Title 7: Education K-12

Part 62: Manufacturing, Career Pathway

Metal Fabrication

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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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Mr. Charles McClelland, Chair
Dr. O. Wayne Gann, Vice-Chair
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Ms. Rosetta Richards
Dr. Tom Burnham, State Superintendent of Education

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Finally, standards in the *Metal Fabrication Curriculum Framework and Supporting Materials* are based on the following:

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

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Applied Academic Credit Benchmarks
Mississippi Department of Education 2007 Mississippi Mathematics Framework Revised

21st Century Skills and Information and Communication Technologies Literacy Standards
In defining 21st century learning, the Partnership for 21st Century Skills has embraced five content and skill areas that represent the essential knowledge for the 21st century: global awareness; civic engagement; financial, economic, and business literacy; learning skills that encompass problem-solving, critical-thinking, and self-directional skills; and Information and Communication Technology (ICT) literacy.

National Educational Technology Standards for Students
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ACT College Readiness Standards

The College Readiness Standards are sets of statements intended to help students understand what is expected of them in preparation for the ACT. These standards are integrated into teaching and assessment strategies throughout the curriculum framework.

Preface

Secondary vocational–technical education programs in Mississippi are faced with many challenges resulting from sweeping educational reforms at the national and state levels. Schools and teachers are increasingly being held accountable for providing true 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.

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; Carl D. Perkins Vocational Education Act IV, 2007; and No Child Left Behind Act of 2001).

Metal Fabrication Executive Summary

Program Description

The Metal Fabrication pathway is designed as a secondary program for preparation to enter the field of metalworking. The Metal Fabrication program includes an introduction to the basic machining metalworking processes as well as an introduction to the basic welding profession. The purpose of the course is to prepare students to continue study in a postsecondary metals program (Welding or Machine Tool Operation) or to begin work at the entry level in a metal occupation. The machining courses in this curriculum is written to the National Institute for Metalworking Skills (NIMS) credentialing standards and the welding courses are written to the National Center for Construction Education and Research (NCCER) certification standards.

Industry Certification

The NIMS is a nationally recognized nonprofit organization that was 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 accredit training programs and facilities that meet NIMS quality requirements. The NIMS organization and standards are accredited by the American National Standards Institute (ANSI) in the metalworking field.

NIMS metalworking standards reflect expertise in areas such as stamping, press brake, roll forming, machining, tool and die making, mold making, screw machining, and machine maintenance and repair. All NIMS standards are industry written and industry validated and subjected to regular, periodic reviews under the procedures accredited and audited by ANSI.

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

NIMS credentials are used throughout the United States by industry to recruit, hire, place, and promote individual workers. NIMS may also be used to measure performance of individuals pursuing metalworking careers. Articulation may be established using the NIMS credentials for articulation among training programs.

Students who study basic machine metalworking processes may pursue, at their cost, a certification with the National Institute for Metalworking Skills, Inc. (NIMS). Students who study this curriculum may pursue certification of the NIMS Level 1 standards for machining. Attaining this certification is an option for the student; therefore, the student is responsible for the financial costs attributed with achievement of the certification.

This curriculum has also been aligned to modules in the Contren program as endorsed by the National Center for Construction Education and Research (NCCER). Students who study this curriculum using the CONTREN materials under the supervision of an instructor who has been certified by the NCCER are eligible to be tested on each module in the welding area. Students who successfully pass these tests may be certified to the NCCER by the instructor and will receive documentation from NCCER. The Manufacturing welding curriculum framework is aligned to the NCCER Core and Welding.

Articulation

This program was designed to articulate to postsecondary Automotive Machinist Tech and postsecondary Machine Tool Operations.

High School Program	Community College Program	Community College Course
Metal Fabrication	Automotive Machinist Tech	MST 1114—Power Machinery I
	Machine Tool Operations	AUV 1116—Fundamentals for Automotive Machinists

Assessment

Students will be assessed using the Metal Fabrication MS-CPAS2 test. The MS-CPAS2 blueprint can be found at http://info.rcu.msstate.edu/services/curriculum.asp. If there are questions regarding assessment of this program, please contact the Manufacturing Cluster Instructional Design Specialists at the Research and Curriculum Unit at 662.325.2510.

Student Prerequisites

In order for students to be successful in the Metal Fabrication program, the following student prerequisites are in place:

1. C or Higher in English (the previous year)
2. C or Higher in Math
3. Instructor Approval and TABE Reading Score (eighth grade or higher)
   OR
4. Instructor Approval

Proposed Applied Academic Credit

The mathematics content in the Metal Fabrication program is meaningful and useful to students who are entering the manufacturing industry. Applied mathematics content was aligned to the 2007 Mississippi Mathematics Framework Revised Academic Benchmarks. It is proposed that upon the completion of this program, students will earn 1/2 Applied Mathematics Credit that can be used for graduation requirements.

The applied academic credit has *not* been approved by the Mississippi Commission on School Accreditation or by the State Board of Education. If there are questions regarding applied academic

credit, please contact the Coordinator of Workforce Education at the Research and Curriculum Unit at 662.325.2510.

Licensure Requirements

The 976 licensure endorsement is needed to teach the Metal Fabrication program. The requirements for the 976 licensure endorsement are listed below:

1. Applicant must hold a 2-year college degree (associate's degree) or higher from an accredited institution of higher education*.
2. Applicant with an associate's degree must have at least 2 years of verifiable occupational experience in the past 10 years. Experience must be appropriate to the subject to be taught.

   Applicant with a bachelor's or higher degree must have at least 1 year of verifiable occupational experience in the past 10 years. Experience must be appropriate to the subject to be taught.
3. Applicant must enroll immediately in the Vocational Instructor Preparation (VIP) or the Redesign Education Program (REP).
4. Applicant must complete the individualized professional development plan (PDP) requirements of the VIP or REP prior to the expiration date of the 3-year vocational license.
5. Applicant must successfully complete the Certificate of Special Merit from the National Institution for Metalworking Skills (NIMS).
6. Applicant must successfully complete the Contren Instructor Certification Training Program (ICTP).
7. Applicant must successfully complete an MDE-approved computer literacy certification exam.
8. Applicant must successfully complete certification for an online learning workshop, module, or course that is approved by the MDE.
9. Applicant must successfully complete the manufacturing certification workshop, module, or course that is approved by the MDE.

Note: If the applicant meets all requirements listed above, that applicant will be issued a **976** endorsement—a 5-year license. If the applicant does not meet all requirements, the applicant will be issued a 3-year endorsement (license), and all requirements stated above must be satisfied prior to the ending date of that license.

*Exception: Teachers with a currently valid license and endorsement #359 Machine Shop or #361 Metal Trades may earn this endorsement based on that #359 or #361 endorsement even if a 2-year college degree is not earned. All other requirements for this endorsement must be satisfied.

Professional Learning

The Professional Learning itinerary for the middle school or individual pathways can be found at http://redesign.rcu.msstate.edu. If you have specific questions about the content of each training session provided, you will need to contact the Research and Curriculum Unit at 662.325.2510 and ask for the Professional Learning Specialist.

Course Outlines

This curriculum framework allows options for local school districts to meet students' needs and scheduling demands. A discussion of each option is listed in the following material.

Option 1

Upon completion of this option, the student will be trained to take the **NIMS Level 1 Certification and Contren Welding Module certification** exams. This curriculum consists of four one-credit courses, which should be completed in the following sequence:

1. Manufacturing Machining I (Course Code: 993202)
2. Manufacturing Machining II (Course Code: 993203)
3. Metal Fabrication I (Course Code: 993204)
4. Metal Fabrication II (Course Code: 993205)

Course Description: Manufacturing Machining I (Course Code: 993202) includes an introduction to the field as well as fundamentals of safety, tools, math, blueprint reading, and milling machinery. This is a one-Carnegie-unit course.

Course Description: Manufacturing Machining II (Course Code: 993203) emphasizes an overview of safety and leadership, the lathe theory, and grinding operations. This course gives student's real-world, hands-on practice in these areas. This one-Carnegie-unit course should only be taken after students successfully pass Metal Fabrication I.

Course Description: Metal Fabrication I (Course Code: 993204) includes a study of precision machining techniques. This course also reinforces safety related to the construction industry. This one-Carnegie-unit course should only be taken after students successfully pass Metal Fabrication II.

Course Description: Metal Fabrication II (Course Code: 993205) includes a study of basic oxy-fuel cutting, plasma arc cutting, gas metal arc, flux core arc, and introduction to gas tungsten arc and shielded metal arc welding. This course also reinforces safety related to the construction industry. This one-Carnegie-unit course should only be taken after students successfully pass Metal Fabrication III.

