2024 Precision Machining

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The Research and Curriculum Unit (RCU), located in Starkville, MS, as part of Mississippi State University, was established to foster educational enhancements and innovations. In keeping with the land-grant mission of Mississippi State University, the RCU is dedicated to improving the quality of life for Mississippians. The RCU enhances intellectual and professional development of Mississippi students and educators while applying knowledge and educational research to the lives of the people of the state. The RCU works within the contexts of curriculum development and revision, research, assessment, professional development, and industrial training.

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Acknowledgments

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Dr. Ray Morgigno, interim state superintendent of education, executive secretary
Mr. Glen V. East, chair
Mr. Matt Miller, vice chair
Dr. Ronnie L. McGehee
Mr. Bill Jacobs
Mr. Mike Pruitt
Mrs. Mary Werner
Dr. Wendi Barrett
Mr. Charlie Frugé, student representative
Ms. Kate Riddle, student representative

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Standards

Standards and alignment crosswalks are referenced in the appendix. Depending on the curriculum, these crosswalks should identify alignment to the standards mentioned below, as well as possible related academic topics as required in the Subject Area Testing Program in Algebra I, Biology I, English II, and U.S. History from 1877, which could be integrated into the content of the units. Mississippi's CTE precision machining is aligned to the following standards:

National Institute for Metalworking Skills, Inc. (NIMS)
NIMS is the nation's only ANSI-accredited developer of precision manufacturing skills standards and competency assessments. NIMS certifies individual skills against standards and accredits programs that meet its quality requirements. Reprinted with permission from NIMS, Copyright © 2008, National Institute for Metalworking Skills, Inc., (703) 352-4971, nims-skills.org

International Society for Technology in Education Standards (ISTE)
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iste.org

College- and Career-Ready Standards
College- and career-readiness standards emphasize critical thinking, teamwork, and problem-solving skills. Students will learn the skills and abilities required by the workforce of today and the future. Mississippi adopted Mississippi College- and Career-Readiness Standards (MCCRS) to provide a consistent, clear understanding of what students are expected to learn so teachers and parents know what they need to do to help them.
mdek12.org/oae/college-and-career-readiness-standards

Framework for 21st Century Learning
In defining 21st-century learning, the Partnership for 21st Century Skills has embraced key themes and skill areas that represent the essential knowledge for the 21st century: global awareness; financial, economic, business, and entrepreneurial literacy; civic literacy; health literacy; environmental literacy; learning and innovation skills; information, media, technology skills; and life and career skills. 21 *Framework Definitions* (2019).
battelleforkids.org/networks/p21/frameworks-resources

Preface

Secondary CTE programs in Mississippi face many challenges resulting from sweeping educational reforms at the national and state levels. Schools and teachers are increasingly being held accountable for providing applied learning activities to every student in the classroom. This accountability is measured through increased requirements for mastery and attainment of competency as documented through both formative and summative assessments. This document provides information, tools, and solutions that will aid students, teachers, and schools in creating and implementing applied, interactive, and innovative lessons. Through best practices, alignment with national standards and certifications, community partnerships, and a hands-on, student-centered concept, educators will be able to truly engage students in meaningful and collaborative learning opportunities.

The courses in this document reflect the statutory requirements as found in Section 37-3-49, *Mississippi Code of 1972*, as amended (Section 37-3-46). In addition, this curriculum reflects guidelines imposed by federal and state mandates (Laws, 1988, Ch. 487, §14; Laws, 1991, Ch. 423, §1; Laws, 1992, Ch. 519, §4 eff. from and after July 1, 1992; Strengthening Career and Technical Education for the 21st Century Act, 2019 [Perkins V]; and Every Student Succeeds Act, 2015).

Mississippi Teacher Professional Resources

The following are resources for Mississippi teachers:

Curriculum, Assessment, Professional Learning
: Program resources can be found at the RCU's website, rcu.msstate.edu.

Learning Management System: An Online Resource
: Learning management system information can be found at the RCU's website, under Professional Learning.

Should you need additional instructions, contact the RCU at 662.325.2510 or helpdesk@rcu.msstate.edu.

Executive Summary

Pathway Description
The Precision Machining pathway is designed as a secondary program for preparation to enter the fields of precision machining and metal turning. The Precision Machining program includes an introduction to the basic machining metalworking processes. The purpose of the course is to prepare students to continue study in a postsecondary metals program (Precision Machining, Machine Tool Operation, and Automotive Machining) or to begin work at the entry level in a machining occupation. The machining courses found in this curriculum align with the National Institute for Metalworking Skills (NIMS) credentialing standards.

College, Career, and Certifications
NIMS is a nationally recognized nonprofit organization established in 1995 to help develop industry standards to maintain the United States' global competitiveness. NIMS sets industry standards and certifies individuals who meet the quality requirements contained in the industry standards. NIMS also accredits training programs and facilities that meet NIMS's quality requirements. The NIMS organization and standards are accredited by the American National Standards Institute (ANSI) in the metalworking field.

