CTECS

BRISTOL TECHNICAL EDUCATION CENTER

PART OF THE CONNECTICUT TECHNICAL EDUCATION AND CAREER SYSTEM

Precision Machining Technology

Curriculum Guide

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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 (one year)

Semester 1 - Quarter 1 & 2 DSA

- 1.1 Shop safety OSHA 10
- 1.2 Introduction to Precision Machining Technology
- 1.3 Hand Tools
- 1.4 Trade Print Reading
- 1.5 Measurements
- 1.6 Layout
- 1.7 Vertical Milling

- 2.1 Shop safety OSHA 10
- 2.2 Layout and Trade Print Reading
- 2.3 Measurement and Quality
- 2.4 Saws and Cut-off machines
- 2.5 Lathes

Semester 2 – Quarter 3 & 4 DSA

- 3.1 Shop Workplace Safety
- 3.2 Employability Skills and Work Ethics
- 3.3 Trade Print Reading GD&T
- 3.4 CamInstructor® & CIMCO Editor®
- 3.5 CNC Mill Programming and Operations
- 3.6 CNC Milling Machines 4^{th} & 5^{th} axis machining
- 3.7 MasterCam®

- 4.1Shop Workplace Safety
- 4.2 CNC Lathe Programming and Operations
- 4.3 Grinding Machines
- 4.4 Continuous Improvements and LEAN Principals
- 4.5Specialty Machines

Semester 1 – Quarter 1 & 2 DSA

Priority Standard Q1.1 Shop Safety (OSHA – 10)

Big Idea(s):

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

Essential Question(s):

- 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)
Q.1.1 Introduction to OSHA	• Explain Workers' rights and employer responsibilities. • Describe worker safety and health resources. • Access inspection and violation reporting procedures.
Q.1.2 Walking-working Surfaces	• Identify walking and working surface hazards. • Recognize employer requirements for protecting workers from hazardous surfaces.
Q.1.3 Emergency Action Plans (EAP) and Fire Protection Plan (FPP)	• Explain the benefits and elements of EAP and FPPs • Identify the five types of fire extinguishers and their use.
Q.1.4 Electrocution Hazards	• Identify and describe major electrocution hazards. • Understand employer requirements for protecting workers from electrocution.
Q.1.5 Personal Protective Equipment (PPE)	• Identify when face head protection should be used. • Understand which types of hand and foot protection should be used for a specific situation. • Recognize the difference between respirator types.
Q.1.6 Hazard Communication system (HCS)	• Describe the different types of Hazard Communication labels. • Understand the employer's responsibilities under the HCS, including training and communication program.

Priority Standard Q1.1 Shop Safety (OSHA – 10)

Resources:

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

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

CareerSafe OSHA-10 General Industry On-line class

https://www.careersafeonline.com/

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 Q1.2 - 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)
Q1.2.1 Evolution of Machine Tools	● Summarize the evolution of machine tools
Q1.2.2 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
Q1.2.3 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

Technical Vocabulary:

Q.2.1 Machine Tool, Computer Numerical Control, Lathe, Milling Machine

Priority Standard Q1.2 - Introduction to Precision Machining Technology

Q.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 Q1.3 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)
Q1.3.1 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
Q1.3.2 Hand Tool Care and Safety	● Demonstrate the safe use & care of all appropriate tools ● Select appropriate hand/bench tool for a specific application

Technical Vocabulary:

Priority Standard Q1.3 Hand Tools

Q1.3.1 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 Mind tap 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 Q1.4 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)
Q1.4.1 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
Q1.4.2 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)
Q1.4.3 Title Blocks and Notes	● Identify and name the parts of a blueprint: ○ Drawing number ○ Part number ○ Revision history block ○ Sheet size ○ Title block ○ Tolerance block ○ Zones ○ General notes

Priority Standard Q1.4 Blueprint Reading

Q1.4.4 Dimensions and Tolerance	• 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

Technical Vocabulary:

Q1.4.1 Blueprint, Orthographic Projection, Isometric View

Q1.4.2 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

Q1.4.3 Drawing number, Part number, Revision, Revision history block, Sheet size, Title block, Tolerance block, Zones, General notes

Q1.4.4 Dimension, Tolerance, Basic size, Unilateral tolerance, Bilateral tolerance, Upper limit, Lower limit, Limit tolerance

Resources:

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

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

Priority Standard Q1.5 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)
Q1.5.1 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
Q1.5.2 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
Q1.5.3 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:

Q1.5.1 Numerator, Denominator

Q1.5.2 Steel Rule, Graduations, Protractor, Fixed Gages, Semi-Precision Instrument

Q1.5.3 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
Section 2 Unit 4 Precision Measurement

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

Priority Standard Q1.5 Measurements

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

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

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 Q1.6 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)
Q1.6.1 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:

Q1.6.1 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 Mind tap 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&

Using the Combination Set for Layout Video:

Priority Standard Q1.6 Layout

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 Q1.7 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)
Q1.7.1 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
Q1.7.2 Milling machine Types	● Distinguish and explain different types of milling machines: ○ Vertical spindle (knee mill) ○ Horizontal spindle (plain & universal) ○ CNC vertical milling center CNC vertical machining center
Q1.7.3 Vertical Milling Machine Components	● Identify the major components of a vertical milling machine: ○ Knee ○ Table ○ Head ○ Base ○ Saddle ○ Drawbar ○ Quill ○ Ram ○ Turret ○ Leadscrew

Priority Standard Q1.7 Milling Machines	
	● Identify what parts of the machine provide motion to the 3 axes: ○ X-axis ○ Y-axis Z-axis (Knee and the quill)
Q1.7.4 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
Q1.7.5 Tool Holding Attachments	● Identify common tool holding attachments, explain their characteristics, and successfully demonstrate the use of: ○ R-8 Tapers ○ R-8 Collets ○ Endmill tool holder ○ Drill Chucks ○ Stub arbor
Q1.7.6 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
Q1.7.7 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:

Priority Standard Q1.7 Milling Machines	
	○ RPM = CS X 3.82/D IPM = FPT X N X RPM
Q1.7.8 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 a 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". ○ “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.
Q1.7.9 Mill Maintenance	● Implement an acceptable "checkout procedure" for proper mill maintenance: ○ Cleaning ○ Lubrication ○ Adjustment
Technical Vocabulary: **Q1.7.2** Vertical Milling Machine, Bridgeport, Endmill **Q1.7.3** Knee, Table, Head, Base, Saddle, Drawbar, Quill, Ram, Turret, Leadscrew, X-axis, Y-axis, Z-axis **Q1.7.4** Endmill, Fly cutter, Face mill, Shell mill, Ballnose endmill **Q1.7.5** R-8 collet, Drill chuck, Arbor **Q1.7.6** Vise, 3-jaw chuck, 4-jaw chuck, Clamp sets, Collet fixtures **Q1.7.7** RPM, CS, D, IPM, FP, Chip load	

Priority Standard Q1.7 Milling Machines

Q1.7.8 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, Tool holding, and Work holding for the Vertical Milling Machine
Section 6 Unit 3 Vertical Milling Machine Operations

Cengage Mind tap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
Section 6 Unit 1: Introduction to the Vertical Milling Machine
Section 6 Unit 2: Tools, Tool holding, and Work holding for the Vertical Milling Machine

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

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

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

Tramming the Head of the Vertical Milling Machine Video:

Priority Standard Q2.1 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)
Q2.1.1 Materials Handling, Storage, USE, and Disposal	● Identify types of material handling equipment. ● Describe hazards associated with material handling activities.
Q2.1.2 Machine Guarding	● Recognize basic machinery parts that expose workers to hazards. ● Identify workplace situations and machinery that requires guarding. ● Understand and identify different types of machines guarding devices.
Q2.1.3 Industrial Hygiene	● Recognize: ○ Chemical Hazards ○ Biological Hazards ○ Physical Hazards ○ Ergonomic Hazards.
Q2.1.4 Bloodborne Pathogens	● Discuss OSHA requirements pertaining to bloodborne pathogens. ● Identify potential routes of exposure from bloodborne pathogens. ● Describe methods of preventing pathogen transmission. ● Demonstrate safe disposal of sharps.
Q2.1.5 Safety Data Sheet (i.e., S.D.S.)	● Identify chemical safety using S.D.S. ● Identify HMIS ● Identify NFPA
Q2.1.6 Ergonomics	● Recognize risk factors associated with work-related musculoskeletal disorders. ● Identify good posture. ● Describe safe lifting techniques.