Option 1

Manufacturing Machining I (Course Code: 993202)

Unit		Title	Hours
1		Orientation, Leadership, and Basic Safety	15
2		Math, Measuring Tools, and Instruments	20
3		Introduction to Blueprints and Hand and Power Tools	25
4		Drill Press and Band Saw Theory and Operation	20
5		Milling Machine Theory and Operation	30
			110

Manufacturing Machining II (Course Code: 993203)

Unit		Title	Hours
8		Orientation, Advanced Leadership, and Employability Skills	5
9		Basic Safety (Review and Reinforcement)	5
4		Drill Press and Band Saw Theory and Operation	75
6		Lathe Theory and Operation	25
			110

Metal Fabrication I (Course Code: 993204)

Unit		Title	Hours
7		Grinding Theory and Operation	5
8		Orientation, Advanced Leadership, and Employability Skills	5
10		Advanced Lathe Operation	55
11		Advanced Milling Operation	35
12		Power Machinery – Computerized Numerical Control	10
			110

Metal Fabrication II (Course Code: 993205)

Unit		Title	Hours
7		Grinding Theory and Operation	5
8		Orientation, Advanced Leadership, and Employability Skills	5
13		Gas Welding/Cutting Processes – Basic Oxy-fuel Cutting and Plasma Arc Cutting (PAC)	15
14		Gas Welding/Cutting Processes – Shielded Metal Arc Welding (SMAW)	45
15		Gas Welding/Cutting Processes – Gas Metal Arc Welding (GMAW) and Flux Core Arc Welding (FCAW)	25
16		Gas Welding/Cutting Processes – Introduction to Gas Tungsten Arc Welding (GTAW)	15
			110

Option 2

This curriculum consists of two two-Carnegie-unit courses.

Course Description: Manufacturing Fundamentals I content 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: Metal Fabrication includes advanced precision machining techniques and an emphasis on welding processes. Welding topics include employability skills, safety, basic oxy-fuel cutting, plasma arc cutting (PAC), gas metal arc welding (GMAW), flux core arc welding (FCAW), gas tungsten arc welding (GTAW), and shielded metal arc welding (SMAW).The course should be taken after the student has successfully passed Metal Fabrication I.

- Scheduling and operating more than one course in the same classroom/laboratory with the same teacher is not allowed.
- Safety will be reinforced and tested at the beginning of each course.
- Students must complete Metal Fabrication courses with a score of 80/C or higher in class work to advance to the next level.

Option 2

Manufacturing Fundamentals (Course Code: 993200)

Unit		Title	Hours
1		Orientation, Leadership, and Basic Safety	25
2		Math, Measuring Tools, and Instruments	20
3		Introduction to Blueprints and Hand and Power Tools	25
4		Drill Press and Band Saw Theory and Operation	20
5		Milling Machine Theory and Operation	30
6		Lathe Theory and Operation	75
7		Grinding Theory and Operation	25
			220

Metal Fabrication (Course Code: 993201)

Unit		Title	Hours
8		Orientation, Advanced Leadership, and Employability Skills	10
9		Basic Safety (Review and Reinforcement)	10
10		Advanced Lathe Operation	55
11		Advanced Milling Operation	35
12		Power Machinery – Computerized Numerical Control	10
13		Gas Welding/Cutting Processes – Basic Oxy-fuel Cutting and Plasma Arc Cutting (PAC)	15
14		Gas Welding/Cutting Processes – Shielded Metal Arc Welding (SMAW)	45
15		Gas Welding/Cutting Processes – Gas Metal Arc Welding (GMAW) and Flux Core Arc Welding (FCAW)	25

16		Gas Welding/Cutting Processes – Introduction to Gas Tungsten Arc Welding (GTAW)	15
			220

Blueprint

You will find the blueprint that corresponds to this document at http://redesign.rcu.msstate.edu/curriculum/.

Research Synopsis

Resources used in the study of Manufacturing Cluster Pathways consisted of phone interviews with industry contacts as well as industry interviews conducted in person. These interviews were used to determine the immediate needs of industries across the state. The manufacturing interviews centered on production maintenance, electronic technician, tool and die maker, machinist, and welding jobs that are becoming increasingly difficult to fill. The 2004–2014 occupational employment projections and the 2006 occupational employment and wage estimates for Mississippi were used to determine where large employment needs would be in the population over a 10-year period. The research also includes curriculum information from the Mississippi Department of Education, institutions of higher learning, and community and junior colleges regarding articulation agreements and degree requirements. The pathways were affirmed through existing Mississippi curriculum blueprints and the expectations provided in the industry interviews.

Industry Job Data – Employment Projections 2004 to 2014 for Mississippi

Note: Compiled by Mississippi Department of Employment Security and Labor Market Information Department

Occupation	2004 Employment	2014 Projected Employment	Total Projected Avg. Annual Job Openings	Average Hourly	Average Annual
Industrial Machinery Mechanics	2,060	2,350	70	$20.06	$41,730
Maintenance and Repair Workers, General	13,970	16,670	540	$13.03	$27,110
Maintenance Workers, Machinery	1,410	1,610	50	$16.56	$34,440
Machinists	1,920	2,250	80	$14.66	$30,500
Millwrights	960	1,070	35	$18.03	$37,500
Welders, Cutters, Solders, and Brazers	6,940	8,150	315	$14.81	$30,800
Helpers - Installation, Maintenance, and Repair Workers	1,370	1,610	70	$10.42	$21,680

Industry Comments and Quotes

All employers indicated that if individuals came to the workplace with a general understanding of problem solving, they could train them in more specific skill areas related to their manufacturing needs. All employers express the desperate need for applicants to have work ethics. The interviewees indicated that the most difficult hurdle for them was finding applicants who displayed courtesy, integrity, self-control, a good attitude, morals, and dependability. Above all, employees must be dependable and

trustworthy and display a desire to be productive citizens. Most industries indicated they do not hire youth straight out of high school due to the maturity level of the individuals and the maturity level expected to perform the job. Almost all of the interviewees indicated that the employees should have computer skills that relate to the job and also have basic math, reading comprehension, and communication skills.

- "I need people who can read measuring devices and individuals who are computer literate. If an individual comes with basic skills, we can teach them higher order measurement that is done in our production process."
- "We need graduates who can read blueprints and who have good math and computer skills."
- "Our welders are required to take an in-house test that is not associated with any nationally recognized certifying agency such as AWS. We don't require a certification, but it would be nice."
- "We need students who have a broad knowledge base. We would prefer to start students learning trades in seventh and eighth grades, narrowing to a more specific curriculum in eleventh and twelfth grades."
- "We require that new employee welders must pass the AWS test and be certified; otherwise, they will have to take a lower paying job or face not being employed by us."
- "We need workers who are multiskilled."
- "We need employees who can problem solve. That way they can work in multiple areas if needed.

Articulation

Secondary Course	Postsecondary Course	Postsecondary Course Code
Metal Fabrication	Machine Tool Operations	MST 1114–6 - Power Machinery I (effective 2006)
Metal Fabrication	Automotive Machinist Tech	AUV 1116 - Fundamentals for Automotive Machinists
Metal Fabrication	Machine Tool Tech Industrial Maintenance Trades	MST 1114–6 - Power Machinery I (effective 2006) MST 1413 - Blueprint Reading MST 1313 - Machine Tool Mathematics IMM 1224 - Power Tool Applications

Course Content

Fundamentals of Manufacturing	Basic Manufacturing Trade Skills	Advanced Skills	Employability
• Safety o OSHA, NFPA, and ANSI regulations o Accident and injury prevention o Safety devices o Lifting procedures o Personal protective equipment • Work-related skills o Reading comprehension o Math skills o Written communication skills o Verbal communication skills o Blueprint reading o Basic hand and power tools o Terminology	• Ability to read measuring devices such as rulers, scales, micrometers, calipers, gauges, and digital and analog meters • Identify and use metal forming equipment such as lathes, drills, shears, and mills. • Identify welding devices and tools such as the types of welders and the hand tools associated with each device.	• Certification in a related field such as American Welding Society • Problem-solving skills (Very limited—Industry indicated individuals can be trained in advanced skills in the field if basic education has been provided.)	• Appearance • Teamwork and co-worker relations • Professionalism • Oral and written communication • Courtesy • Integrity • Self-control • Good attitude • Morals • Dependability • Resume, job application, and interview (ability to fill out forms properly) • Leadership, management, and teamwork • Memberships/professional organizations

Overview of Proposed Metal Fabrication Year 2 Course Content

- Employability life skills
- Shop safety
- Basic trade math
- Blueprint reading
- Hand and power tools
- Lathe operation
- Milling operation
- Grinding operation
- Shielded metal arc welding
- Gas metal welding
- Flux core arc welding
- Gas tungsten arc welding

- Plasma arc cutting
- Intro to robotic welding

Note: Most industry contacts indicated that they did not require a machine tool or welding certificate in order to attain employment with their company; however, the broad knowledge base gained by enrolling in a combined program might increase the students' chances of earning employment. Some industries indicated that they could train the individuals in more advanced skills if they came to the workplace with a broad knowledge base that industry certifications such as National Institute for Metalworking Skills (NIMS) may provide. Most industry contacts indicated that they hire experienced people and leave the weed-out process to other companies. Only two companies indicated that a 2-year welding program would be beneficial.

All contacts indicated that a certification would be advantageous for graduates when applying for employment. Most industry contacts thought that skills should begin at an earlier age provided the students know the area of concentration. They suggested beginning trade skill training in earlier grades.

Using This Document

Each secondary vocational–technical course consists of a series of instructional units that focus on a common theme. All units have been written using a common format, which includes the following components:

Unit Number and Title

Suggested Time on Task

An estimated number of clock hours of instruction that should be required to teach the competencies and objectives of the unit. A minimum of 140 hours of instruction is required for each Carnegie unit credit. The curriculum framework should account for approximately 75–80% of the time in the course.

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.

Suggested Teaching Strategies

This section of each unit indicates research-based strategies that can be used to enable students to master each competency. Emphasis has been placed on strategies that reflect active learning methodologies. Teachers should feel free to modify or enhance these suggestions based on needs of their students and resources available in order to provide optimum learning experiences for their students.