The NIMS Level 1 credential consists of bench work, layout, milling, drill press, surface grinding, and lathing between centers. Students are required to perform a NIMS-approved project in each area in order to attain credentialing in those areas. Students must be able to complete the NIMS project with 100% accuracy before being allowed to take an additional online written test. Once the performance evaluation and the online test are administered and passed, the students will receive a NIMS certification for each area successfully completed—bench work, layout, milling, drill press, surface grinding, and lathing between centers. The NIMS organization awards credentials for each competency area in the Level 1 module after the successful completion of projects and written tests.

Grade Level and Class Size Recommendations
It is recommended that students enter this program as sophomores. Exceptions to this are a district-level decision based on class size, enrollment numbers, student maturity, and CTE delivery method. This is a hands-on, lab- or shop-based course. Therefore, a maximum of 15 students is recommended per class, with only one class with the teacher at a time.

Student Prerequisites
For students to experience success in the program, the following student prerequisites are suggested:

1. C or higher in English (the previous year)
2. C or higher in high school-level math (last course taken or the instructor can specify the level of math instruction needed)
3. Instructor approval and Test of Adult Basic Education (TABE) reading score (eighth grade or higher)

or

1. TABE reading and math score (eighth grade or higher)

2. Instructor approval

or

1. Instructor approval

Assessment
The latest assessment blueprint for the curriculum can be found at rcu.msstate.edu/curriculum

Teacher Licensure
The latest teacher licensure information can be found at mdek12.org/oel/apply-for-an-educator-license.

Professional Learning
If you have specific questions about the content of any of training sessions provided, please contact the RCU at 662.325.2510 or helpdesk@rcu.msstate.edu.

Course Outlines

Option 1—Four 1-Carnegie-Unit Courses

This curriculum consists of four 1-credit courses, which should be completed in the following sequence:

1. **Fundamentals of Precision Machining—Course Code: 993405**
2. **Application of Precision Machining—Course Code: 993406**
3. **Theory of Precision Machining—Course Code: 993407**
4. **Advanced Skills of Precision Machining—Course Code: 993408**

Course Description: Fundamentals of Precision Machining
Fundamentals of Precision Machining includes an introduction to the field of precision machining and the fundamentals of safety, tools, basic math, blueprint reading, and milling machinery.

Course Description: Application of Precision Machining
Application of Precision Machining emphasizes an overview of safety and leadership, lathe theory, and grinding operations and gives students hands-on practice in these areas.

Course Description: Theory of Precision Machining
Theory of Precision Machining includes a study of precision machining techniques and advanced lathe operation.

Course Description: Advanced Skills of Precision Machining
Advanced Skills of Precision Machining emphasizes the study of precision machining techniques in advanced milling and computer numerical control (CNC) operations.

Fundamentals of Precision Machining—Course Code: 993405

Unit	Unit Title	Hours
1	Orientation, Leadership, and Basic Safety	25
2	Math, Measuring Tools, and Instruments	25
3	Introduction to Blueprints and Hand and Power Tools	30
4	Bench and Pedestal Grinding (Offhand Grinding)	30
5	Drill Press and Band Saw Theory and Operation	30
Total		**140**

Application of Precision Machining—Course Code: 993406

Unit	Unit Title	Hours
6	Lathe Theory and Operation	75
7	Milling Machine Theory and Operation	40
8	Introduction to Lathe and Milling Skills	25
Total		**140**

Theory of Precision Machining—Course Code: 993407

Unit	Unit Title	Hours
9	Orientation, Advanced Leadership, and Employability Skills	8
10	Basic Safety	17
11	Advanced Lathe Operation	115
Total		**140**

Advanced Skills of Precision Machining—Course Code: 993408

Unit	Unit Title	Hours
12	Advanced Milling Operation	95
13	Grinding Theory and Operation	15
14	Computerized Numerical Control	30
Total		**140**

Option 2—Two 2-Carnegie-Unit Courses

This curriculum consists of two 2-credit courses, which should be completed in the following sequence:

1. **Precision Machining I—Course Code: 993403**
2. **Precision Machining II—Course Code: 993404**

Course Description: Precision Machining I
Precision Machining I includes orientation and leadership, basic safety, math, measuring tools and instruments, blueprints, hand and power tools, lathe theory and operation milling, machine theory and operation, and grinding operations. Safety is emphasized in each unit and every activity.

Course Description: Precision Machining II
Precision Machining II includes advanced precision machining techniques in lathing, vertical milling, and CNC.

Precision Machining I—Course Code: 993403

Unit	Unit Title	Hours
1	Orientation, Leadership, and Basic Safety	25
2	Math, Measuring Tools, and Instruments	25
3	Introduction to Blueprints and Hand and Power Tools	30
4	Bench and Pedestal Grinding (Offhand Grinding)	30
5	Drill Press and Band Saw Theory and Operation	30
6	Lathe Theory and Operation	75
7	Milling Machine Theory and Operation	40
8	Introduction to Lathe and Milling Skills	25
Total		**280**

Precision Machining II—Course Code: 993404

Unit	Unit Title	Hours
9	Orientation, Advanced Leadership, and Employability Skills	8
10	Basic Safety	17
11	Advanced Lathe Operation	115
12	Advanced Milling Operation	95
13	Grinding Theory and Operation	15
14	Computerized Numerical Control	30
Total		**280**

