TENNESSEE DEPARTMENT OF EDUCATION
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Principles of Machining II

Primary Career Cluster:	Manufacturing
Consultant:	Bethany King Wilkes, (615) 532-2844, Bethany.Wilkes@tn.gov
Course Code:	~~TBD~~5923
Prerequisite(s):	*Algebra I* (3102), *Geometry* (3108), *Physical Science* (3202), *Principles of Manufacturing* (5922), and *Principles of Machining I* (5929). Recommended co-requisites: *Advanced Algebra & Trigonometry* (3124) and *Physics* (3231)
Credit:	2~~1~~
Grade Level:	11
Graduation Requirement:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Manufacturing courses.
Programs of Study and Sequence:	This is the third course in the *Machining Technology* program of study.
Necessary Equipment:	~~Refer to the equipment list found on the Manufacturing website.~~Equipment lists can be found at http://www.tn.gov/education/cte/Manufacturing.shtml.
Aligned Student Organization(s):	SkillsUSA: http://www.tnskillsusa.com/ Brandon Hudson, (615) 532-2804, Brandon.Hudson@tn.gov
Coordinating Work-Based Learning:	If a teacher has completed work-based learning training, ~~appropriate student placement can be offered~~he or she can offer placement. To learn more, please visit http://www.tn.gov/education/cte/wb/.
Available Student Industry Certifications:	None
Dual Credit or Dual Enrollment Opportunities:	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
Teacher Endorsement(s):	070, 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, 531, 537, 551, 552, 553, 554, 555, 556, 575, 582, 584, 585, 596
Required Teacher Certifications/Training:	All endorsements listed above require NIMS industry certification with the exception of: 531, 537, 551, 552, 553, 554, 555, 556, 575, 582, 584, 585, 596
Teacher Resources:	http://www.tn.gov/education/cte/Manufacturing.shtml

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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 and 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. Students will 1) examine blueprints and specification drawings to plan and implement the manufacture of products, 2) machine parts to specifications using both manual and computer-controlled machine tools, and 3) measure, examine, and test completed products to check for defects and conformance to specifications. Standards in this course are aligned with Tennessee Common Core State Standards for English Language Arts & Literacy in Technical Subjects and Tennessee Common Core State Standards in Mathematics.*

Program of Study Application

This is the third course in the *Machining Technology* program of study. For more information on the benefits and requirements of implementing this program in full, please visit the Manufacturing website at http://www.tn.gov/education/cte/Manufacturing.shtml.

Course Standards

Measurement and Mathematical Concepts for Machining

1) 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
    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. (TN CCSS Reading 3, 7; TN CCSS Math N-Q, G-GMD)

2) 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.
    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. (TN CCSS Reading 3, 7; TN CCSS Math N-Q, A-REI, F-TF, G-SRT)

3) 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~~Brinell~~ hardness of a piece of stainless steel to determine the recommended cutting speed with a carbide-tipped cutting tool. (TN CCSS Reading 3, 4; TN CCSS Math N-Q, A-SSE, A-CED, A-REI, G-MD)

Safety

4) 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 ~~fastidiously~~ employ the appropriate personal protective equipment (PPE), as recommended by Occupational, Safety & Health Administration (OSHA) regulations. Incorporate safety procedures and complete safety test with 100 percent accuracy. (TN CCSS Reading 1, 2, 3, 7; TN CCSS Math N-Q)

Design

5) 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~~.~~
    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. (CCSS Reading 3, 4, 7; TN CCSS Writing 4; TN CCSS Math N-Q, G-CO, G-GMD, G-MG)

6) 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. (TN CCSS Reading 1, 4, 5; TN CCSS Writing 4, 7; TN CCSS Math N-Q)

Operations & Control

7) Manage and coordinate~~orchestrate~~ 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
    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. (TN CCSS Reading 3, 7; TN CCSS Math N-Q, G-C, G-GMD, G-MG)

8) 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. (CCSS Reading 3, 5, 7; TN CCSS Math N-Q, A-REI, G-MG)

Production & Processing

9) 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. (TN CCSS Reading 1, 5, 7; TN CCSS Writing 1, 4, 7; TN CCSS Math N-Q)

10) 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. (TN CCSS Reading 3; TN CCSS Writing 2, 4, 6, 7; TN CCSS Math N-Q)

11) 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. (TN CCSS Reading 3, 4, 7; TN CCSS Writing 1, 4; TN CCSS Math N-Q)

12) 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
    e. Creating a presentation for the design and construction of the manufactured product

    (TN CCSS Reading 3, 4, 7, 9; TN CCSS Writing 1, 2, 4, 7; TN CCSS Math N-Q)

Standards Alignment Notes

*References to other standards include:

- TN CCSS Reading: Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects; Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 11-12 Students (page 62).
    - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 6, 8, and 10 at the conclusion of the course.
- TN CCSS Writing: Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects; Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 11-12 Students (pages 64-66).
    - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 3, 5, 8, 9, and 10 at the conclusion of the course.
- TN CCSS Math: Common Core State Standards for Mathematics; Math Standards for High School: Numbers and Quantity, Algebra, Functions, Geometry.
    - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project-based activities or collaborate on lesson planning. Students who are engaging in activities listed above should be able to demonstrate quantitative, algebraic, functional, and geometric reasoning as applied to specific technical concepts. In addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.
- 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.