11.3.1 CNC Speeds and Feeds	● Calculate speeds for the lathe: ○ G97 ○ G96 CSS ○ RPM=(CSS X 3.82) / Dia. ● Calculate feeds for the lathe: ○ Feed for lathes in IPR ■ Roughing feeds .005” - .015” per rev. ■ Finishing feeds .001” - .003” per rev. ● Calculate speeds for the mill: ○ RPM=(CSS X 3.82) / Dia. ● Calculate feeds for the mill: ○ Used with M3/M4/M5 ○ G94 IPM ○ Feed = N x IPT x RPM ■ N = # of Cutting edges/flutes ■ IPT = Inch per tooth (Chip load) ○ Tapping on mill either Inch Per Revolution or Inch Per Minute and a slower RPM. (400 – 800) ■ IPM= RPM X Thread Pitch ■ G98 IPM command

Priority Standard 11.3 CNC Programming and Operations	

11.3.2 Canned Cycles	• Demonstrate an understanding of lathe canned cycles
	  ○ Drill canned cycle G74
	  ○ Tapping canned cycle
	  ■ G99 for IPR
	  ■ Feed for tapping on lathe:
	  ● IPR = 1/TPI
	  ■ Floating tap holder G32
	  ■ Rigid tap holder G84
	  ● Use with M29 S
	  ○ Rough/finish turning canned cycle G71/G70
	  ■ U, R
	  ■ P, Q, U, W, F
	  ○ Threading canned cycle G76
	  ■ X, Z, P, Q, R, F
	• Demonstrate an understanding of mill canned cycles
	  ○ Peck drill canned cycle
	  ■ G73
	  ● Q, R
	  ■ G83 (deep holes)
	  ● Q, R
	  ● I, J, K
	  ○ Tapping canned cycle
	  ■ G84 RH threads , G74 LH threads
	  ■ R, Z, F
	  ■ Feed for tapping on mill:
	  ● IPR = 1/TPI
	  ● IPM = IPR / RPM
	  ■ Rigid tap holder G84 M29 S

Priority Standard 11.3 CNC Programming and Operations	

11.3.3 CNC Programming	• Demonstrate and understanding of modal codes
	
	• Demonstrate an understanding of lathe codes:
	  ○ M-codes
	  ○ Tool change
	  ○ Program stop
	  ○ Coolant
	• Demonstrate an understanding of the principle of Tool Nose Radius Compensation (TNRC) on the lathe
	
	• Demonstrate an understanding of mill codes:
	  ○ M-codes
	  ○ Tool change
	  ○ Program stop
	  ○ Coolant
	  ○ Work offsets (G54-G59)
	  ○ Tool height offset (G43 and H)
	  ○ Dwell (G82)
	• Demonstrate an understanding of Cutter Radius Compensation (G41 & G42)

11.3.4 CNC Milling and Turning Operations	• Demonstrate how to startup a machine:
	  ○ Main breaker on
	  ○ Power on
	  ○ Clear alarms
	  ○ Powerup-restart/machine home
	• Demonstrate how to manually move machine using:
	  ○ Handle jog
	  ○ Jog keys
	  ○ MDI
	  ○ ATC
	• Perform a tool change
	• Load a program into the machines memory
	• Set tool length offsets using
	  ○ Shim/touch-off
	  ○ Probe
	• Set work coordinate systems using
	  ○ Edge finder
	  ○ Probe
	• Tool geometry offsets
	• Wear offsets

Priority Standard 11.3 CNC Programming and Operations

Technical Vocabulary:

11.3.1 CSS, IPR, IPM, IPT, Chip load

11.3.2 Canned Cycle, Rigid tapping

11.3.3 Modal, M-Codes, TNRC, Work offset, Tool height offset, Cutter radius compensation

11.3.4 MDI, ATC, Probe, Handle jog, Power up-restart, Geometry offset, Wear offset

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

Priority Standard 11.3 CNC Programming and Operations

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

NIMS Programming, Setup and Operations Links:
Performance Standards CNC Turning
CNC Lathe Programming Setup & Operations

Performance Standards CNC Milling
CNC Milling: Programming Setup & Operations

Priority Standard 11.4 Milling Machine Operations

Big Idea(s):

- Milling machines can create almost any shape, pocket, or profile.