Career Pathway Outlook

Overview

Precision machining professionals operate equipment that creates the parts for consumer products. According to the Precision Machined Products Association (PMPA), precision machinists make the components critical to today's technologies. These machining professionals will operate lathes, mills, molding, casting, or core-making machines while adjusting machine settings and repairing or replacing damaged cutting tools during production. Career fields in precision machining include machine setters that understand welding, soldering, brazing, milling, and planning; machine operators and tenders; CNC tool operators and programmers; model makers; foundry mold and coremakers; patternmakers; etc. The largest employers of metal and plastic machine workers are fabricated metal product manufacturing (25%), plastics and rubber products manufacturing (17%), transportation equipment manufacturing (15%), primary metal manufacturing (11%), and machinery manufacturing (11%). Industrial partners in Mississippi have mentioned that students need to become multi-taskers and problem-solvers, develop the ability to read blueprints, read precision measuring instruments, understand production processes, have math and computer skills, and be willing to research precision machining-related trades. Employers indicated that if individuals entered the workplace with problem-solving skills, specifically, this would assist in their training to meet a company's manufacturing needs. The top five national occupations that make up metal and plastic machine careers are as follows: (1) cutting, punching, and press machine setters and operators, (2) molding, core-making, and casting machine setters and operators, (3) CNC tool operators, (4) multiple machine tool setters and operators, and (5) grinding, lapping, polishing, and buffing machine tool setters and operators.

Most careers in precision machining require at least an associate degree, although careers with the highest earning potential—engineers and postsecondary teachers, for example—usually require advanced degrees.

Needs of the Future Workforce

From 2021 to 2031, about 101,700 openings for metal and plastic machine workers are projected each year, on average, according to the U.S. Bureau of Labor Statistics. In Mississippi, the average employment growth total from 2020 to 2030 is projected to increase by 9.5% for all general occupations combined. The data given in Table 1.1 below, including the average hourly earnings, was compiled from the Mississippi Department of Employment Security in 2022.

Table 1.1: Current and Projected Occupation Report

Description	Jobs, 2020	Projected Jobs, 2030	Change (Number)	Change (Percent)	Average Hourly Earnings, 2022
Adhesive Bonding Machine Operators and Tenders	390	390	0	0.0%	$12.96

Aircraft Mechanics and Service Technicians	1,130	1,180	50	4.4%	$32.28
Avionics Technicians	90	90	0	0.0%	$34.11
Calibration and Engineering Technologists and Technicians	600	650	50	8.3%	$22.17
Cleaning, Washing, and Metal Pickling Equipment Operators and Tenders	40	50	10	25.0%	$12.56
Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	1,830	1,830	0	0.0%	$20.63
Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	240	240	0	0.0%	$15.97
Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders	740	760	20	2.7%	$18.31
Industrial Engineering Technologists and Technicians	360	380	20	5.6%	$31.59
Industrial Machinery Mechanics	5,110	5,450	340	6.7%	$26.26
Machinist	2,880	3,040	160	5.6%	$19.88
Maintenance Workers, Machinery	520	560	40	7.7%	$23.69
Mechanical Engineering Technologists and Technicians	100	110	10	10.0%	$24.88
Medical Appliance Technicians	160	210	50	31.3%	$21.41
Metal-Refining Furnace Operators and Tenders	180	190	10	5.6%	$17.20
Mixing and Blending Machine Setters, Operators, and Tenders	1,350	1,410	60	4.4%	$19.55
Motorboat Mechanics and Service Technicians	130	140	10	7.7%	$18.08
Motorcycle Mechanics	130	140	10	7.7%	$19.11
Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	520	530	10	1.9%	$16.42

Packaging and Filling Machine Operators and Tenders	3,040	3,300	260	8.6%	$14.11
Pourers and Casters, Metal	50	50	0	0.0%	$16.65
Precision Instrument and Equipment Repairers	120	120	0	0.0%	$25.88
Rolling Machine Setters, Operators, and Tenders, Metal and Plastic	430	430	0	0.0%	$14.97
Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	80	80	0	0.0%	$18.72
Sheet Metal Workers	1,510	1,570	60	4.0%	$21.86

Source: Mississippi Department of Employment Security; mdes.ms.gov (2022).

Perkins V Requirements and Academic Infusion

The Precision Machining curriculum meets Perkins V requirements of introducing students to and preparing them for high-skill, high-wage occupations in metalworking fields. It also offers students a program of study, including secondary, postsecondary, and institutions of higher learning courses, that will further prepare them for metalworking careers. Additionally, this curriculum is integrated with academic college- and career-readiness standards. Lastly, it focuses on ongoing and meaningful professional development for teachers as well as relationships with industry.

Transition to Postsecondary Education

The latest articulation information for secondary to postsecondary can be found at the Mississippi Community College Board website, mccb.edu.

Best Practices

Innovative Instructional Technologies

Classrooms should be equipped with tools that will teach today's digital learners through applicable and modern practices. The Precision Machining educator's goal should be to include teaching strategies that incorporate current technology. To make use of the latest online communication tools—wikis, blogs, podcasts, and social media platforms, for example—the classroom teacher is encouraged to use a learning management system that introduces students to education in an online environment and places more of the responsibility of learning on the student.