Suggested Assessment Strategies

This section indicates research-based strategies that can be used to measure student mastery. Examples of suggested strategies could include rubrics, class participation, reflection, and journaling. Again, teachers should feel free to modify or enhance these suggested assessment strategies based on local needs and resources.

Integrated Academic Topics, 21st Century Skills and Information and Communication Technology Literacy Standards, ACT College Readiness Standards, and Technology Standards for Students

This section identifies related academic topics as required in the Subject Area Testing Program (SATP) in Algebra I, Biology I, English II, and U.S. History from 1877, which are integrated into the content of the unit. Research-based teaching strategies also incorporate ACT College Readiness standards. This section also identifies the 21st Century Skills and Information and Communication Technology Literacy skills. In addition, national technology standards for students associated with the competencies and suggested objectives for the unit are also identified.

References

A list of suggested references is provided for each unit. The list includes some of the primary instructional resources that may be used to teach the competencies and suggested objectives. Again, these resources are suggested, and the list may be modified or enhanced based on needs and abilities of students and on available resources.

Unit 1: Orientation, Leadership, and Basic Safety

Competency 1: Describe local program and vocational/career technical center policies and procedures. (DOK 1) SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, MOT, MHT, MFA, MBL, MGO, MOC

Suggested Objectives

a. Describe local program and vocational/career technical center policies and procedures including dress code, attendance, academic requirements, discipline, and transportation regulations.

Suggested Teaching Strategies

- Discuss school policy and MS-CPAS2 requirements using the school handbook, and discuss the history of the occupational skill and how it relates to today's technology. R1, R2
- Have a student with higher reading ability partner with a student who has lower reading ability to read the course syllabus and career center rules. Have students discuss the ramifications of breaking rules and regulations set forth by the school, department, and/or instructor. R1, R2, R3, R4, R5, R6, W1, W2, W3, CS1, CS2, CS3, CS4, CS5, T1, T2, T3
- To determine if the students understand the school rules, use a "hook" to get the students involved in the classroom exercise. Start by giving the students scenarios that set up a rule violation, and then call on a student to discuss what may happen as a result of rule breaking. Have students act out punishment scenarios. Assign one student to be a school director or principal, and have another student act as a student offender. The student offender should give a defense of the rule violation about why he or she broke the school regulation. The mock principal should evaluate the offense using the school rules and regulations and then make a decision regarding punishment. After the role-play activity, ask students in the class to give their opinion about the seriousness of the offense and if they think the punishment given by the thespian principal is fair. Make sure to reinforce the schools rules and regulations before moving on to another topic.
- Have students relate school offenses and the punishment that is given by the administrator. They may use historical punishments they are familiar with as long as names of student offenders are not mentioned and as long as the punishment was an actual event. Try to avoid stories that may be apparently made up.
- Have the student develop a written report using illustrations from photographs or clip art about the consequences of cutting out or dropping out of school. Have students search various media sources such as the Internet for student dropout rate, employment opportunity for dropouts, crime committed by dropouts, and so forth.

Suggested Assessment Strategies

- Use the **Role-play Rubric** to evaluate student role-plays.
- Use the **Written Report Rubric** to evaluate the report.
- Have students show mastery of this competency by posting a product of choice to their Blackboard electronic portfolios.

Competency 2: Describe employment opportunities and responsibilities. (DOK 2) SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, MOT, MHT, MFA, MBL, MGO, MOC

Suggested Objectives

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.

Suggested Teaching Strategies

- Use a "hook" by getting the students to discuss what their expectations are from their high school degrees and how they plan to use their high school diplomas. Ask the students if they plan to attend a community or senior college after graduating high school. Let the students interact with one another and discuss what they want to do with their skills. Discuss how the skills learned in your classroom relate to postsecondary courses available in higher education. R1, R2, W1, CS1, CS2, CS3, CS4, CS5, T1, T2, T3
- Give a brief history of the county/city school district, when the career technical center was built, and why it was built. Tell the students whom the vocational complex is intended to serve (industry needs). R1, R2, R3, W1
- Have students research area job opportunities that are available within the local industry relating to manufacturing. Allow students to use any media available to them so that they are focused on job availability by using the most desirable method to them. R1, R2, R3, R4, R5, R6, W1, CS2, T1, T2, T3, T4, T5, T6
- Use an industry guest speaker or take the class on a field trip (if possible) to impart job opportunities within the community, state, national, and global market. Have the guest speaker or field trip tour guide discuss specifically what is expected by employers and customers of employers. R1, W1, CS1, CS2, CS3, CS4, CS5
- Have a former student come in and discuss the benefits of completing the manufacturing course. Have a former student talk to the class about how the course helped him or her in his or her life. R1, W1, CS1, CS2, CS3, CS4, CS5

Suggested Assessment Strategies

- Have students reiterate the issues mentioned by the industry speakers. Have the students write a short essay and/or perform a visual poster presentation on the comments made by industry speakers. Students should be given the freedom to create a document or poster by using their interpretation of what the speaker said.
- After initially discussing what each student plans to do after graduation, have students perform Internet research on community colleges that offer manufacturing degrees and certificates. The manufacturing areas may include architectural drafting design, electronic and electrical technology, machine tool technology, welding technology, and any other metal trade or industrial type of course. Have students relate how the high school manufacturing course relates to postsecondary courses that are available to them at their nearest local community college or university. Overall, encourage the students to pursue manufacturing careers, and guide them in programs that are offered after high school graduation.
- Have students research and verbally report on job opportunities found in a newspaper, journal, or other publications and media sources. Have students tape the article to a piece of paper and then write several points the article mentions. Students could submit the article

for a daily grade.

- Have students show mastery of this competency by posting a product of choice to their Blackboard electronic portfolios.

Competency 3: Explore leadership skills and personal development opportunities provided for students by student organizations to include SkillsUSA. (DOK 2) SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, MOT, MHT, MFA, MBL, MGO, MOC

Suggested Objectives

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.

Suggested Teaching Strategies

- Use PowerPoint demonstrations and information retrieved from the SkillsUSA Web site, and/or show videos on past state level or national level SkillsUSA competitions. The national SkillsUSA Web site is http://www.skillsusa.org/, and the Mississippi SkillsUSA Web site is http://www.mde.k12.ms.us/vocational/SkillsUSA/. If your school has historical video with past students attending the state competition, you may show that to the students to try and peak their interest in SkillsUSA. Ask students to elaborate on how they value leadership, what makes a good leader, and why they think they would be good leaders. Ask about the accomplishments of the students in other areas such as athletics, academics, and so forth. R1, R2, CS1, CS2, CS3, CS5, T1, T2
- Discuss the advantages of joining SkillsUSA, and elaborate on how the students should value what SkillsUSA means to students, schools, and industry. After explaining what SkillsUSA encompasses, ask the students how membership in SkillsUSA would personally benefit them. R1, R2, R3, W1, W2, CS1, CS2, CS3, CS5, T1, T2, T3
- Use interclass student competition. Have one class compete against other classes. For example, have the morning class compete against the afternoon class. Assign team tasks to groups within the classroom so that students have the opportunity to grow their leadership abilities. Develop cleanup crews that are responsible for areas of the classroom/shop areas. Award points per team per nine weeks to encourage team competition among project groups. Use team-building concepts to create student cooperation and teamwork. CS1, CS2, CS3, CS4, CS5
- Have students research the history of areas of Manufacturing (i.e., lathes, milling, grinding, and welding) using the Internet for class presentations. Students should include the history of blacksmithing and progress to current metal trade processes. R1, R2, R3, R4, R5, R6, W1, W2, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6

Suggested Assessment Strategies

- Have students write a short essay (1/2-page minimum) about how SkillsUSA is an important organization and how it can benefit the manufacturing trade program by preparing leadership in the world of work. The essay should include how the organization incorporates leadership skills (soft skills) with tangible career skills taught in the manufacturing program.

Use the **Written Report Rubric** to evaluate student writings.

- As the semester progresses, assign projects to individuals or to teams, and have them compete for first, second, and third place just as SkillsUSA individuals and teams compete. Evaluate each team using an average grade point and the SkillsUSA competition rubrics. Each grade is used for a percentage of the individual's grade assessment.
- Use peer-to-peer evaluation using a task checklist by performing an assignment and then evaluating each other.
- Have students create posters depicting the history of an assigned metal trade area. The poster should show how technology has changed the metal trade profession in the last century. For example, one reason that may have contributed to the sinking of the Titanic was the brittleness of the ship's hull caused by the frigid water in the icy Atlantic Ocean. A good reference for this information is found at the following Web site: http://www.metallurgy.nist.gov/webpages/TFoecke/titanic/Titanic.pdf. Make sure the students explain when this information was confirmed and how metallurgy changed to compensate for water temperature affecting the hull of seagoing ships. Use the **Poster Rubric** to evaluate student work.

Competency 4: Describe general safety rules for working in a shop/lab and industry. (DOK 1) SAF, HTO, PTO, MBR, COM, MHT, MFA, MBL, MOC

Suggested Objectives

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 and accidents.
e. Explain the need for evacuation policies and the importance of following them.
f. Investigate employer's substances abuse policy and how it relates to safety.
g. Demonstrate the safety procedures when working near pressurized or high temperature.

