Department of Education | College, Career and Technical Education

May 2024

Principles of Machining II

Primary Career Cluster:	Advanced Manufacturing
Course Contact:	CTE.Standards@tn.gov
Course Code(s):	C13H06
Prerequisite(s):	*Algebra I* (G02X02, G02H00), *Geometry* (G02X03, G02H11), *Physical Science* (G03H00), and *Principles of Machining I* (C13H09). Recommended co-requisite: *Physics* (G03H20)
Credit:	2
Grade Level:	11
Elective Focus - Graduation Requirement:	This course satisfies two of three credits required for an elective focus when taken in conjunction with other 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 third course in the *Machining Technology* program of study.
Aligned Student Organization(s):	SkillsUSA: 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 a 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.

- **Standards 1.1-1.3** | Students can shadow an employee and see how important proper measurements are in machining.
- **Standard 2.1** | Include a safety briefing in a visit to an industry partner/job site.
- **Standards 3.1, 5.1** | Set up a student run enterprise at the school that produces products for people in the school.
- **Standard 4.1** | Produce a product that is evaluated or used by a local company.
- **Standard 5.4** | Do a project that is used by a local industry or evaluated by local industry managers.

Course Description

Principles of Machining II is an advanced level contextual course that builds on the introductory skills learned in the entry-level manufacturing and machining courses, stressing the concepts and practices in a production environment supported by advanced machining and engineering facilities. Working with the course instructor and team members in a cooperative learning environment, students will design, produce, and maintain products that are defined by detailed technical specifications. Emphasis is placed on quality control, safety engineering codes and standards, and production-grade machining systems, building on the learner's past knowledge, current experiences, and future conduct as a career machinist. Upon completion of this course, proficient students will be able to examine blueprints and specification drawings to plan and implement the manufacture of products, and machine parts to specifications using both manual and computer-controlled machine tools. Students will also be able to measure, examine, and test completed products to check for defects and conformance to specifications.

Course Standards

1. Measurement and Mathematical Concepts for Machining

1.1 Measurement: Determine the appropriate units and record accurate and repeatable **measurements of length, diameter, and thickness** to complete projects using:

a. rules, gages, calipers, and micrometers;
b. tools equipped with dials, vernier scales, and digital readouts;
c. both metric and English scales;
d. appropriate standards of accuracy and precision; and
e. satisfactory tolerances permissible for a given task.

For example, while grinding a piece to a specified thickness, measurements with a metric vernier caliper are used to achieve a value within the tolerance specified by the drawing.

1.2 Measurement of Angles: Determine the appropriate units and record accurate and repeatable **measurements of angles** to complete projects by:

a. applying principles of trigonometry, Cartesian geometry, and/or polar geometry, distinguishing when and which principles apply to a given machining task; and
b. using angle gages, a plate protractor, a universal bevel protractor with vernier scale, square, and/or a sine bar and gage blocks or adjustable parallel.

For example, measure the angle formed by two surfaces of a machined part to the nearest 0.01 degree using a sine bar.

1.3 Measurement of Material Properties: Determine the appropriate units and record accurate and repeatable **measurements of material properties** such as hardness, pH, and load/elongation test curves of stress, strain, modulus, and yield. Interpret test values and curves, and use calculated results to make informed decisions. For example, measure the Rockwell hardness of a piece of stainless steel to determine the recommended cutting speed with a carbide-tipped cutting tool.

2. Safety

2.1 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 and Health Administration (OSHA) regulations. Incorporate safety procedures and complete safety test with 100 percent accuracy.

3. Design

3.1 Interpret Drawings: Visualize and **interpret engineering drawings** for projects to:

a. create an accurate bill of materials;
b. identify and interpret geometric dimensioning, and tolerancing symbols and nomenclature; and
c. identify primary and secondary datums.

For example, lay out correctly dimensioned bolt holes in a radial pattern specified by a drawing, and select proper tools to complete the required operations.

3.2 Plan to Handle Materials: Anticipate the **consequences and handling requirements of metals, alloys, ceramics, polymers, and composites to properly and safely handle and machine these materials**. For example, research the material properties for the bill of materials for a project in preparation for choosing cutting tools, speeds, and handling.

4. Operations & Control

4.1 Operation of Machining Tools: Manage and coordinate the **operation of the cutting pieces, feeds, and mounts associated with both manual and computer-numerical-controlled (CNC) machining tools** to complete advanced projects involving:

a. milling machines, such as indexing operations using a dividing head and rotary tables;
b. lathes, such as re-chase and internal threads, taper turning with taper attachments and compound rests, internal tapered surfaces, follower and steady rests; and
c. grinders, such as grinding pieces between centers, operating radius dressers, cylindrical grinders, and inside diameter (ID) grinders.

For example, select the correct cutting tools and speeds for the CNC processes to create Delrin (plastic) shafts and gears for a class robotics project.

4.2 Heat-Treatments: Correctly, safely, and efficiently **schedule, configure, administer, and verify heat-treatments to machined parts** according to blueprint specifications. For example, while properly attired and equipped, use an oven or torch to harden and temper a W1-grade steel bolt to yield a hardened, tamper-proof bolt.

5. Production & Processing

5.1 Planning for Production: Solve manufacturing-related problems by analyzing and weighing the constraining factors including **schedule, cost, materials, and equipment**, as well as productivity, regulations, maintenance, and quality. For example, as part of an assigned machining project, draft, obtain approval, and implement a schedule for completion, including ordering materials, planning the sequence of machining and stepwise approvals, and determining a target for final delivery, justifying all recommendations with supporting evidence.

5.2 Quality Control: **Employ statistical quality control test methods and techniques**, especially on large volume processes, to minimize defects and waste due to poor quality. For example, use statistical sampling, measuring, and charting to monitor and detect the need for corrective action on a mass production of thread cutting. Upon completion of testing, draft a written report documenting the findings in the proper format that a quality control inspector would deliver to a supervisor or other superior.

5.3 New Machining Technologies: Explore and develop one's skills with **new and emerging machining and manufacturing technologies**, such as 3D printing, laser etching, computer-controlled machining, and digital manufacturing methods. For example, produce a small plastic part using a 3D printer, and then produce the same part with a CNC production method using G- and M-codes; compare the material cost and waste, manpower, scheduling, etc. of the two methods and provide written justification to persuade a prospective manufacturer, wholesaler, or other supplier why one method is more cost-effective, efficient, or profit-maximizing than the other.

5.4 Solve a Manufacturing Problem: Demonstrate and practice teamwork, problem-solving, and decision-making skills required for success as a career machinist in a manufacturing environment. Applying the skills acquired in the previous standards, examine **a given manufacturing problem to research and plan a solution that will result in the creation of a prototype for a manufactured product**. This process will include but is not limited to the following:

a. reading and interpreting relevant engineering drawings;
b. assessing prototyping processes;
c. using engineering drawings as a planning tool for programming software to design the prototype;
d. crafting appropriate documentation and justification of decisions made in the design process, for the purposes of explaining as well as persuading; and
e. creating a presentation for the design and construction of the manufactured product.

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.