Essential Question(s):

- How has the versatility of milling machines allowed machinists to develop complex components for planes, helicopters, submarines, etc?

Learner Outcomes

Students will know	As evidenced by: (oral, written, or performance)
11.4.1 Pockets	• Identifying the cutting tools and processes for cutting a pocket • Select a cutter of the correct diameter and center cutting capability • Identify if the corners can be drilled for a smaller radius • Demonstrate how to machine a pocket on a part to a specified length, width, and depth
11.4.2 Profiles	• Identify how to mill an outer profile of a part to a specified surface finish • Demonstrate how to hold a profile tolerance
11.4.3 Single Point Boring	• Use the milling machine to bore a hole to a location within +/- .002" and within +/- .001" Dia.
11.4.4 Rotary Table and Dividing Head	• Identify parts of a rotary table and dividing head • Explain the basic setup and operation of the rotary table and dividing head • Perform simple indexing calculations • Demonstrate basic set-up and operation of the rotary table and dividing head

Technical Vocabulary:

11.4.1 Pocket, Corner radius

11.4.2 Profile, Profile tolerance

11.4.3 Bore

11.4.4 Rotary table, Indexing

Priority Standard 11.4 Milling Machine Operations

Resources:

Precision Machining Technology, second edition text:
Section 6 Unit 3 Vertical Milling Machine Operations
Section 6 Unit 4 Indexing and Rotary Table Operations

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
Section 6 Unit 3: Vertical Milling Machine Operations
Section 6 Unit 4: Indexing and Rotary Table Operations

Boring Head Operations on the Milling Machine Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887880&

Machine Trades Print Reading 6th edition:
Unit 8 Contours

Tooling University:
NIMS Core Manual Milling Skills 261

NIMS Manual Vertical Milling Links:
Performance Standards Vertical Milling Level I
NIMS Machining Level I Preparation Guide Milling

Priority Standard 11.5 Blueprint Reading and GD&T

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)
11.5.1 Sectional Views	• Identify various section lines
11.5.2 Auxiliary Views	• Identify various auxiliary views
11.5.3 Geometric Dimensioning & Tolerancing	• Describe the purpose of GD&T tolerancing • Distinguish between traditional tolerancing and GD&T • Identify GD&T symbols • Describe the major categories of geometric tolerances • Identify datum surfaces • Define the meaning of GD&T symbols • Explain the measuring methods used to measure features for GD&T • Describe the contents of the feature control frame
11.5.4 Material Condition Modifiers	• Interpret the meaning of material condition modifiers • Describe the material condition modifiers

Technical Vocabulary:

11.5.1 Cutting plane, Cutting plane line, Full section, Half section, Broken out section, Offset section, Removed section

11.5.3 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

11.5.4 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 11.6 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)
11.6.1 Indicators	● Setup a drop indicator ● Setup test indicators with a stand ● Set an indicator using gage blocks or a master gage ● Measure runout, total runout, and concentricity of round stock using a v-block
11.6.2 Optical Comparators	● Measure a radius ● Measure an angle ● Measure hole locations
11.6.3 Go/No-Go Gages	● Explain the differences between plug gages and external gages ● Calculate Go/No-Go setup for both plug and external gages
11.6.4 Coordinate Measuring Machine (CMM)	● Explain the use of a coordinate measuring machine (CMM) by: ○ Qualify the CMM with a maximum of .0002” form error ○ Demonstrate the ability to set datums and origins ○ Demonstrate the use of the CMM by measuring a part to a NIMS inspection plan

Technical Vocabulary:

11.6.1 Drop indicator, Test indicator

11.6.2 Optical comparator (Shadow graph)

11.6.3 Go/No-Go gage, Plug gage, External gage

Priority Standard 11.6 Inspection Setups and Coordinate Measuring Machines (CMM)
11.6.4 CMM, Form error
Resources: Precision Machining Technology, second edition text: Section 2 Unit 4 Precision Measurement Tooling University: Hole Standards and Inspection 141 Advanced Hole Inspection 341 Introduction to CMM Arms 362 Inspecting with CMMs 361 Hole Standards and Inspection 141 Inspecting with Optical Comparators 351 Conceptos básicos de CMM 120 (Spanish) Inspección con CMM 220 (Spanish)

Priority Standard 11.7 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)
11.7.1 Lean Manufacturing	● Define lean manufacturing ● DOWNTIME ○ Defects ○ Overproduction ○ Waiting ○ Non-utilized talent ○ Transportation ○ Inventory ○ Motion ○ Extra-processing ● Define waste in terms of lean manufacturing ● Identify common types of waste ● Describe the importance of continuous improvement
11.7.2 Five S	● Define Five S ● List the activities of the Five S approach ● Describe the challenges to implementing a 5S program ● Describe the advantages to implementing a 5S program

Technical Vocabulary:

11.7.1 Lean manufacturing, Waste, Continuous improvement

11.7.2 Five S

Resources:

Tooling University:

Priority Standard 11.7 Continuous Improvement and Lean Manufacturing Principles

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)

What is Lean? Lean Manufacturing & Lean Enterprise | ASQ

5S - What are The Five S's of Lean? | ASQ

Who Moved My Cheese [Original] - Spencer Johnson

Priority Standard 11.8 Lathe Operations

Big Idea(s):

- Lathes are capable of holding workpieces using a wide variety of unique and purpose-driven devices.
- Lathes are crucial for the creation of threads.

Essential Question(s):

- How can different work-holding devices change the way parts can be manufactured?
- What is the importance of having specific characteristics to a thread?

Learner Outcomes

Students will know	As evidenced by: (oral, written, or performance)
11.8.1 Lathe Safety	● Identify all safety devices and explaining their function(s) ○ Emergency stop ○ Chip shields ○ Spindle brake ○ Chuck key removal ○ Safety glasses ○ Safety shoes ○ Jewelry (as it relates to moving parts) ○ Long hair (as it relates to moving parts) ○ Loose clothes (as it relates to moving parts) ○ Medication ○ Chips ● Explain how personal items can become safety hazards ● Identify and analyze the moving parts of a lathe that can cause injury ● Determine and use all required personal safety equipment when operating a lathe
11.8.2 Work Holding Devices	● Identify and explain the use of these work-holding devices: ○ Lathe centers / dog ○ Faceplate ○ Four-Jaw Chuck ○ Mandrels ○ Steady rest ○ Follower rest

Priority Standard 11.8 Lathe Operations	
	● Demonstrate the use of these common work-holding devices ● Demonstrate proper installation of centers and dog in a three jaw chuck for turning on centers ○ Aligning lathe centers within +/- .001" using test bar and dial indicator
11.8.3 Thread Terminology	● Identify and explain: ○ Screw Thread ○ Nominal Size ○ Pitch ○ Lead ○ Pitch Diameter ○ Major Diameter ○ Minor Diameter ○ Class of fit ○ Acme ○ Tapered pipe ○ Metric ○ Left-handed threads ● Identify the different sizes and styles of threads
11.8.4 Thread Measurement	● Identify the ways to measure threads: ○ Ring / Plug thread gage ○ Thread (Pitch) micrometer ○ Three wire method ● Utilize the three-wire thread measuring system to measure threads ● Utilize a thread thread (pitch) micrometer to measure threads
11.8.5 Single Point Threading	● Identify and setup procedure for turning threads including: ○ Compound tool rest angle OD /ID ○ Pitch selection ○ Setting quick change gearbox ○ Cutting tool orientation/alignment ○ Cutting speed ○ Threading dial / Half nut ● Demonstrate the set-up procedure and perform thread chasing ● Use the lathe in a responsible and safe manner to perform the operations of: ● Demonstrate the set-up procedure and perform thread chasing