Suggested Teaching Strategies

- Use PowerPoint presentations from the Contren Learning Series (NCCER). This should prepare the students for school shop safety and NCCER examinations. R1, R2
- Show safety videos such as the Farm Bureau Safety Video. The following Web site has good safety points: http://www.woodzone.com/articles/shop_safety.htm. R1, R2
- Have industry representatives visit to discuss and/or demonstrate safe practices that relate to their industry. If possible, the industry representative should provide actual company costs that relate to job injuries over the past 5 years. The representative should also elaborate on what happens when the employee is injured such as lost production, increase in insurance costs, profit loss, employee overtime salary loss, employee pain and suffering, and so forth. R1, W1, CS1, CS2, CS3, CS4, CS5
- Discuss the school shop/lab safety rules that pertain to the school premises, and explain that the student must pass the class safety test with 100% competency in order to work in the school shop/lab. Instruct the students that they will not be allowed to work in the shop area unless they learn the school and shop safety rules and regulations. R1, R2

Suggested Assessment Strategies

- After administering a Contren Learning Series (NCCER) safety test that students must pass

with 100% mastery, have the students go to the shop area and demonstrate how to safely operate a hand tool such as a hacksaw. Be very critical of the students to make sure that they follow safe practices. Use the **Shop Safety Checklist** to help determine if the students fully understand shop procedures and safety.

- Have students do a simulated OSHA inspection to locate mock (teacher-made) safety violations. Place air hoses across walkways to create trip hazards, pressurize a leaky air hose, open breaker panel doors to expose breakers, lay out an extension cord that has frayed wiring, block fire extinguishers so that it is difficult to access them in the event of fire, block emergency exits with trash bins to inhibit escape, and so forth. Have students walk around the shop and locate safety violations, document the violation, and propose a remedy for the safety issue.
- Have students perform an Internet search about how much injuries cost employers for assigned injuries such as severed finger, lacerations, blunt force, vision loss, and hearing loss. Students should make a list (or print out) of the costs for workplace injuries in the metal trade industry. A good reference for this type of data is OSHA, a division of the U.S. Department of Labor: http://www.osha.gov/oshstats/work.html.
- Have students develop safety posters that illustrate safety rules that were discussed in class. Use the **Poster Rubric** to evaluate student work.

Competency 5: Identify and apply safety around Manufacturing operations. (DOK 1) SAF, HTO, PTO, MBR, COM, MHT, MFA, MBL, MOC

Suggested Objectives

a. Use proper safety practices when performing Manufacturing operations.
b. Recognize and explain personal protective equipment.
c. Inspect and care for personal protective equipment.

Suggested Teaching Strategies

- Explain the proper safety precautions in and around the Manufacturing equipment and shop area. R1, R2
- Demonstrate the proper safety precautions when using Manufacturing equipment in the classroom or shop/lab. CS1, CS2, CS3, CS4, CS5, T1, T2, T4, T6
- Lay out all the personal protective equipment on a shop table, and illustrate proper use of each device. Have students create a graphical dictionary using a digital camera and a word processing program to illustrate each device. Have students key in the definitions of each device and the importance of its use. CS1, CS2, CS3, CS4, CS5, T1, T2, T4, T6
- Lay out broken personal protective equipment on a shop table, and discuss what is wrong with the broken items. CS1, CS2, CS3, CS4, CS5, T1, T2, T4, T6
- Discuss how to inspect and care for personal protective equipment. R1, R2, CS1, CS2, CS3, CS4, CS5, T1, T2, T4, T6

Suggested Assessment Strategies

- Lay out the shop personal protective equipment, and have students identify functioning and non-functioning personal protective equipment.
- Give students a shop test to identify safety equipment by laying out good and defective equipment mixed so that students must select the proper tool.
- Give students a particular hand tool, and have them explain how each piece of safety

equipment is used in the shop.
- Perform a mock project, and have the students perform a mock operation using instructor-selected tools.
- Have the students identify the proper safety equipment that is associated with specific equipment located in the shop.

Competency 6: Explain lifting. (DOK 3) SAF, MBR, COM, MHT, MOC

Suggested Objectives

a. Identify and explain the procedures for lifting heavy objects.

Suggested Teaching Strategies

- Explain proper lifting procedures, and explain the importance of safety when lifting tall or long workpieces. R1, R2, R3, W1, W2
- Demonstrate the proper lifting procedures used in class, and explain the benefits of team lifting and when to use. CS1, CS2, CS3, CS4, CS5, T1, T2, T4, T6
- Have an industry representative or a health-care professional discuss back-related injuries. R1, W1, CS1, CS2, CS3, CS4, CS5

Suggested Assessment Strategies

- Have the students demonstrate how to lift a box by using the proper lifting procedure that was illustrated by the instructor. Then have two students demonstrate how to lift a long or tall workpiece using the lifting procedure that was illustrated by the instructor. Have students work together to develop a lifting poster that can be displayed throughout the shop and classroom.
- Have students research jobs that require heavy lifting, and discuss results with the class by describing how back injuries occur and how their injuries affect related costs.

Competency 7: Explain the material safety data sheet (MSDS). (DOK 2) SAF, HTO, PTO, MBR, COM, MHT, MFA, MBL, MOC

Suggested Objectives

a. Explain the function of the MSDS.
b. Interpret the requirements of the MSDS.

Suggested Teaching Strategies

- Explain what MSDS sheets are and how they are used in the workplace. R1, R2, R3, W1, CS1
- Illustrate how industry requires everything that is used on the jobsite to have an MSDS. CS1, CS2, T1, T2, T4, T6
- Discuss the national poison hotline. R1, R2, R3
- Have students use the shop chemicals and then locate and identify the proper MSDS information located in the shop. R1, R2, R3, CS1

Suggested Assessment Strategies

- Have students acquire an MSDS sheet used in the home.
- Have students explain verbally or in writing the emergency procedures as described on the MSDS of a specific product. Have students use Inspiration to document the emergency

procedures.

- Have students properly interpret a mock MSDS chemical sheet. The **MSDS Sheet** at the end of this unit is an example of an MSDS sheet for welding anti-splatter paste. The students should be able to locate emergency contact phone numbers, the chemical name, properties, flash point, reactivity, and other important information.
- Have students explain emergency procedures in the event of a chemical spill. For example, locate the emergency exits, telephone numbers, eye wash and showers, spill kits, and emergency evacuation routes.

Competency 8: Explain fires. (DOK 1) SAF, HTO, MBR, COM, MOT, MOC, MPT

Suggested Objectives

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.

Suggested Teaching Strategies

- Explain the fire triangle—fuel, oxygen, and heat—and then explain what flash point is for various shop materials. R1, R2, CS1.
- Explain and discuss the various types of fires with students such as wood, grease, electrical, and metal fires. Then explain the classes of fire extinguishers and with what types of fire to use them. R1, R2, R3
- Demonstrate the proper use of a fire extinguisher. The following is a video clip that illustrates how a fire extinguisher works and how to use it to put out fires: http://videos.howstuffworks.com/howstuffworks/34-how-a-fire-extinguisher-works-video.htm. R1, CS1, CS2, T1, T2
- Discuss with students how to prevent a fire in the Manufacturing shop area. Explain that cardboard, paper, oily rags, and so forth should be cleared from the work area before machining or welding takes place. The best way to put out a fire is to prevent it in the first place. Discuss how linseed oil and other lubricants can ignite through chemical reaction if oily rags are piled on top of each other and allowed to create excessive heat as they decompose. Elaborate on shop fire safety by explaining how metal trash cans, not plastic, should always be used in a Manufacturing shop due to fire hazard and prevention. Have students look around the shop for potential fire hazards, and have them debate about what is a legitimate concern regarding fire prevention practices. R1, R2, R3, W1, W2, W3, CS1, CS2, T1, T2

Suggested Assessment Strategies

- Have students discuss the classes of material flash point, fire extinguishers, and the proper use of fire extinguishers. Have students search the Internet to find the flash point of common refuse such as cardboard and then find the typical flame temperature of an oxy-fuel torch. They should find that the temperature of the torch flame is much greater than the flash point of cardboard. They should deduce that using a cutting torch around paper products, oils, and other flammable items is extremely unsafe. Have students summarize their findings in a blog. Use the **Blog Rubric** to evaluate student work.
- Have students locate possible fire hazards within the shop area, and have students locate shop fire extinguishers, hoses, and emergency exits. Give the students copies of your shop blueprint, and have them draw symbols on the print depicting where the fire suppression

equipment is located. You may have to hand sketch a blueprint to give them, or you may have them draw their own blueprint of the building layout.

- Have students check the fire extinguishers in the shop or career technical building for current inspection validation. If there is a fire extinguisher available that is used or damaged, place it in a wall hanger and let the students inspect it. This will give them an example of a fire extinguisher that is not valid and needs maintenance or replacement.

Competency 9: Explain safety in and around Manufacturing and electrical situations. (DOK 2) SAF, HTO PTO, MBR, COM, MOT, MHT, MFA, MBL, MGO, MOC, MIM, MFS, MIB, MST, MPT, MRG, MAM, MPT

Suggested Objectives

a. Explain injuries when electrical contact occurs.
b. Explain safety around Manufacturing and electrical hazards.
c. Explain action to take when an electrical shock occurs.