Differentiated Instruction

Students learn in a variety of ways, and numerous factors—students' backgrounds, emotional health, and circumstances, for example—create unique learners. By providing various teaching and assessment strategies, students with various learning preferences can have more opportunity to succeed.

CTE Student Organizations

Teachers should investigate opportunities to sponsor a student organization. There are several here in Mississippi that will foster the types of learning expected from the Precision Machining curriculum. SkillsUSA is an example of a student organization with many outlets for manufacturing. Student organizations provide participants and members with growth opportunities and competitive events. They also open the doors to the world of manufacturing careers and scholarship opportunities.

Cooperative Learning

Cooperative learning can help students understand topics when independent learning cannot. Therefore, you will see several opportunities in the Precision Machining curriculum for group work. Students need to be able to work collaboratively with others and solve problems without excessive conflict to function in today's workforce. The Precision Machining curriculum provides opportunities for students to work together and help each other complete complex tasks. There are many field experiences within the Precision Machining curriculum that will allow and encourage collaboration with professionals currently in the metalworking field.

Work-Based Learning

Work-based learning is an extension of understanding competencies taught in the Precision Machining classroom. This curriculum is designed in a way that necessitates active involvement by the students in the community around them and the global environment. These real-world connections and applications link to all types of students to knowledge, skills, and professional dispositions. Work-based learning should encompass ongoing and increasingly more complex involvement with local companies and electrical professionals. Thus, supervised collaboration and immersion into the manufacturing industry around the students are keys to students' success, knowledge, and skills development.

Professional Organizations

Association of Career and Technical Education
acteonline.org

International Society for Technology in Education
iste.org

Mississippi Manufacturing Association (MMA)
mma-web.org

National Institute for Metalworking Skills, Inc.
nims-skills.org

SkillsUSA
skillsusa.org

Skills USA—Mississippi
mdek12.org/CTE/SO/SkillsUSA

Using This Document

Competencies and Suggested Objectives
A competency represents a general concept or performance that students are expected to master as a requirement for satisfactorily completing a unit. Students will be expected to receive instruction on all competencies. The suggested objectives represent the enabling and supporting knowledge and performances that will indicate mastery of the competency at the course level.

Teacher Resources
All teachers should request to be added to the Canvas Resource Guide for their course. For questions or to be added to the guide, send a Help Desk ticket to the RCU by emailing helpdesk@rcu.msstate.edu.

Perkins V Quality Indicators and Enrichment Material
Some of the units may include an enrichment section at the end. This material will greatly enhance the learning experiences of students. If the precision machining program is using a national certification, work-based learning, or another measure of accountability that aligns with Perkins V as a quality indicator, this material could very well be assessed on that quality indicator. It is the responsibility of the teacher to ensure all competencies for the selected quality indicator are covered throughout the year.

Unit 1: Orientation, Leadership, and Basic Safety

Competencies and Suggested Objectives
1. Describe local program and career technical center policies and procedures. DOK1 a. Describe local program and career technical center policies and procedures, including dress code, attendance, academic requirements, discipline, and transportation regulations.
2. Describe employment opportunities and responsibilities. DOK2 a. Relate employment opportunities, including potential earnings, employee benefits, job availability, place of employment, working conditions, and educational requirements to students' success in a secondary or postsecondary manufacturing curriculum. b. Describe basic employee responsibilities.
3. Explore leadership skills and personal development opportunities provided to students by student organizations, including SkillsUSA. DOK2 a. Demonstrate effective team-building and leadership skills. b. Practice appropriate work ethics. c. Demonstrate the ability to follow verbal and written instructions and communicate effectively in on-the-job situations. d. Discuss the history of the metal trade industry to include materials, terminology, and techniques.
4. Explain safety in and around electrical situations. DOK2 a. Explain injuries when electrical contact occurs. b. Explain safety around electrical hazards. c. Explain the actions to take when an electrical shock occurs.
5. Describe general safety rules for working in a shop, laboratory, and/or industry. DOK1 a. Describe how to avoid on-site accidents. b. Explain the relationship between housekeeping and safety. c. Explain the importance of following all safety rules and company safety policies. d. Explain the importance of reporting all on-the-job injuries, accidents. and near misses. e. Explain the need for evacuation policies and the importance of following them. f. Investigate the employer's substance abuse policy and how it relates to safety. g. Demonstrate the safety procedures when working near pressurized or high temperatures.
6. Identify and apply safety around manufacturing operations. DOK1 a. Use proper safety practices when performing manufacturing operations. b. Recognize and explain personal protective equipment (PPE). c. Inspect and care for PPE.
7. Explain lifting. DOK3 a. Identify and explain the procedures for lifting heavy objects.
8. Explain the safety data sheet (SDS). DOK2 a. Explain the function of the SDS. b. Interpret the requirements of the SDS.

9. Explain fires. DOK1
    a. Explain the process by which fires start.
    b. Explain fire prevention of various flammable liquids.
    c. Explain the classes of fire and the types of extinguishers.