Technical Vocabulary:

Q2.1.1 PPE, Emergency Shut-off, Shield/Guards, Eye Wash Station, Lock-out/Tag-out

Priority Standard Q2.1 Shop Safety (OSHA 10)

Q2.1.2 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

Q2.1.5 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 Mind tap 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 Q2.2 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)
Q2.2.1 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

Q2.2.2 BPR Symbols and Notations	• Identify the following blueprint symbols:
	  ○ Diameter
	  ○ Depth
	  ○ Counterbore (Spot face)
	  ○ 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)

Q2.2.3 Dimensions and Tolerance	• Identify the types of dimensions on a blueprint:
	  ○ Dimension types
	  ■ Inches
	  ■ Fraction
	  ■ Metric
	  ■ Angular
	• Calculate the tolerance for a given dimension
	• Convert between inches to metric
	• Understand the division of a circle:
	  ○ Degrees
	  ○ Minutes

Priority Standard Q2.2 Layout & Blueprint Reading	
	○ Seconds
Q2.2.4 Classes of Fit	● 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

Technical Vocabulary:

Q2.2.1 Baseline, Datum

Q2.2.2 Diameter, Radius, Depth, Counterbore, Countersink, Spot face, Blind hole

Q2.2.3 Inches, Metric, Degrees, Minutes, Seconds

Q2.2.4 Allowance

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:
Machinery's Handbook 29th Edition.pdf

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

Priority Standard Q2.3 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)

Q2.3.1 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.

Q2.3.2 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

Priority Standard Q2.3 Measurement and Quality	
	● 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
Q2.3.3 Indicators	● Identify and explain the common uses of dial and digital indicators ● 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
Q2.3.4 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

Priority Standard Q2.3 Measurement and Quality	
Q2.3.5 Algebraic Functions	● Demonstrate the ability to solve algebraic formulas: ○ Order of Operations ■ PEMDAS ○ Solving for a variable
Q2.3.6 Trigonometry	● Identify the sides of a triangle ○ Adjacent, Opposite, Hypotenuse ● Use the Pythagorean Theorem to calculate an unknown side of a right triangle ● Demonstrate the ability to solve right triangles using sine, cosine, and tangent trigonometric functions
Q2.3.7 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 ● Set up a gage block build and measure a given angle
Q2.3.8 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.
Q2.3.9 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:

Priority Standard Q2.3 Measurement and Quality

	○ Material Selection ○ Machines to be used ○ Work holding ○ 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

Technical Vocabulary:

Q2.3.1 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**

Q2.3.2 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

Q2.3.3 Dial indicator

Q2.3.4 Gage pins

Q2.3.5 Order of Operations

Q2.3.6 Pythagorean theorem, Adjacent side, Complementary angle, Hypotenuse, Opposite side, SIne, Cosine, Tangent, Trigonometry

Q2.3.7 Gage blocks, Sine tools (Bar and plate), wringing

Q2.3.8 Optical comparator (Shadowgraph), Mylar

Q2.3.9 Inspection plan, Process plan, Quality Assurance (QA), Quality control (QC)

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

Priority Standard Q2.3 Measurement and Quality

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

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

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

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

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

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

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

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

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

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

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

Priority Standard Q2.4 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)
Q2.4.1 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
Q2.4.2 Saw Operations	● Identify the differences and uses for: ○ Horizontal band saw ○ Power hacksaw ○ Vertical band saw ● 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.