Suggested Teaching Strategies

- Discuss how electrical burns occur to workers in the Manufacturing area, especially when working with equipment that has frayed wiring or is not properly grounded. R1, R2, CS1
- Show students the locations of shop safety disconnect switches, and simultaneously explain lock-out/tag-out procedures. PowerPoint slide shows and videos that aid in training lock-out/tag-out are available on the Internet, such as the following: http://www.phpl.uark.edu/ehs/slideshows/LockOutTagout/LOCK%20OUT%20-%20TAG%20OUT.ppt. R1, CS1, CS2, T1, T2, T4
- Explain safety features that shop equipment may have in the electrical circuit. Discuss overloading electrical circuits by excessively long extension cords, ganged cords, and improper size conductor within the electrical cord. Also discuss AFCI and GFCI circuit interrupters. R1, R2, CS1, T1, T2, T3, T4, T5, T6

Suggested Assessment Strategies

- Have students perform lock-out/tag-out on a machine located in the shop area.
- Have students identify electrical hazards in the shop. Have them search for broken pipes, exposed wiring, frayed cords, broken light bulbs, and so forth.
- Have students use the Internet to research how to perform lock-out/tag-out procedures, and have students demonstrate how to apply lock-out/tag-out on a piece of equipment located in the shop area. While students are searching on the Internet, have them look up vendors that sell lock-out/tag-out devices and have them price items that are commonly used such as a padlock, hasp, laminated tag, electrical plug, and manual valve locking devices.

Standards

21st Century Skills Standards

CS1 Flexibility and Adaptability
CS2 Initiative and Self-direction
CS3 Social and Cross-cultural Skills
CS4 Productivity and Accountability
CS5 Leadership and Responsibility

ACT College Readiness Standards

R1 Main Ideas and Author's Approach
R2 Supporting Details
R3 Sequential, Comparative, and Cause–Effect Relationships
R5 Meaning of Words
R6 Generalizations and Conclusions
W1 Expressing Judgments
W2 Focusing on the Topic
W3 Developing a Position

National Industry Standards

SAF - Basic Safety
MAT - Introduction to Construction Math
HTO - Introduction to Hand Tools
PTO - Introduction to Power Tools
BLU - Introduction to Blueprints
MBR - Basic Rigging
COM - Basic Communication Skills
EMP - Basic Employability Skills
MOT - Orientation to the Trade
MHT - Millwright Hand Tools
MFA - Fasteners and Anchors
MBL - Basic Layout
MGO - Gaskets and O-rings
MOC - Oxy-fuel Cutting
MIM - Intermediate Trade Math
MFS - Field Sketching
MIB - Intermediate Blueprint Reading
MST - Specialty Tools
M MRG - Rigging
MAM - Advanced Trade Math
MPT - Precision Measuring Tools

National Educational Technology Standards

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T5 Digital Citizenship
T6 Technology Operations and Concepts

Suggested References

Textbooks

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Jeffus, L. (1999). *Welding principles and applications.* Albany, NY: Delmar.

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Associated Web Sites

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Massachusetts Institute of Technology. (n.d.). Introductory MIT courses. In *MIT open courseware*. Retrieved December 7, 2007, from http://ocw.mit.edu/OcwWeb/hs/intro-courses/introcourses/index.htm

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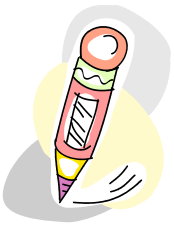
Walter, R. A. (Ed.). (n.d.). *Journal of Industrial Teacher Education*. Retrieved December 7, 2007, from http://scholar.lib.vt.edu/ejournals/JITE/

For additional references, activities, and Web resources, please refer to the Manufacturing Technology B.R.I.D.G.E. Web site: http://www.rcu.blackboard.com (available only to registered users).

Suggested Rubrics and Checklists

Written Report Rubric



NAME: DATE: PERIOD:

	Exemplary 4 Points	Accomplished 3 Points	Developing 2 Points	Beginning 1 Point	Score
Content	Clear thesis and focus that remain apparent	Thesis and focus that remain apparent	Addresses subject matter with minimal support	Does not focus on topic	
Grammar	Correct and effective use of grammar and mechanics	Occasional errors in use of grammar and mechanics	Problems in use of grammar and mechanics	Repeated errors in use of grammar and mechanics	
Organization	Ideas flow smoothly and logically with clarity and coherence.	Logical order and appropriate sequencing of ideas with adequate transition	Some evidence of an organizational plan or strategy	Lacks organization	
				Total	

Comments:

Poster Rubric

NAME: DATE: PERIOD:

	Exemplary 4 Points	Accomplished 3 Points	Developing 2 Points	Beginning 1 Point	Score
Required Content	The poster includes all required content elements as well as additional information.	All required content elements are included on the poster.	All but one of the required content elements are included on the poster.	Several required content elements are missing.	
Labels	All items of importance on the poster are clearly labeled with labels that are easy to read.	Almost all items of importance on the poster are clearly labeled with labels that are easy to read.	Many items of importance on the poster are clearly labeled with labels that are easy to read.	Labels are too small to read, or no important items are labeled.	
Attractiveness	The poster is exceptionally attractive in terms of design, layout, and neatness.	The poster is attractive in terms of design, layout, and neatness.	The poster is acceptably attractive though it may be a bit messy.	The poster is distractingly messy or very poorly designed.	
Grammar	There are no grammatical or mechanical mistakes on the poster.	There are one to two grammatical or mechanical mistakes on the poster.	There are three to four grammatical or mechanical mistakes on the poster.	There are more than four grammatical or mechanical mistakes on the poster.	
				Total	

Comments:

Guest Speaker Evaluation Form

Student's Name: _____

Guest Speaker's Name: _____

Date: _____

1. Please evaluate the following statements with a checkmark in the appropriate space:

Key: SA – Strongly Agree, A – Agree, N – Neutral, D – Disagree, SD – Strongly Disagree

	SA	A	N	D	SD
The presentation stimulated my interest.	( )	( )	( )	( )	( )
The content was clearly presented.	( )	( )	( )	( )	( )
The content was challenging.	( )	( )	( )	( )	( )
Handouts and materials were helpful.	( )	( )	( )	( )	( )

2. Please rate the guest speaker:

____ Extraordinary ____Excellent ____ Good ____ Fair ____Poor

Additional Comments:

3. What was your favorite element of the presentation?

4. What career or lifestyle knowledge did you take from the presentation?

5. What was your least favorite part of the presentation?

6. How would you improve or change it?

7. What do you still need or want to know?

Shop Safety Checklist

Student's Name:_____ Date:_____

_____ 1. Safety glasses

_____ 2 Gloves (if applicable)

_____ 3. Proper footwear

_____ 4. Respirators (if applicable)

_____ 5. Hard hats/helmets (if applicable)

_____ 6. Hearing protection

_____ 7. Proper shirt (buttoned, long sleeves if applicable)

_____ 8. Proper pant (without cuffs, especially when welding). Pant length should extend to the instep of the boot or shoe.

_____ 9. Footwear (absolutely no open-toed shoes). High-top leather boots should be worn.

_____ 10. Clear or shaded face shield (if applicable)

_____ 11. Respects work proximity of others

_____ 12. Considers others' safety while they are in his or her work area

_____ 13. Forethought—collects the required tools prior to starting the task

_____ 14. Cleans up spills immediately

_____ 15. Keeps walkways and work area free of trip hazards

_____ 16. Stores oily rags in a covered metal container (if applicable)

_____ 17. Periodically removes excess cutting oils and filings from shop machinery (if applicable)

_____ 18. Keeps all tools in their places and tags tools that need to be repaired or discarded

_____ 19. Uses proper lifting technique

_____ 20. Cleans work area after completion of tasks

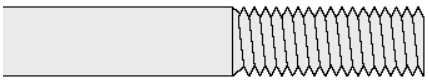
Competency 1: Apply the four basic math skills with whole numbers, fractions, and percents. (DOK 1)
MAT, HTO, PTO, BLU, COM, EMP, MHT, MFA, MBL, MGO, MIM, MFS, MIB, MST, MRG, MPT, WSS, WOC, BMP, WQT, SWS, SES, SBF, GWB, JFA, WSY, RWD, PAC, GFM, GFP, TFM, TPW, PTM, CPM, L1B, LIL, 1VM, 1DP, 1SG, 1TB, 1TC, 1CM, 1CT, 2TB, 2TC, 2PL, 2FA, 2CG, 2CM, 2CT, PRA1, SGM1, TTA1

Suggested Objectives

a. Add, subtract, multiply, and divide whole numbers, decimals, and fractions.
b. Convert whole numbers to fractions, and convert fractions to whole numbers.
c. Convert decimals to percents and percents to decimals.
d. Convert fractions to decimals.
e. Convert fractions to percents.