Note: Safety is to be taught as an ongoing part of the program. Students are required to complete a written safety test with 100% accuracy before entering the shop for lab simulations and projects. This test should be documented in each student's file.

Unit 2: Math, Measuring Tools, and Instruments

Competencies and Suggested Objectives
1. Apply the four basic math skills with whole numbers, fractions, and percentages. DOK1 a. Add, subtract, multiply, and divide whole numbers, decimals, and fractions. b. Convert whole numbers to fractions and fractions to whole numbers. c. Convert decimals to percents and percents to decimals. d. Convert fractions to decimals. e. Convert fractions to percents.
2. Perform basic mathematical calculations related to machine shop operations. DOK1 a. Convert metric measurements to English measurements. b. Solve basic angles and sides. c. Calculate the amount of material for a given project. d. Compute distances according to a drawn plan.
3. Identify and perform functions using various measuring tools and instruments (e.g., micrometer, dial indicator, height gauge, and digital caliper). DOK2 a. Read a rule to the nearest 1/32 in. b. Lay out lines with a rule. c. Describe the care and use of various rules.

Unit 3: Introduction to Blueprints and Hand and Power Tools

Competencies and Suggested Objectives
1. Read, analyze, and design a blueprint. DOK2 a. Identify terms and symbols commonly used on blueprints. b. Relate information on prints to real parts/models. c. Interpret various symbols to locate various elements. d. Interpret a plan to determine the layout. e. Explain the basic layout of a blueprint. f. Describe the information in a title block. g. Identify the lines used on blueprints.
2. Demonstrate the use and maintenance of various hand and power tools. DOK3 a. Identify and discuss the use of common hand and power tools. b. Discuss the rules of safety. c. Select and demonstrate the use of tools. d. Explain the procedures for maintenance.

Unit 4: Bench and Pedestal Grinding (Offhand Grinding)

Competencies and Suggested Objectives
1. Describe safety in operating a bench or pedestal grinder and the reasons for using offhand grinding. DOK3 a. Describe grinding safety. b. Describe the safety rules that apply to bench and pedestal grinding. c. Identify grit and abrasive properties and bonding agents. d. Define grain size, bond grade, and bond type.
2. Perform maintenance operations to a manufacturer's specifications and grinding operations to the teacher's specifications. DOK4 a. Remove and replace a grinding wheel. b. Dress a wheel flat. c. Grind a workpiece flat and parallel. d. Grind a workpiece square, to an angular surface, and to dimension.

Unit 5: Drill Press and Band Saw Theory and Operation

Competencies and Suggested Objectives
1. Identify and describe the types of drilling machines, including hand-powered and drill press, and the rules for the safe operation of each. DOK2 a. Describe the rules for the safe use of a hand-powered drill and drill press. b. Identify work-holding and setup devices in drill press operations. c. Lay out holes and drill, ream, countersink, and counterbore according to project specifications.
2. Identify and describe the safe operation of the types of power saws. DOK2 a. Identify and describe the rules for the safe use of power saws. b. Describe factors that determine saw blade selection. c. Describe factors to consider in the care and cleaning of power saws. d. Lay out and cut stock with a band saw according to specifications.

Unit 6: Lathe Theory and Operation

Competencies and Suggested Objectives
1. Identify the parts, rules, and care of the metal lathe. DOK3 a. Identify the four major parts of the lathe. b. Set up a lathe and determine the rpm and feed rate according to the manufacturer's specifications for the basic lathe operations. c. Explain the advantages and disadvantages of carbide tip cutting tools and demonstrate how to freehand grind using a high-speed steel (HSS) turning tool.
2. Perform procedures for a machining operation. DOK3 a. Identify terms and procedures for lathe operations. b. Discuss the rules of safety. c. Demonstrate centering a workpiece in a four-jaw chuck on the lathe. d. Face a part to length. e. Perform a straight turning operation. f. Perform a chamfer operation. g. Perform a center drilling operation. h. Perform a knurling operation. i. Perform a cutoff operation. j. Tap a blind hole. k. Cut external and internal threads on the lathe. l. Install a chuck on a lathe. m. Mount and align a part in a four-jaw chuck on a lathe to the instructor's specifications. n. Turn a taper with a compound rest and a taper attachment. o. Perform a boring operation. p. Perform wet and dry cuts.

Unit 7: Milling Machine Theory and Operation

Competencies and Suggested Objectives
1. Differentiate between the types of vertical milling machines. DOK2 a. Identify the different types of vertical milling machines. b. Explain the use and safety of each type of milling machine.
2. Identify the parts, cutting tools, and basic maintenance of a vertical milling machine. DOK2 a. Identify the major parts of a vertical mill. b. Identify the cutting tools used on a vertical mill. c. Clean and lubricate a vertical mill following the manufacturer's specifications. d. Determine the rpm and feed rate.
3. Perform operations on a milling machine. DOK4 a. Perform operations on a vertical milling machine. b. Perform end milling, side milling, slotting, drilling, reaming, boring, and fly cutting operations. Mount cutters and cutter holders; mount and align a swivel vise; mill a key seat, a given angle, and a straight boring operation; align the head square to the table; perform a mill operation with head tilted to 45°; and divide head operations.