Priority Standard Q2.4 Saws and Cut-off Machines	
	○ Cut raw material to length within +/ 1/16" on a horizontal power saw
Q2.4.3 Care and Maintenance	● 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
Q2.4.4 Blade Terminology	● 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
Technical Vocabulary: **Q2.4.2** Horizontal band saw, Power hacksaw, Vertical band saw **Q2.4.3** Kerf, Bimetal, Carbide tooth, Pitch (of blade teeth), Teeth Per Inch (TPI)	
Resources: Precision Machining Technology, second edition text: Section 3 Unit 4 Saws and Cutoff Machines Cengage Mind tap 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& 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 Q2.5 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 work holding device is critical for safety, accuracy, and efficiency.
- Multiple factors affect the selection of tools and tool holding 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 work holding attachments?
- Why is it important to calculate speeds and feeds?

Learning Outcomes

Students will know	As evidenced by: (oral, written, or performance)
Q2.5.1 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 Q2.5 Lathes	
Q2.5.2 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
Q2.5.3 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
Q2.5.4 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
Q2.5.5 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
Q2.5.6 Speeds and Feeds	● Identify factors that determine lathe cutting feeds and speeds. ● Use algebraic formulas and conversion tables to calculate speeds and feeds based on job requirements

Priority Standard Q2.5 Lathes	
	Time in minutes = L (length of cut) / RPM *feed rate **rpm = CS X 3.82 / D**
Q2.5.7 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.
Q2.5.8 Lathe Maintenance	● Implement an acceptable “checkout procedure” for proper lathe maintenance including: ○ Cleaning ○ Lubrication ○ Adjustment
Q2.5.9 Angles and Tapers	● Identify methods and accessories utilized in taper turning and explaining the advantages and disadvantages of each ○ Tool bit

Priority Standard Q2.5 Lathes

	○ 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:

Q2.5.2 Apron, Bed, Carriage, Compound rest, Cross slide, Half nut, Head stock, Lead screw, Saddle, Spindle, Spindle nose, Swing, Tailstock, Ways

Q2.5.3 Three-Jaw Chuck, 5C Collet

Q2.5.4 Rocker-type Tool holder, Tool Post, Quick-change Tool holder, Drill chuck, Taper-shank, Indexable tool post

Q2.5.5 Boring bar, Facing & Turning tools, HSS tool bit, Knurling Tool, Roughing tool, Finishing tool, Grooving & Cutoff (Parting) tool, Brazed carbide, Insert tool cutter

Q2.5.9 Offset tailstock method, Taper attachment, Tailstock offset, TPF, TPI, Tool bit method

Resources:

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

Cengage Mind tap 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&

Priority Standard Q2.5 Lathes

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

Semester 2 – Quarter 3 & 4 DSA

Priority Standard Q3.1 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)
Q3.1.1 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
Q3.1.2 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
Q3.1.3 First Aid	● Describe procedures for dealing with various injuries. ● Explain the dangers bloodborne pathogens ● Score 100% on safety test
Q3.1.4 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
Q3.1.5 Safety Data Sheet (i.e., M.S.D.S.)	● Identify chemical safety using S.D.S. ● Identify HMIS ● Identify NFPA

Priority Standard Q3.1 Shop/Workplace Safety

Technical Vocabulary:

Q3.1.3 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 Q3.2 Employability Skills and Work Ethic

Big Idea(s):

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

Essential Question(s):

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

Learning Outcomes	
Students will know	**As evidenced by: (oral, written, or performance)**
Q3.2.1 Employability Skills	● Explain the importance of interpersonal skills related to work ethic and key characteristics which are important for success in the workplace: ○ Attendance (Punctuality) ○ Character ○ Teamwork ○ Attitude ○ Productivity ○ Organizational Skills ○ Communication ○ Cooperation ○ Respect
Q3.2.2 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
Q3.2.3 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
Q3.2.4 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

Priority Standard Q3.2 Employability Skills and Work Ethic

Technical Vocabulary:

Q3.2.1 Attendance (Punctuality), Character, Teamwork, Attitude, Productivity, Organizational Skills, Communication, Cooperation, Respect