Suggested Teaching Strategies

- Give a sample math test to assess student abilities. Once the test is graded, evaluate the level of knowledge. Pair the students so that a student with weak math skills works with a student that has greater math skills.[R1, W1, M1]
- Have students solve word problems related to Manufacturing. For example, a piece of round stock is used to make a steel bushing. The inside diameter is 7/32 in. The outside radius is 1/2 in. Using these measurements, what is the bushing wall thickness?[R1, W1, M1]
- Have students solve word problems related to Manufacturing such as the following, Katie needs to find various lengths of square stock: 1/2 + 17/4, 5/4 + 23/8, 5/2 + 31/16. Convert the sums to mixed numbers so that she will know where to find them on her tape measure.[R1, W1, M1]
- Create a "hook" by getting the students involved in a real machine shop project. Explain the use of math within the shop. For example, calculate rpm or feed rate. Have students work through the rpm and feed rate to create a 1/2 - 13-in. threaded bolt using the shop lathe. Once the students have calculated the required measurements, go to the shop equipment and set the machine to lathe a bolt. Step the students through setting up the lathe and how to lathe threads. Finally, actually cut the treads in a piece of round stock using the students' calculated rpm and feed rate. After cutting the thread, give the students a 1/2 - 13-in. nut, and let them see if the correct thread was made using their figures. Under close supervision and coaching, the students should calculate the accurate rpm and feed rate, making this project an instructional success.[R1, W1, M1]



- Demonstrate how to convert calculated fractions to use on a tape measure. Give the students several pieces of precut straight metal bars. Have students give the measurement in 1/4-, 1/32-, and 1/64-in. measurements for the same piece of material. The students should learn the relationship between incremental measurements.[R1, W1, M1, M7]
- Grab the students' attention by demonstrating how to convert fractions to decimals and percents. Cut a round piece (disc) from plate steel. Then cut the circular piece into pie-shaped pieces. If possible, cut the disc into 32 equal pieces. Give each student a piece of metal until

the pieces are gone. Then start collecting pieces of metal one at a time. Illustrate how eight 1/32 pieces (8/32 = 0.250 or 25% of the circle) of the pie equals 1/4 of the total circle. Elaborate by collecting more pieces (16/32 = 0.500 or 50% of the circle). Allow the students to practice using the circle while calculating fractions and decimals. You may make other shapes such as squares and linear bars by doing the same exercise. You may also relate the 100ths, halves, quarters, tenths, and twentieths into dollar values.[R1, W1, M1, M7]

Suggested Assessment Strategies

- Students should explain the increments of the tape measure by measuring something in the room that is common to all students. For example, give the students a standard household tape measure, and have them measure a door height. If the standard interior main door is 80 in. tall, that could be illustrated as being 6 ft 6 in., 2,560 1/32nd of an inch, and 5,120 1/64ths of an inch. Also, percentage can be illustrated such as one half (50%) of the door's height is 1,280 1/32nd of an inch. Explain that all measures can be represented in many incremental measures.
- Students should calculate metal trade formulas using shop math. For example, rpm = (CS*4)/Diameter. Bring a piece of 4-in. round stock into the classroom, and have students calculate the finishing rpm of cutting the workpiece to 3.500 in., 2.000 in., and 1.000 in.
- Use a tap and drill chart to convert decimals to fractions and vice versa. Have students convert fractional drill sizes to decimal equivalents and vice versa. Have students then relate the drill size to various fractions' representations. For example, a 3/8-in. drill bit will drill a hole that is 12/32nds of an inch, 24/64ths of an inch, or 0.375 thousandths of an inch. This can be replicated throughout the drill size selection. Once they have a grasp on drill diameter, have the students calculate the radius for the same drill sizes. A 3/8ths drill size has a radius of 6/32nds of an inch, which is also 3/16ths of an inch. Many combinations can be used by simply changing drill sizes to bigger or smaller diameters.

Competency 2: Perform basic mathematical calculations related to machine shop operations. (DOK 1)
MAT, BLU, MFA, MBL, MGO, MOC, MIM, MIB, MST, MAM, MPT, L1B, LIL, 1VM, 1DP, 1SG, 1TB, 1TC, 1CM, 1CT, 2TB, 2TC, 2PL, 2FA, 2CG, 2CM, 2CT, GEO1, PRA3, PRA4, SGM4, TTA2, TTA3

Suggested Objectives

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.

Suggested Teaching Strategies

- Discuss the metric system and its relevance to the global manufacturing market.[R1, W1, M1, M7]
- Lay out English and metric wrenches on a table for show and tell, and let the students see how the wrenches differ. Most students may see little difference in the wrenches until they are allowed to use them on a bolt head. Drill holes in a board, and screw standard SAE and metric hex head bolts in the holes. Let the students use the wrenches to turn the bolt heads. Allow the students to associate the proper wrench with the proper bolt size.[R1, W1, M1, M7, T1, T2]
- Have students do a simple layout project on paper, poster board, or sheet metal using a machinist protractor to find angles given by the instructor. Have students cut out simple objects. Start with a 4-in. square, a 2-in. square, and a 1-in. square. Then progress to more difficult shapes such as circles, arcs, and triangles. Measure the objects, and give the students

feedback regarding the quality of the cuts, shape dimension, and cutting safety.[M1, M7, T1, T2]

- Have students create a material list from a given blueprint to calculate the minimum amount of material needed to complete a project.[R1, R2, R3, W1, W2, W4, W5, M1]
- Demonstrate how to solve for missing dimensions on a blueprint. Create a simple blueprint with four dimensions. Provide the students with three of the dimensions, and require them to solve for the missing data.[R1, R2, R3, W1, W2, W4, W5, M1, M7]

Suggested Assessment Strategies

- Give a written assessment on lecture material regarding global markets that use the metric system and how the metric system is used in the United States.
- Label 20 bolts screwed into a board with whole numbers. Allow the students to choose the properly sized wrench to adjust the bolt head. The students should be allowed to make their own tool selections. Assess a grade by how many wrenches of the correct size they used.
- Have students cut the proper angles used in the layout project. Give students a piece of poster board, and assign angled cuts that should be made. Using measurement tools, have students lay out the angles and mark prior to making the cuts. The Pythagorean theorem is a great way to teach angles and cuts. Pythagorean theorem measures may be as follows: A^2 x $B^2 = C^2$, or a 3-in. (opposite side), 4-in. (adjacent), and 5-in. (hypotenuse) right triangle will result in a 30°, 60°, and 90° angle at the three points of the triangle. 6, 8, and 10 are also easy numbers to use with the Pythagorean theorem.
- Inspect the final project to determine if the students correctly calculated the material list needed to properly complete a project.
- Have students solve for missing dimensions on a given blueprint.

Competency 3: Identify and perform functions using various measuring tools and instruments (micrometers, dial indicators, height gauge, and digital caliper). (DOK 2) [MAT, HTO, BLU, COM, MHT, MIM, MIB, MST, MPT, L1B, LIL, 1VM, 1DP, 1SG, 1TB, 1TC, 1CM, 1CT, 2TB, 2TC, 2PL, 2FA, 2CG, 2CM, 2CT, PRA4]

Suggested Objectives

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.

Suggested Teaching Strategies

- Demonstrate how to read a rule to the nearest 1/32 in. Demonstrate using an ordinary metal tape so the students who own a measuring tape can practice at home. Have students measure something commonly found in the classroom such as a dry erase marker. The measurement should be made on an item that is less than an inch in diameter or in length. Once students grasp measuring items less than 1 in., you may gradually increase the lengths so the students will have to include inch measures.[R1, W1, M1, M7]
- Demonstrate how to use micrometers by measuring bar stock within the shop. Give students a piece of 1/2-in. round stock, and let them measure the diameter. Ask them if the stock was actually 0.500 or if it was larger or smaller than the stipulated stock size. The same may be done for square stock.[R1, W1, W2, M1, M2, M3, CS1, CS2, CS4, T1, T2]
- Demonstrate how a dial indicator works while using a lathe. Set up an off-centered piece of round stock in a lathe. Then set up the dial indicator. As the piece is hand rotated, allow the students to watch the dial indicator needle. Then have students debate among themselves

how to remedy the out-of-center workpiece.[R1, R2, M1, M7, CS1, T1, T2]

- Demonstrate how to use a height gauge using a surface plate. Use a combination square to show how the height gauge relates to height measurement. Let the students measure the height of a quarter dollar and then the height of a nickel. Have students compare the size differences between the two coins.[R1, R2, M1, M7, CS1, T1, T2]
- Demonstrate how to use a dial caliper using various finished parts. Explain how the quality of the finished part is determined by using measurement devices such as dial calipers.[R1, R2, M1, M7, CS1, T1, T2]
- Use a straight rule to draw lines on paper, poster board, or sheet metal for layout. Give the students a shape to draw that includes dimensions. Have students lay out the part on paper first before progressing to sheet metal or sheet steel.[R1, W1, M1]
- Lecture on the proper cleaning and storage of scales, rules, and shop measurement devices.[R1, R2]

Suggested Assessment Strategies

- Have students measure lengths of the project assigned by the instructor to determine the length of material to the nearest 1/32 in.
- Have students measure a finished machine project with a micrometer. A shoulder bolt, hardened flat steel, or tooling punch are good items to use in measurement projects.
- Have the students demonstrate how to properly clean measurement equipment and store the tool.

Standards

21st Century Skills Standards

CS1 Flexibility and Adaptability
CS2 Initiative and Self-direction
CS3 Social and Cross-cultural Skills
CS4 Productivity and Accountability
CS5 Leadership and Responsibility

Mississippi Academic Standards

SGM1 Apply concepts of rational numbers, and perform basic operations emphasizing the concepts of ratio, proportion, and percent with and without the use of calculators.
SGM4 Apply appropriate techniques, tools, and formulas to determine measurements with a focus on real-world problems. Recognize that formulas in mathematics are generalized statements about rules, equations, principles, or other logical mathematical relationships.
PRA1 Apply concepts and perform basic operations using real numbers in real-world contexts.
PRA3 Identify and apply geometric principles to polygons, angles, and two- and three-dimensional figures.
PRA4 Understand measurable attributes of objects, and apply various formulas in problem-solving situations.
TTA1 Understand relationships between numbers and their properties, and perform operations fluently.
TTA2 Understand, represent, and analyze patterns, relations, and functions.
TTA3 Understand geometric principles of polygons, angles, and figures.
GEO1 Compute and determine the reasonableness of a result in mathematical and real-world situations with and without technology.