Unit 8: Introduction to Lathe and Milling Skills

Competencies and Suggested Objectives
1. Lathe: Describe safety precautions, methods for measuring thread-pitch diameters, and calculation of dimensions using taper formulas with 0.010 tolerance. DOK2 a. Describe safety precautions. b. Describe methods for measuring thread-pitch diameters. c. Calculate dimensions using taper formulas. d. Turn a taper with a taper attachment and turn a taper with a compound. Perform boring, cutting external threads to relief, picking up threads, and cutting internal threads.
2. Mill: Align a vise using a dial indicator to 0.005 tolerance and mill a quarter-inch keyway to 0.005 tolerance. DOK2 a. Perform drilling, countersinking and counterboring, and aligning and starting a tap.

Unit 9: Orientation, Advanced Leadership, and Employability Skills

Competencies and Suggested Objectives
1. Describe local program and career technical center policies and procedures. DOK1 a. Describe local program and career technical center policies and procedures, including dress code, attendance, academic requirements, discipline, and transportation regulations.
2. Describe employment opportunities and responsibilities. DOK2 a. Describe employment opportunities, including potential earnings, employee benefits, job availability, place of employment, working conditions, and educational requirements. b. Describe basic employee responsibilities. c. Design a résumé and complete a job application.
3. Demonstrate the ability to follow verbal and written instructions and communicate effectively in on-the-job situations. DOK3 a. Perform projects through written instruction. b. Perform projects through oral instruction.

Unit 10: Basic Safety

Review and Reinforcement
Competencies and Suggested Objectives
1. Describe general safety rules for working in a shop, laboratory, and/or industry. DOK1 a. Describe how to avoid on-site accidents. b. Explain the relationship between housekeeping and safety. c. Explain the importance of following all safety rules and company safety policies. d. Explain the importance of reporting all on-the-job injuries, accidents, and near misses. e. Explain the need for evacuation policies and the importance of following them. f. Explain the employer's substance abuse policy and how it relates to safety. g. Demonstrate the safety procedures when working near pressurized or high temperatures.
2. Identify and apply safety around manufacturing operations. DOK1 a. Use proper safety practices when welding or working around manufacturing operations. b. Explain the term "proximity work."
3. Identify and explain the use of various barriers and confinements. DOK2 a. Explain the safety requirements for working in confined areas. b. Explain and practice lock-out/tag-out procedures. c. Explain the different barriers and barricades and how they are used. d. Recognize and explain personal protective equipment (PPE). e. Inspect and care for PPE.
4. Explain lifting. DOK2, SAF a. Identify and explain the procedures for lifting heavy objects.
5. Explain the safety data sheet (SDS). DOK1 a. Explain the function of the SDS. b. Interpret the requirements of the SDS.
6. Explain fires. DOK2, SAF a. Explain the process by which fires start. b. Explain fire prevention of various flammable liquids. c. Explain the classes of fires and the types of extinguishers.
7. Explain safety in and around electrical situations. DOK3 a. Explain injuries when electrical contact occurs. b. Explain safety around electrical hazards. c. Explain the actions to take when an electrical shock occurs.

Note: Safety is to be taught as an ongoing part of the program. Students are required to complete a written safety test with 100% accuracy before entering the shop for lab simulations and projects. This test should be documented in each student's file.

Unit 11: Advanced Lathe Operation

Competencies and Suggested Objectives
1. Describe safety precautions, methods for measuring thread-pitch diameters, and calculation of dimensions using taper formulas to 0.003 tolerance. DOK2 a. Describe methods for measuring thread-pitch diameters. b. Calculate dimensions using taper formulas.
2. Perform various operations according to specifications. DOK2 a. Perform chamfer, recessing, knurling, drilling and recessing a hole, aligning and starting a tap using a lathe center, and cutoff. b. Perform turning a taper with a taper attachment, turning a taper with a compound, boring, cutting external threads to relief, picking up threads, and cutting internal threads.

Unit 12: Advanced Milling Operation

Competencies and Suggested Objectives
1. Adjust speed and feed rates, clean and lubricate, mount arbors and adjust arbor support bushing, mount a cutter, mill a keyway, and perform selected operations. DOK2 a. Adjust machine speed and feed rates; clean and lubricate. b. Mount arbors and adjust arbor support bushing and mount a cutter according to specifications. c. Perform selected operations according to specifications.
2. Mount and remove cutters and cutter holders, align a vise using a dial indicator, and perform selected vertical milling and boring operations. DOK2 a. Mount and remove cutters and cutter holders; mount and align a vise. b. Perform selected milling and boring operations according to specifications.

Unit 13: Grinding Theory and Operation

Competencies and Suggested Objectives
1. Describe safety, magnetic chuck work, surface grinding operations, and reasons for truing and balancing a grinding wheel. DOK3 a. Describe grinding safety. b. Describe safety rules that apply to magnetic chuck work. c. Identify surface grinding operations. d. Explain reasons for truing and balancing grinding wheels.

