TN Department of Education | College, Career and Technical Education

May 2024

Principles of Machining I

Primary Career Cluster:	Advanced Manufacturing
Course Contact:	CTE.Standards@tn.gov
Course Code(s):	C13H09
Pre-requisite(s):	*Algebra I* (G02X02, G02H00)*, Principles of Manufacturing* (C13H05) Recommended: *Geometry* (G02X03, G02H11), *Physical Science* (G03H00)
Credit:	1
Grade Level:	10
Elective Focus - Graduation Requirement:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Advanced Manufacturing courses.
POS Concentrator:	This course satisfies one out of two required courses that meet the Perkins V concentrator definition, when taken in sequence in the approved program of study.
Programs of Study and Sequence:	This is the second course in the *Machining Technology* program of study.
Aligned Student Organization(s):	Skills USA: http://www.skillsusatn.org/
Coordinating Work-Based Learning:	Teachers are encouraged to use embedded WBL activities such as informational interviewing, job shadowing, and career mentoring. For information, visit https://www.tn.gov/education/educators/career-and-technical-education/work-based-learning.html.
Promoted Tennessee Student Industry Credentials:	Credentials are aligned with postsecondary and employment opportunities and with the competencies and skills that students acquire through their selected program of study. For a listing of promoted student industry credentials, visit https://www.tn.gov/education/educators/career-and-technical-education/student-industry-certification.html.
Teacher Endorsement(s):	070, 157, 230, 231, 232, 233, (042 and 043), (042 and 044), (042 and 045), (042 and 046), (042 and 047), (042 and 077), (042 and 078), (042 and 079), (043 and 044), (043 and 045), (043 and 046), (043 and 047), (043 and 077), (043 and 078), (043 and 079), (044 and 045), (044 and 046), (044 and 047), (044 and 077), (044 and 078), (044 and 079), (045 and 046), (045 and 047), (045 and 077), (045 and 078), (045 and 079), (046 and 047), (046 and 077), (046 and 078), (046 and 079), (047 and 077), (047 and 078), (047 and 079), (077 and 078), (077 and 079), (078 and 079), 470, 477, 501, 502, 522, 523, 531, 537, 551, 552, 553, 554, 555, 556, 557, 575, 582, 584, 585, 596, 598, 700, 701, 705, 706, 707, 760, 982
Required Teacher Certifications/Training:	Some endorsements require NIMS industry certification to teach this course. Please refer Occupational Endorsement License Guide for a full list.
Teacher Resources:	https://www.tn.gov/education/educators/career-and-technical-education/career-clusters/cte-cluster-advanced-manufacturing.html Best for All Central: https://bestforall.tnedu.gov/

Course at a Glance

CTE courses provide students with an opportunity to develop specific academic, technical, and 21st century skills necessary to be successful in career and in life. In pursuit of ensuring every student in Tennessee achieves this level of success, we begin with rigorous course standards which feed into intentionally designed programs of study.

Students engage in industry relevant content through general education integration and experiences such as career and technical student organizations (CTSO) and work-based learning (WBL). Through these experiences, students are immersed with industry standard content and technology, solve industry-based problems, meaningfully interact with industry professionals and use/produce industry specific, informational texts.

Using a Career and Technical Student Organization (CTSO) in Your Classroom

CTSOs are a great resource to put classroom learning into real-life experiences for your students through classroom, regional, state, and national competitions, and leadership opportunities. Below are CTSO connections for this course, note this is not an exhaustive list.

- Participate in CTSO Fall Leadership Conference to engage with peers by demonstrating logical thought processes and developing industry specific skills that involve teamwork and project management.
- Participate in contests that highlight job skill demonstration. These include Career Pathways Showcase, Job Interview, Automated Manufacturing Technology, Additive Manufacturing, CNC Milling, and CNC Technician.

Using Work-Based Learning (WBL) in Your Classroom

Sustained and coordinated activities that relate to the course content are the key to successful work-based learning. Possible activities for this course include the following. This is not an exhaustive list.

- **Standard 1.2** | Include a safety briefing in a visit to an industry partner/job site.
- **Standard 2.1** | Visit an industry partner that has old and new machines.
- **Standard 3.1** | Visit an employer and talk with those employees about career options.
- **Standards 4.1-4.3** | Students can shadow an employee and see how important proper measurements are in machining.
- **Standards 5.1-5.4** | Have the students do a project that is useful to a local employer. The employer can critique the student's drawings.
- **Standards 6.1-6.2** | Visit an industry that uses multiple materials to see how the materials are handled and how different materials perform.
- **Standards 7.1-7.2** | Set up a student run enterprise at the school that produces products for people at the school.
- **Standards 8.1-8.2** | Have a local industry person visit the class to discuss and demonstrate the importance of quality control.

Course Description

Principles of Machining I is designed to provide students with the skills and knowledge to be effective in production environments as a machinist, CNC operator, or supervisor. Upon completion of this course, proficient students will demonstrate safety practices concerning machining technology, proper measurement and layout techniques, reading and interpreting drawings and blueprints, production design processes, and quality control procedures. Upon completion of this course, students will be knowledgeable about potential postsecondary education and career opportunities related to machining technology and will be prepared to enroll in more advanced machining courses in high school.

Course Standards

1. Safety

1.1 Demonstrate Safety: Maintain safety records and **demonstrate adherence to industry-standard practices regarding general machine safety, tool safety, and fire safety** to protect all personnel and equipment. For example, when operating tools and equipment, regularly inspect and carefully employ the appropriate personal protective equipment (PPE) as recommended by Occupational, Safety & Health Administration (OSHA) regulations; American Society for Testing Materials, ANSI Z49.1: Safety and Welding, Cutting, and Allied Processes; and state and national code requirements. Be able to distinguish between rules and explain why certain rules apply. Incorporate safety procedures and complete the safety test with 100 percent accuracy.