ACT College Readiness Standards

E1 Topic Development in Terms of Purpose and Focus
E2 Organization, Unity, and Coherence
E3 Word Choice in Terms of Style, Tone, Clarity, and Economy
E4 Sentence Structure and Formation
E5 Conventions of Usage
E6 Conventions of Punctuation
M1 Basic Operations and Applications
M2 Probability, Statistics, and Data Analysis
M3 Numbers: Concepts and Properties
M7 Measurement
R1 Main Ideas and Author's Approach
R2 Supporting Details
R3 Sequential, Comparative, and Cause–Effect Relationships
W1 Expressing Judgments
W2 Focusing on the Topic
W3 Developing a Position

W4 Organizing Ideas
W5 Using Language

National Industry Standards

MAT - Introduction to Construction Math
HTO - Introduction to Hand Tools
PTO - Introduction to Power Tools
BLU - Introduction to Blueprints
COM - Basic Communication Skills
EMP - Basic Employability Skills
MHT - Millwright Hand Tools
MFA - Fasteners and Anchors
MBL - Basic Layout
MGO - Gaskets and O-rings
MOC - Oxy-fuel Cutting
MIM - Intermediate Trade Math
MFS - Field Sketching
MIB - Intermediate Blueprint Reading
MST - Specialty Tools
MRG - Rigging
MAM - Advanced Trade Math
MPT - Precision Measuring Tools
WSS - Welding Safety
WOC - Oxy-fuel Cutting
BMP - Base Metal Preparation
WQT - Weld Quality
SWS - Equipment and Setup (SMAW)
SES - Electrodes and Selection (SMAW)
SBF - Beads and Fillet Welds (SMAW)
GWB - Groove Welds with Backing (SMAW)
JFA - Joint Fit-up and Alignment
WSY - Welding Symbols
RWD - Reading Welding Detail Drawings
PAC - Plasma Arc Cutting (PAC)
GFM - Equipment and Filler Metals (GMAW and FCAW)
GFP - GMAW and FCAW – Plate
TFM - Equipment and Filler Metals (GTAW)
TPW - Plate (GTAW)
PTM - Preheating and Post-weld Heat Treatment of Metals
CPM - Physical Characteristics and Mechanical Properties of Metals
L1B - Benchwork
LIL - Layout
1VM - Vertical Milling
1DP - Drill Press
1SG - Surface Grinding
1TB - Turning – Between Centers
1TC - Turning – Chucking

1CM - CNC Milling
1CT - CNC Turning
2TB - Turning – Between Centers
2TC - Turning – Chucking
2PL - Milling – Precision Locations
2FA - Grinding – Flats and Angles
2CG - Cylindrical Grinding
2CM - CNC Milling
2CT - CNC Turning

National Educational Technology Standards

T1 Creativity and Innovation
T2 Communication and Collaboration

Suggested References

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For additional references, activities, and Web resources, please refer to the Manufacturing Technology B.R.I.D.G.E. Web site: http://www.rcu.blackboard.com (available only to registered users).

Competency 1: Read, analyze, and design a blueprint. (DOK 2) MAT, BLU, COM, MBL, MGO, L1B, LIL, 1VM, 1DP, 1SG, 1TB, 1TC, 1CM, 1CT, 2TC, 2PL, 2FA, 2CG, 2CM, 2CT, GEO1, PRA3, PRA4, TTA2, TTA3

Suggested Objectives

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 layout.
e. Explain basic layout of a blueprint.
f. Describe the information in a title block.
g. Identify the lines used on blueprints.

Suggested Teaching Strategies

- Have students use a word processing document, a digital camera, and classroom resources to identify, define, and illustrate terms and symbols with students and show them examples on a blueprint: lines, circles, hidden lines, centerlines, tangents, arcs, and so forth. R1, R2, W1, M1, M7
- Bring in an object with multiple parts that can be disassembled, and show how parts align. R1, R2, R3, W1, T1, T2, T3, T4, T5, T6
- Show the students an example of a finished part that has been made from a blueprint. Allow the students to compare the physical object with the blueprint. R1, R2, R3, W1, T1, T2, T3, T4, T5, T6
- Discuss the parts of the blueprint: legend, title block, border, drawing area, and the revision block. Give students a sample drawing for reference. R1, R2, W1, M1, M7
- Explain what the title block and parts list encompass. Explain the scale that applies to the physical part as compared to the paper blueprint. R1, R2, W1, M1, M7
- Show and explain lines found on a blueprint (i.e., centerline, dimension, hidden line, object lines, extension line, break lines, etc.) that represent how a part is visualized. R1, R2, W1, M1, M7

Suggested Assessment Strategies

- Have students locate various terms and symbols from a teacher-assigned blueprint. Evaluate student work using teacher observation. If a student does not locate a correct term or symbol, re-teach and re-evaluate.
- Have students draw a blueprint of a simple object assigned by the teacher. A common soft drink can is a good item to blueprint. The blueprint should include a title block, material list, auxiliary views, and detailed drawings of each part of the whole object. The students should make drawings that encompass orthographic and isometric drawings. Evaluate the blueprint for accuracy.
- Give students a print with missing measurements and dimensions. Have students identify whether or not they could make the part with the information given and what information they need to complete the print.
- Give students a blueprint with missing data, words, and symbols using a blackboard, smart board, overhead projector, or activity sheet. Then let the students debate what is missing and how the blueprint can be corrected. Be sure that there are enough blueprints and enough missing data on the blueprints to allow every student an opportunity to solve a problem.

- As the semester progresses, give students a blueprint and have the students build an assigned part using shop equipment. A shape can be created using 1/2-in. PVC piping and fittings. Provide the students with a complete length of pipe, fittings, and a blueprint. Allow students to select hand tools to perform the task. Using the blueprint, the students should cut the proper length of tubing and fit them together with the PVC fitting to create the shape shown on the blueprint. The fitting may be saved and used again next year as long as the pieces are not permanently glued and fitted with pipe.

Competency 2: Demonstrate the use and maintenance of various hand and power tools. (DOK 3) SAF, HTO, PTO, MHT, MFA, MBL, MGO, MOC, L1B, LIL, 1DP

Suggested Objectives

a. Identify and discuss the use of common hand and power tools.
b. Discuss rules of safety.
c. Select and demonstrate the use of tools.
d. Explain the procedures for maintenance.

Suggested Teaching Strategies

- Lay shop hand tools on a table, and discuss the proper identification and use of the tools. Have the students log the tools in their journals so that they can look at the description at a later date. The students should be encouraged to make a sketch of the tool so they can reference the appearance of the tool. Assign each student a hand tool, and then have students use the Internet, books, or magazines to find uses of the shop hand tools. Also have students research names for tools that often relate to slang or name brand. For example, a pair of Channel Lock name-brand pliers are often used in industry but are technically referred to as pump pliers. The pump pliers are also referred to as "slip joint pliers," which is a slang term. After giving the students time to locate reference materials, ask them to share their findings with the class. Allow students to interject their personal experience using various hand tools such as adjustable wrenches, screwdrivers, and pump pliers. E1, R1, W1, W2
- Explain the appropriate personal protective equipment (PPE) when using hand and power tools. Have students record what each device is used for in their journals. The students should be encouraged to make a sketch of the PPE so they can reference the appearance of the devices at a later date. Let students practice using PPE and also locating the items in the shop storage area. E1, R1, R2, W1
- Discuss the proper care for hand and power tools. Have students write the care for each tool in their journals, and have them perform the cleanup on the tool. Assign students different tools, and have the students use the Internet, sale catalogs, or other periodicals to determine the cost of the shop tools. One common item used in metal trade professions is a 120-V electric hand drill with a 1/2-in. keyed chuck. Have students research several media to find average pricing for the hand tools they are using. Once the research is concluded, create a tool list on the chalk/dry erase board. Let each student write the cost of each tool, and have a student volunteer to tally the tool costs for the shop. This exercise should give the students an understanding of the expensive equipment they will be responsible for using and maintaining. E1, R1, R2, R3, W1
- Demonstrate proper use and safe procedures for using hand and power tools. You may begin by demonstrating how to properly drill a hole in a 1/2-in. piece of flat steel. Show the students how to use a ball-peen hammer and a center punch properly to mark the drill

location. Next, demonstrate how to select the proper drill bit to bore through steel plate. Show the students how to load and tighten the drill bit in the drill chuck. One of the most important steps of drilling a hole is to make sure the bit is rotating in the correct direction. Students often overlook bit rotation and ruin drill bits while trying to bore holes. Demonstrate how to set the center of the bit into the center punch crater, and then begin drilling. Finally, show the students how to properly feed the bit through the metal and finish the hole.[E1, R1, R2, R3, W1]

- Demonstrate cleaning and oiling of tools as well as tool storage.[E1, R1, R2, R3, W1]

Suggested Assessment Strategies

- Lay out hand and power tools on a shop table, and have students identify the hand tools and what tasks they perform in the metal trade area. Allow students to use selected hand tools to perform a task such as disassemble a gear box. Let them see how each piece of the gear assembly works together to create rotational torsion.