Q3.2.2 Interpersonal skills

Q3.2.3 Initiative

Q3.2.4 Dependability

Resources:

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

Cengage Mind tap 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

Priority Standard Q3.3 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)
Q3.3.1 Sectional Views	● Identify various section lines
Q3.3.2 Auxiliary Views	● Identify various auxiliary views
Q3.3.3 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
Q3.3.4 Material Condition Modifiers	● Interpret the meaning of material condition modifiers ● Describe the material condition modifiers

Technical Vocabulary:

Q3.3.1 Cutting plane, Cutting Plane line, Full section, Half section, Broken out section, Offset section, Removed section

Q3.3.3 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

Q3.3.4 Material condition modifiers, MMC, LMC

Resources:

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

Cengage Mind tap 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 Q3.4 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)
Q3.4.1 Absolute and Incremental Positioning	● Describe the difference between the two positioning systems ● Demonstrate the ability to plot points using both systems
Q3.4.2 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)
Q3.4.3 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:

Q3.4.1 Absolute programming, Incremental programming

Q3.4.2 Rapid, Linear interpolation, Modal, Origin, Clockwise, Counter clockwise, Machine zero, G-code, M-code, Safety block, Cartesian Coordinate system, End of block

Q3.4.3 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

Cengage Mind tap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
Section 8 Unit 1: CNC Basics

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

Priority Standard Q3.4 CamInstructor® & CIMCO Edit®

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 Q3.5 CNC Mill 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)
Q3.5.1 CNC Speeds and Feeds	● Calculate speeds for the mill: ○ RPM=(CSS X 3.82) / Dia.
Q3.5.2 Canned Cycles	● 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 Q3.5 CNC Mill Programming and Operations

Q3.5.3 CNC Programming	● 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)
Q3.5.4 CNC Milling and 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 machine's memory ● Set tool length offsets using ○ Shim/touch-off ○ Probe ● Set work coordinate systems using ○ Edge finder ○ Probe ● Tool geometry offsets ● Wear offsets

Technical Vocabulary:

Q3.5.1 CSS, IPR, IPM, IPT, Chip load

Q3.5.2 Canned Cycle, Rigid tapping

Q3.5.3 Modal, M-Codes, TNRC, Work offset, Tool height offset, Cutter radius compensation

Q3.5.4 MDI, ATC, Probe, Handle jog, Power up-restart, Geometry offset, Wear offset

Priority Standard Q3.5 CNC Mill Programming and Operations

Resources:

Precision Machining Technology, second edition text:
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 Mind tap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
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 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 Advanced Machining Skills 151
NIMS Core Mill Programming and Setup Skills 231

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

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

NIMS Programming, Setup and Operations Links:

Performance Standards CNC Milling
CNC Milling: Programming Setup & Operations

Priority Standard Q3.6 CNC 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)
Q3.6.1 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
Q3.6.2 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:

Q3.6.1 multi-axis, 4th axis, 5th axis, Common core toolpath

Q3.6.2 Work-coordinate system

Resources:

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

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

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

Priority Standard Q3.6 CNC Milling Machines (4 and 5 Axis Machining)

Setup & Operate - CNC 4 Axis Mill
Setup & Operate - CNC 5 Axis Mill

CNC Programming: Principles and Applications; Michael Mattson

https://www.cnccookbook.com/4-axis-cnc-in-2020-the-definitive-guide/

Priority Standard Q3.7 MasterCAM®

Big Idea(s):

- CAD/CAM software's 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)
Q3.7.1 Features of MasterCam®	● Explain the major components and features: ○ User coordinate system ○ Menus and icons ○ Basic Commands
Q3.7.2 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
Q3.7.3 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
Q3.7.4 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
Q3.7.5 Tool Motion	● Demonstrate the procedures to verify tool motion using: ○ Verify ○ Backplot ○ Simulation
Q3.7.6 Post-Processors	● Demonstrate the post-processor procedures necessary to translate files into M&G Code