Unit 14: Computerized Numerical Control

Competencies and Suggested Objectives
1. Describe computerized numerical control (CNC), including the codes and the input of a pre-written program. DOK2 a. Describe the operations of CNC. b. Describe codes used in a CNC machine.
2. Safely operate a CNC machine. DOK2 a. Debug the program. b. Download the program. c. Execute the program. d. Input a pre-written program into a PC. e. Print a hard copy of the program.

Student Competency Profile

Student's Name: _____

This record is intended to serve as a method of noting student achievement of the competencies in each unit. It can be duplicated for each student, and it can serve as a cumulative record of competencies achieved in the course.

In the blank before each competency, place the date on which the student mastered the competency.

Unit 1: Orientation, Leadership, and Basic Safety		
	1.	Describe local program and career technical center policies and procedures.
	2.	Describe employment opportunities and responsibilities.
	3.	Explore leadership skills and personal development opportunities provided to students by student organizations, including SkillsUSA.
	4.	Explain safety in and around electrical situations.
	5.	Describe general safety rules for working in a shop, laboratory, and/or industry.
	6.	Identify and apply safety around manufacturing operations.
	7.	Explain lifting.
	8.	Explain the safety data sheet (SDS).
	9.	Explain fires.
Unit 2: Math, Measuring Tools, and Instruments		
	1.	Apply the four basic math skills with whole numbers, fractions, and percentages.
	2.	Perform basic mathematical calculations related to machine shop operations.
	3.	Identify and perform functions using various measuring tools and instruments (e.g., micrometer, dial indicator, height gauge, and digital caliper).
Unit 3: Introduction to Blueprints and Hand and Power Tools		
	1.	Read, analyze, and design a blueprint.
	2.	Demonstrate the use and maintenance of various hand and power tools.
Unit 4: Bench and Pedestal Grinding (Offhand Grinding)		
	1.	Describe safety in operating a bench or pedestal grinder, and the reasons for using offhand grinding.
	2.	Perform maintenance operations to a manufacturer's specifications and grinding operations to the teacher's specifications.
Unit 5: Drill Press and Band Saw Theory and Operation		
	1.	Identify and describe the types of drilling machines, including hand-powered and drill press, and the rules for the safe operation of each.
	2.	Identify and describe the safe operation of the types of power saws.

Unit 6: Lathe Theory and Operation		
	1.	Identify the parts, rules, and care of the metal lathe.
	2.	Perform procedures for a machining operation.
Unit 7: Milling Machine Theory and Operation		
	1.	Differentiate between the types of vertical milling machines.
	2.	Identify the parts, cutting tools, and basic maintenance of a vertical milling machine.
	3.	Perform operations on a milling machine.
Unit 8: Introduction to Lathe and Milling Skills		
	1.	Lathe: Describe safety precautions, methods for measuring thread-pitch diameters, and calculation of dimensions using taper formulas with 0.010 tolerance.
	2.	Mill: Align a vise using a dial indicator to 0.005 tolerance and mill a quarter-inch keyway to 0.005 tolerance.
Unit 9: Orientation, Advanced Leadership, and Employability Skills		
	1.	Describe local program and career technical center policies and procedures.
	2.	Describe employment opportunities and responsibilities.
	3.	Demonstrate the ability to follow verbal and written instructions and communicate effectively in on-the-job situations.
Unit 10: Basic Safety		
	1.	Describe general safety rules for working in a shop, laboratory, and/or industry.
	2.	Identify and apply safety around manufacturing operations.
	3.	Identify and explain the use of various barriers and confinements.
	4.	Explain lifting.
	5.	Explain the safety data sheet (SDS).
	6.	Explain fires.
	7.	Explain safety in and around electrical situations.
Unit 11: Advanced Lathe Operation		
	1.	Describe safety precautions, methods for measuring thread-pitch diameters, and calculation of dimensions using taper formulas to 0.003 tolerance.
	2.	Perform various operations according to specifications.
Unit 12: Advanced Milling Operation		
	1.	Adjust speed and feed rates, clean and lubricate, mount arbors and adjust arbor support bushing, mount a cutter, mill a keyway, and perform selected operations.
	2.	Mount and remove cutters and cutter holders, align a vise using a dial indicator, and perform selected vertical milling and boring operations.
Unit 13: Grinding Theory and Operation		
	1.	Describe safety, magnetic chuck work, surface grinding operations, and reasons for truing and balancing a grinding wheel.

Unit 14: Computerized Numerical Control		
	1.	Describe computerized numerical control (CNC), including the codes and the input of a pre-written program.
	2.	Safely operate a CNC machine.

Appendix A: Industry Standards

	Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Standards															
Level 1															
L1B			X	X	X	X	X	X	X	X	X	X	X	X	X
LIL			X	X		X	X	X	X			X	X		
1VM			X	X				X	X				X		
1DP			X	X	X	X									
1SG			X	X				X	X				X	X	
1TB			X	X			X		X			X	X		
1TC			X	X			X		X			X			
1CM			X	X											X
1CT			X	X											X

National Institute for Metalworking Skills (NIMS) - NIMS Machining Level 1

L1B Benchwork

1. Given a process plan, blueprint, and access to hand tools, produce a part with two holes prepared for hand tapping, a hole prepared (reamed) for the press fit of a bushing, and a stud for one of the tapped holes. Deburr the part, hand drill and hand tap the holes, press in the bushing, and install the stud. File chamfer.