Priority Standard 11.8 Lathe Operations	
	• Set-up and manually thread to a shoulder, a minimum 1" length within standard Machinery's Handbook class 2 pitch tolerance • Use algebraic formulas to calculate dimensions necessary to produce threads on a lathe: **Pitch= $\frac{1}{TPI}$** **d = $\frac{.86}{TPI}$ (depth of thread)**

Technical Vocabulary:

11.8.2 Lathe centers, Dog, Faceplate, Four-Jaw Chuck, Mandrels, Steady rest, Follower rest

11.8.3 Screw Thread, Nominal Size, Pitch, Lead, Pitch Diameter, Major Diameter, Minor Diameter, Class of fit, Acme, Tapered pipe, Metric thread

11.8.4 Ring / Plug thread gage, Thread (Pitch) micrometer, Three wire method

11.8.5 Half-nut (Threading dial)

Resources:

Precision Machining Technology, second edition text:
Section 3 Unit 6 Drilling, Threading, Tapping, and Reaming
Section 5 Unit 2 Workholding and Toolholding Devices for the Lathe
Section 5 Unit 4 Manual Lathe Threading

Cengage Mindtap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
Section 3 Unit 6: Drilling, Threading, Tapping, and Reaming
Section 5 Unit 2: Workholding and Toolholding Devices for the Lathe
Section 5 Unit 4: Manual Lathe Threading

External Threading on the Lathe Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&id=1840887869&snapshotId=3554665&

Internal Threading on the Lathe Video:
https://ng.cengage.com/static/nb/ui/evo/index.html?eISBN=9781285733791&snapshotId=3554665&id=1840887870&

Machine Trades Print Reading 6th edition:
Unit 11 Threads

Tooling University:
Thread Standards and Inspection 151
Introduction to Fastener Threads 221

Priority Standard 11.8 Lathe Operations

Overview of Threaded Fasteners 231
Threading on the Engine Lathe 301
NIMS Core Turning Skills 132
NIMS Core Manual Turning Skills 262

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

NIMS Between Centers Links:
Turning.doc (nims-skills.org)
Microsoft Word - Machining 1 Performance Guide.doc (nims-skills.org)

NIMS Turning Chucking Links:
Turning.doc (nims-skills.org)
Microsoft Word - Machining 1 Performance Guide.doc (nims-skills.org)

Priority Standard 11.9 MasterCAM®

Big Idea(s):

- CAD/CAM softwares 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)
11.9.1 Features of MasterCam®	● Explain the major components and features: ○ User coordinate system ○ Menus and icons ○ Basic Commands
11.9.2 File Types	● Explain the functions of file types used with CAD/CAM systems: ○ CAD- .dwg, .prt ○ CAM- .mcam, .nci, .nc ● Demonstrate the process of importing or exporting files from a variety of file sources outside the CAD/CAM system ● Understand how to convert files from one format to another within the CAD/CAM system
11.9.3 Two-dimensional Part Geometry	● Demonstrate the construction of 2D part geometry using: ○ Line, line parallel, line perpendicular ○ Circle, arc, filet ○ Rectangle ○ Trim, break, divide, extend, join
11.9.4 Tool Motion Parameters	● Demonstrate the procedures to create tool motions based on necessary part geometry and product finish: ○ Define part boundaries ○ Drill, contour, or pocket routines ○ Multi-passes ○ Lead-in & lead-out ○ Depth of cut ○ Cutter compensation ○ Speed & feed calculations
11.9.5 Tool Motion	● Demonstrate the procedures to verify tool motion using: ○ Verify ○ Backplot

Priority Standard 11.9 MasterCAM®	
	○ Simulation
11.9.6 Post-processors	● Demonstrate the post-processor procedures necessary to translate files into M&G Code ● Identify how to select and modify parameters of a post
11.9.7 Three-dimensional Part Geometry	● Demonstrate the procedures to construct 3D part geometry from 2D wireframe: ○ Extrude ○ Surface ○ Power Surface

Technical Vocabulary:

11.9.1 User coordinate system

11.9.2 File types

11.9.3 Trim, Break, Divide, Extend, Join, Filet

11.9.4 Multi-passes, Lead-in, Lead-out

11.9.5 Verify, Backplot, Simulation

11.9.6 Post processing, Post

11.9.7 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

Priority Standard 11.9 MasterCAM®
Tooling University: NIMS Core Mill Programming and Setup Skills 231 NIMS Core Lathe Programming and Setup Skills 232

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

Priority Standard 12.1 Shop/Workplace Safety

Technical Vocabulary:

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

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

Priority Standard 12.2 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?