1.2 Safety Guidelines: Adhering to proper **safety guidelines**, develop a schedule and create documents for a checklist to perform daily, weekly, and/or monthly routine maintenance on hand tools, conventional machines, and computer numerical control (CNC) machine tools. The checklist should also include, but is not limited to, cleaning the work area and appropriately handling and disposing of environmentally hazardous materials.

2. Overview of Machining Technology

2.1 Machining Technology: Describe **machining technology** and how it has affected the workforce and the manufacturing industry in particular. Summarize early machining tools, how power sources changed, basic machine tool operation, non-traditional machining processes, and automated machining processes.

3. Career Exploration

3.1 Careers: Explain how the role of a machinist has changed with the evolution of machining technology. Describe the **various machining job categories** and their characteristics. Identify the skills, education, and training requirements to become a machinist. Summarize possible postsecondary institutions (e.g., colleges of applied technology, community colleges, and four-year universities) and professional organizations (National Institute for Metalworking Skills [NIMS]).

4. Measurement and Layout

4.1 Measuring Tools: Given a specific machining task, **select the appropriate tool and accurately measure solid shapes or simple parts**. Record the measurements in both English and metric units using the correct number of significant figures. Perform basic mathematical calculations and/or calibrations using tools such as the following:

a. micrometers,
b. verniers,
c. dial Calipers,
d. gages,
e. dial indicators, and
f. helper measuring tools (e.g., calipers, telescoping gage, small hole gage).

4.2 Interpret Measurements: Calculate the speeds, feeds, and depth of cut for various machines and determine the tools needed for machining a simple part. **Correctly interpret recorded measurements** and use them to set up or adapt a process.

4.3 Layout: Identify and explain the proper use of the following common **layout tools used in machining technology**. Given a specific machining task, use a multistep layout procedure to locate and mark lines, circles, arcs, and points for drilling holes and making cuts. Such as:

a. lines: layout dye, scriber, divider, surface plate, v-blocks, straightedge, squares; and
b. angles: plain protractor, vernier protractor.

5. Blueprint Reading and Interpretation

5.1 Symbols, Lines, and Figures: Demonstrate technical literacy in the **symbols, lines, and figures** devised by the American National Standards Institute (ANSI). Distinguish between the past and present metalworking symbols (e.g., counterbore, countersink, and drill) and explain why it is important to be familiar with both.

5.2 Dimensions: Classify and compare the different types of **dimensions on drawings** needed to produce a part or an object. Read and interpret drawings that are dimensioned in fractional inches, decimal inches, and in metric units. For example, drawings dimensioned in decimal parts of a unit indicate greater precision.

5.3 Interpret Drawings: Examine and **interpret drawings to manufacture an object**. Report and define information necessary to complete a machining task, such as the materials to be used, required surface finish, tolerances, quantity of units, scale, assembly and subassembly instructions, past revisions, and the name of the object. Explain the interpretation of drawings and provide supporting evidence.

5.4 Detail and Assembly Drawings: Given a set of machining drawings, **distinguish between the detail and the assembly drawings**. Compare and contrast the characteristics and applications of each. Describe a multistep procedure to use the drawings in order to complete a series of tasks related to a given assignment. For example, use the scale of a drawing to determine dimensions not explicitly shown on the drawing.

6. Materials

6.1 Metal Classifications: Using the following classifications, explain **how metals are classified,** identify general characteristics of each type, and describe related safety precautions that should be applied during machining procedures.

a. ferrous metals
b. nonferrous metals
c. high-temperature metals
d. rare metals

6.2 Materials: Investigate the chemical and physical **properties of materials** used in the machining process. Considering the following common materials, list the principal properties relevant to machining tasks.

a. carbon steels
b. stainless steels
c. structural steels
d. cast iron
e. aluminum

7. Production Design Process to Machine Parts

7.1 Manufacture a Part: Determine strategies to **manufacture a simple part**. The strategies should include designing a flow process that organizes equipment and materials needed for cutting, drilling, milling, grinding, and/or other machining operations. Also, organize a plan for layout, set up, and performance of tapping, countersinking, counterboring, and reaming as needed. Implement the above strategies to manufacture the part.

7.2 Production Design Process: Develop and manufacture a product idea, accounting for given specifications and potential constraints. Prior to manufacturing the product, use the following multi-step process to **outline a plan demonstrating how the product will be manufactured efficiently**. The plan should include justification for the number of parts needed, how the parts were standardized, and the ability to process the parts.

a. develop initial designs
b. refine designs
c. create a conceptual model and prototype
d. present design ideas
e. obtain management approval for design
f. manufacture the final product

8. Quality Control

8.1 Measure and Weigh Parts: **Measure, weigh, and visually inspect machined parts**. Record and compare data to given project specifications using class-defined analysis methods. Interpret and communicate results both written and verbally. If necessary, recommend changes that will reduce the number of product defects during the manufacturing process.

8.2 Testing: Explain destructive and nondestructive **testing** used as **quality control techniques** to prevent manufacturing defects in machining technology. Explain the importance of accurate measuring tools that are calibrated by the National Institute of Standards Technology (NIST) guidelines. In addition, explore other testing techniques such as the use of coordinate measuring machines (CMM), use of optical comparators, radiographic inspection, magnetic particle inspection, ultrasonic inspection, and laser inspection. Compare and contrast these techniques and provide specific examples for when they are most appropriately used. Cite evidence to justify the examples.

Standards Alignment Notes

*References to other standards include:

- P21: Partnership for 21st Century Skills Framework for 21st Century Learning
    - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.