Other Evaluation Criteria

1. Free of sharp edges or burrs
2. Go/NoGo gauge for the threads
3. Length of stud within 0.03 of basic dimension and square to surface

Accuracy Level: +/- 0.015 unless otherwise specified on the blueprint

LIL Layout

1. Given a surface plate, surface gage, layout height gage, combination set, scriber, layout ink, prick punch, ball-peen hammer, process plan, and part print, lay out hole locations, radii, and surfaces matching the specifications.

Other Evaluation Criteria

1. Layout ink is applied to the surface appropriately.
2. Lines are struck once.
3. Intersections are clean and clear.
4. Punch marks are centered on intersections.

Accuracy Level: +/- 0.015 unless otherwise specified on the blueprint.

1VM Vertical Milling

1. Given raw material, print, hand, precision, and cutting tools, as well as access to an appropriate vertical milling machine and its accessories, produce a part matching the blueprint specifications using appropriate trade techniques and speeds and feeds. The part specified should require squaring up from the raw state, have at least one milled slot, require the location of at least two drilled and reamed holes within positional tolerance of 0.014 in., and have three steps controlled by tolerances of +/- 0.005 in.

Other Evaluation Criteria

1. Finishes are at least 125 Ra microinches.

2. No sharp edges

Accuracy Level: +/- 0.015 on all fractions, +/- 0.005 on all decimals unless otherwise specified on the blueprint.

Finished surfaces are to be square within 0.005 over 4 in.

Finished surfaces are to be 125 Ra microinches unless otherwise specified.

1DP Drill Press

1. Given a part print and hand, precision, and cutting tools, as well as access to a drill press and its accessories, produce a part matching the process plan and the blueprint specifications. Each hole must have at least two secondary operations. The secondary operations will consist of reaming, spot facing, countersinking, counterboring, and counterdrilling. At least one hole must be a blind hole and one a through hole. At least one hole will/may be power tapped.

Other Evaluation Criteria

1. Finishes are at least 250 Ra microinches.
2. No sharp edges
3. The mouths of all holes are lightly countersunk.

Accuracy Level: +/- 1/64 on all fractions, holes square within 0.005 per inch, drilled diameters, +0.006, -0.000

Reamed diameters are +0.001, -0.000, +/- 0.005 on all decimals unless otherwise specified on the blueprint.

1SG Surface Grinding

1. Given a block squared up on a mill, part print, hand and precision tools, and choice of a grinding wheels, as well as access to a surface grinder and its accessories, dress the wheel, produce a part matching the print specifications using appropriate trade techniques. The part specified will be in the semi-finished state having been squared up and milled. Finishing the part will require the precision finishing of the six faces of the block to tolerances common to precision grinding for squareness, size, and surface finish characteristics.

Other Evaluation Criteria

1. Finishes are at least 32 Ra microinches or better.
2. Free of sharp edges

Accuracy Level: +/- 0.001 on all decimals unless otherwise specified on the print.

Square within 0.001 over 4 in.

1TB Turning – Between Centers

1. Given raw material, process plan, part print, and hand, precision, and cutting tools, as well as access to an appropriate turning machine and its accessories, produce a part matching the process plan and the part print specifications using appropriate trade techniques and speeds and feeds. The part specified should have at least three diameters within +/- 0.002, one UNC external thread, one UNF external thread, and require part be turned end for end to complete.

Other Evaluation Criteria

1. Finishes are at least 125 Ra microinches.
2. No sharp edges

Accuracy Level: +/- 0.015 on all fractions, +/- 0.005 on all decimals unless otherwise specified on the part print

Diameters are to be coaxial within 0.002 total runout.

1TC Turning – Chucking

1. Given raw material, part print, and hand, precision, and cutting tools, as well as access to an appropriate turning machine and its accessories, produce a part matching the print specifications using appropriate trade techniques and speeds and feeds. The part specified should have at least three diameters within +/- 0.005 in., two bores within +/- 0.005 in., one UNC external thread, and require at least two chuckings or other workholding setup.

Other Evaluation Criteria

1. Finishes are at least 125 Ra microinches.
2. No sharp edges

Accuracy Level: +/- 0.015 on all fractions, +/- 0.005 on all decimals unless otherwise specified on the blueprint

Diameters are to be coaxial within 0.002 total runout.

1CM CNC Milling

1. Performance Standard: Write a program at the machine or off-line. Set up the machining operation, and perform standards given on mill operations (2.10) to develop a simple part (with linear and circular interpolations).
2. Accuracy Level: Match the requirements of the part print and 63 Ra microinch finish.

1CT CNC Turning

1. Performance Standard: Write a program at the machine or off-line. Set up the machining operation, and perform all standards given on lathe operations (2.9) to develop a simple part (with linear and circular interpolations).
2. Accuracy Level: Match the requirements of the part print.