Priority Standard Q3.7 MasterCAM®	
	• Identify how to select and modify parameters of a post
Q3.7.7 Three-dimensional Part Geometry	• Demonstrate the procedures to construct 3D part geometry from 2D wireframe: ○ Extrude ○ Surface ○ Power Surface

Technical Vocabulary:

Q3.7.1 User coordinate system

Q3.7.2 File types

Q3.7.3 Trim, Break, Divide, Extend, Join, Filet

Q3.7.4 Multi-passes, Lead-in, Lead-out

Q3.7.5 Verify, Back plot, Simulation

Q3.7.6 Post processing, Post

Q3.7.7 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 Mind tap Lessons; Hoffman, Precision Machining Technology, 2nd Edition:
Section 8 Unit 3: CNC Turning: Programming
Section 8 Unit 6: CNC Milling: Programming
Section 8 Unit 8: Computer-Aided Design and Computer-Aided Manufacturing

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

CNC Programming: Principles and Applications; Michael Mattson

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

Priority Standard Q4.1 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)
Q4.1.1 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
Q4.1.2 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
Q4.1.3 First Aid	● Describe procedures for dealing with various injuries. ● Explain the dangers bloodborne pathogens ● Score 100% on safety test
Q4.1.4 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
Q4.1.5 Safety Data Sheet (i.e., M.S.D.S.)	● Identify chemical safety using S.D.S. ● Identify HMIS ● Identify NFPA

Technical Vocabulary:

Q4.1.1 PPE, Emergency Shut-off, Shield/Guards, Eye Wash Station, Lock-out/Tag-out

Resources:

Precision Machining Technology, second edition text:

Priority Standard Q4.1 Shop/Workplace Safety

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 Q4.2 CNC Lathe 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)
Q4.2.1 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.
Q4.2.2 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 ■

Priority Standard Q4.2 CNC Lathe Programming and Operations	
Q4.2.3 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
Q4.2.4 CNC 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 machine's memory ● Set tool length offsets using ○ Shim/touch-off ○ Probe ● Set work coordinate systems using ○ Probe ● Tool geometry offsets ● Wear offsets
Technical Vocabulary: **Q4.2.1** CSS, IPR, IPM, IPT, Chip load **Q4.2.2** Canned Cycle, Rigid tapping **Q4.2.3** Modal, M-Codes, TNRC, Work offset, Tool height offset, Cutter radius compensation **Q4.2.4** MDI, ATC, Probe, Handle jog, Power up-restart, Geometry offset, Wear offset	

Priority Standard Q4.2 CNC Lathe Programming and Operations

Resources:

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

Cengage Mind tap 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 8: Computer-Aided Design and Computer-Aided Manufacturing

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

CNC Programming: Principles and Applications; Michael Mattson

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

Haas Tip of The Day:
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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

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

Priority Standard Q4.3 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)
Q4.3.1 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
Q4.3.2 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)
Q4.3.3 Cylindrical Grinders (ID & OD)	● Identify the basic parts of the machine ● Understand the basic operation
Q4.3.4 Jig Grinder	● Identify the basic parts of the machine ● Understand the basic operation
Q4.3.5 Vertical Grinder (Blanchard)	● Identify the basic parts of the machine ● Understand the basic operation

Priority Standard Q4.3 Grinding Machines

Q4.3.6 Centerless Grinder	• Identify the basic parts of the machine • Understand the basic operation

Technical Vocabulary:

Q4.3.2 Abrasive type, Grade, Structure, Bond, Grain size

Q4.3.3 Cylindrical grinder

Q4.3.4 Jig grinder

Q4.3.5 Vertical grinder

Q4.3.6 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 Mind tap 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 Q4.4 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)
Q4.4.1 Continuous Improvement	● Define the lean principle of continuous process improvement ● Describe the steps of 5S
Q4.4.2 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:

Q4.4.1 Sort, Set in order, Shine, Standardize, Sustain

Q4.4.2 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 Q4.5 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)
Laser Cutting Overview 261
Plasma Cutting 283