Learner Outcomes

Students will know	As evidenced by: (oral, written, or performance)
12.2.1 Continuous Improvement	• Define the lean principle of continuous process improvement • Describe the steps of 5S
12.2.2 Lean Manufacturing	• Define the concept of lean • Describe culture in the workplace • List the pros and cons of developing a lean culture • Describe the lean concept of kaizen • Describe how to reinforce lean practices

Technical Vocabulary:

12.2.1 Sort, Set in order, Shine, Standardize, Sustain

12.2.2 Lean, Kaizen

Resources:

Tooling University:
Continuous Process Improvement: Managing Flow 124
Developing a Lean Culture 135
Mejora continua de procesos: Gestión de flujo 124 (Spanish)
Mejora continua de procesos: Identificación y eliminación de desperdicio 125 (Spanish)
Introducción a las Cinco S (5S) 155 (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 • Describe common orientations of rotational axes on 5-axis CNC machines • Describe multi-axis CNC machine operations • 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 • Demonstrate how to change between varying views and WCS • 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:

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

Unit 18 Print Reading Review

CamInstructor® :
http://www.caminstructor.com/login
Setup & Operate - CNC 4 Axis Mill
Setup & Operate - CNC 5 Axis Mill

CNC Programming: Principles and Applications; Michael Mattson

Priority Standard 12.4 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 subtractively?

Learner Outcomes

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

Priority Standard 12.4 Additive Manufacturing	
	• Describe the future of additive manufacturing.
Technical Vocabulary: **12.4.2** 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 12.5 Destructive and Non-Destructive Quality Testing

Big Idea(s):

- Destructive and non-destructive testing methods are essential to guarantee the quality of manufactured components.
- Destructive and non-destructive testing are lucrative careers within manufacturing.

Essential Question(s):

- Which industries or manufacturing processes might rely more on destructive testing?
- How does destructive testing affect the cost of a manufactured product?

Learner Outcomes

Students will know	As evidenced by: (oral, written, or performance)
12.5.1 Non-destructive testing	● Identify and explain common methods of non-destructive testing ○ Measuring ○ Radiography ○ Eddy current test ○ Fluorescent penetrate ○ Magnetic particle ○ Ultrasonic
12.5.2 Destructive Testing	● Identify and explain common methods of destructive testing ○ Environmental ○ Corrosion ○ Fracture and mechanical ○ Fatigue ○ Hardness ○ Residual stress measurement ○ Tensile (elongation) ○ Torsion

Technical Vocabulary:

12.5.1 Non-destructive testing, Radiography, FPI, MPI

12.5.2 Destructive testing, Tensile, Torsion, Fatigue

Resources:

Tooling University:
Nondestructive Testing 211
Hardness Testing 221

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 ● Describe the use of a CNC Swiss-type lathe ● Describe the characteristics and benefits of the guide bushing ● Describe live tooling on the CNC Swiss-type lathe ● Describe the possible axes associated with the CNC Swiss-type lathe
12.6.2 EDM	● Define EDM ● Describe the following machines: ○ Wire ○ Sinker ○ Hole-making ● Describe the function of dielectric fluids
12.6.3 Laser Cutting	● Describe common laser cutting equipment: ○ CO2 ○ Solid-state ○ Fiber
12.6.4 Plasma Cutters	● Describe plasma cutting machines

Technical Vocabulary:

12.6.1 Swiss machines

12.6.2 EDM, Wire EDM, Sinker EDM

12.6.3 Laser cutters

12.6.4 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)

Priority Standard 12.6 Specialty Machines
Laser Cutting Overview 261 Plasma Cutting 283