  Note: If the manufacturing program does not have a gear box, elicit a local industry to donate a new, broken, or worn-out gear box. All you need is something to demonstrate how to take apart and reassemble using shop hand tools. Gear boxes are a great item to use during demonstrations because of the machine tooling that was used to produce the housing, bearing slots, and gears. The gear box can be used in other lectures such as lathing, milling, and grinding.
- Have students list five to ten safety rules in their daily journals for various hand tools found in the shop. Call on the students one at a time to orally present one of their safety rules. Instruct the students that they must not discuss the same rule as previously discussed by other students. Once the rule has been spoken, another student cannot use that safety rule for discussion.
- Have students list five to ten safety rules in their daily journals for various power tools found in the shop. Call on the students one at a time to orally present one of their safety rules. Instruct the students that they must not discuss the same rule as previously discussed by other students. Once the rule has been spoken, another student cannot use that safety rule for discussion.
- Have students select the proper hand-powered drill and drill bit size for a 1/4-in. hole, install the bit in the drill chuck, and drill a hole in 1/4-in. mild steel plate. Make sure the students wear eye protection and return the equipment to the proper storage location after use.
- Have the students give oral reports on the proper procedure for maintenance of an assigned set of tools. Encourage the students to use the Internet, books, magazines, or other media to research proper maintenance of a particular tool. For example, storing a ball-peen hammer in a bucket of oily sand will keep the hammer from rusting, and the oil will also maintain the tightness of the handle within the hammer head by swelling the wood inside the hammer head hole.

Standards

Mississippi Academic Standards

PRA3 Identify and apply geometric principles to polygons, angles, and two- and three-dimensional figures.
PRA4 Understand measurable attributes of objects, and apply various formulas in problem-solving situations.
TTA2 Understand, represent, and analyze patterns, relations, and functions.
TTA3 Understand geometric principles of polygons, angles, and figures.
GEO1 Compute and determine the reasonableness of a result in mathematical and real-world situations with and without technology.

ACT College Readiness Standards

E1 Topic Development in Terms of Purpose and Focus
M1 Basic Operations and Applications
M7 Measurement
R1 Main Ideas and Author's Approach
R2 Supporting Details
R3 Sequential, Comparative, and Cause–Effect Relationships
W1 Expressing Judgments
W2 Focusing on the Topic

National Industry Standards

SAF - Basic Safety
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2TC - Turning – Chucking

2PL - Milling – Precision Locations
2FA - Grinding – Flats and Angles
2CG - Cylindrical Grinding
2CM - CNC Milling
2CT - CNC Turning

National Educational Technology Standards

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T5 Digital Citizenship
T6 Technology Operations and Concepts

Suggested References

Textbooks

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For additional references, activities, and Web resources, please refer to the Manufacturing Technology B.R.I.D.G.E. Web site: http://www.rcu.blackboard.com (available only to registered users).

Unit 4: Drill Press and Band Saw Theory and Operation

Competency 1: Identify and describe the safe operation of the types of power saws. (DOK 2) SAF, MAT, BLU, COM, MOT, MBL, MIM, MIB, MST, MPT, MRG, MAM

Suggested Objectives

a. Identify and describe rules for 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.

Suggested Teaching Strategies

- The instructor will present a video on the given task. The student will develop several questions and answers from the video. E1
- The instructor will demonstrate identification and interpretation of the specific task concerns. The student will utilize a variety of resources to write a report to identify and interpret task concerns. E1, E2, E3, E5, E8, E9, E10
- Divide the students into groups and assign each group a specific task. Have each group construct a poster listing components and the diagram of the task. E4, E3, E5
- Actual pictures from the lab will be shown and discussed about the specific task. The students will perform each task assigned.

Suggested Assessment Strategies

- The questions and answers will be evaluated for content and clarity.
- A report will be presented to the class. A rubric will be used to evaluate the presentation.
- Evaluate the poster for content and clarity.
- A checklist will be used to evaluate the task.

Competency 2: Identify and describe the types of drilling machines, including hand powered and drill press, and the rules for safe operation of each. (DOK 2) SAF, MAT, BLU, COM, MOT, MBL, MIM, MIB, MST, MPT, MRG, MAM

Suggested Objectives

a. Describe safety rules for the safe use of a hand power drill and drill press.
b. Identify work-holding and setup devices in drill press operations.
c. Lay out holes and drill, ream, countersink, and counter bore according to project specifications.

Suggested Teaching Strategies

- Describe safety rules for the safe use of a hand power drill and drill press.
- Identify work-holding and setup devices in drill press operations.
- Lay out holes and drill, ream, countersink, and counter bore according to project specifications.

Suggested Assessment Strategies

- A written test will be given for the terminology.
- A checklist will be used to observe the students while they are performing safety inspections and operation procedures to complete a given task.

Standards

21st Century Skills Standards

CS1 Flexibility and Adaptability
CS2 Initiative and Self-direction
CS3 Social and Cross-cultural Skills
CS4 Productivity and Accountability
CS5 Leadership and Responsibility

ACT College Readiness Standards

E1 Topic Development in Terms of Purpose and Focus
E2 Organization, Unity, and Coherence
E3 Word Choice in Terms of Style, Tone, Clarity, and Economy
E4 Sentence Structure and Formation
E5 Conventions of Usage
E6 Conventions of Punctuation
M1 Basic Operations and Applications
M2 Probability, Statistics, and Data Analysis
M3 Numbers: Concepts and Properties
M4 Expressions, Equations, and Inequalities
M5 Graphical Representations
M6 Properties of Plane Figures
M7 Measurement
M8 Functions
R1 Main Ideas and Author's Approach
R2 Supporting Details
R3 Sequential, Comparative, and Cause–Effect Relationships
R5 Meaning of Words
R6 Generalizations and Conclusions
S1 Interpretation of Data
S2 Scientific Investigation
S3 Evaluation of Models, Inferences, and Experimental Results
W1 Expressing Judgments
W2 Focusing on the Topic
W3 Developing a Position
W4 Organizing Ideas
W5 Using Language

National Industry Standards

SAF - Basic Safety
MAT - Introduction to Construction Math
HTO - Introduction to Hand Tools
PTO - Introduction to Power Tools
BLU - Introduction to Blueprints
MBR - Basic Rigging

COM - Basic Communication Skills
MOT - Orientation to the Trade
MHT - Millwright Hand Tools
MFA - Fasteners and Anchors
MBL - Basic Layout
MGO - Gaskets and O-rings
MIM - Intermediate Trade Math
MFS - Field Sketching
MIB - Intermediate Blueprint Reading
MST - Specialty Tools
MRG - Rigging
MAM - Advanced Trade Math
MPT - Precision Measuring Tools
PAC - Plasma Arc Cutting (PAC)

National Educational Technology Standards

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T5 Digital Citizenship
T6 Technology Operations and Concepts

Suggested References

Textbooks

Davis, D. (1996). *Practical problems in mathematics for manufacturing*. Albany, NY: Delmar.

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Competency 1: Differentiate between the types of milling machines. (DOK 2) SAF, COM, MST, MPT, MPT, L1B, LIL, 1VM, 1DP, 1CM, 2PL, 2CM

Suggested Objectives

a. Identify the different types of milling machines.
b. Explain the use and safety of each type of milling machine.

Suggested Teaching Strategies

- Give the students a handout on the different milling machines. Explain how the milling machines differ, and have students make sketches of what they think the vertical and horizontal milling machines may look like. Show the students pictures of the actual milling machines so they know what each looks like. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5
- Give the students a handout depicting the various parts for the vertical milling machine. Have students make notes on the major parts of the vertical milling machine. Then have the students research the vertical milling machine using the Internet. Have students report on the variances found among different manufacturers of milling machines. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, M1, M2, M3, M4, M5, M6, M7, M8, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Using a shop mill, demonstrate the various functions that milling machines encompass, and explain the dangers of the milling machine and the ways to avoid being injured by using safe practices. Have the students research injuries caused by milling machines on the Internet or other media, and then have the students share their findings with the class. Also have students make posters about milling safety, and have them explain the safety concepts (http://www.youtube.com/watch?v=c6mtUIbs5vk&NR=1). E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6

Suggested Assessment Strategies

- Have students identify different milling machines and the major parts of each. Then have students locate bits and other consumable items used in milling operations. At this point, the students should use the Internet or other types of media to determine the cost for instructor-assigned tool bits. Have the students determine tooling cost variation of a vertical mill. Give the students an order worksheet to submit for a grade. The costs on the worksheet should reflect the actual up-to-date tooling cost (see the **Milling Cost Assignment Checklist** at the end of this unit).
- Have the students use the Internet to research uses of the vertical mill. Then allow students to verbally explain their findings of their research of the vertical milling machine.
- Without energizing the mill, have students demonstrate how to safely operate a milling machine located within the school shop/lab. The students should not be allowed to use notes or other media to aid in their presentations.

Competency 2: Identify the parts, cutting tools, and basic maintenance of a vertical milling machine. (DOK 2) SAF, COM, MST, MPT, MPT, L1B, LIL, 1VM, 1DP, 1CM, 2PL, 2CM

Suggested Objectives

a. Identify the major parts of a horizontal and vertical mill.
b. Identify the cutting tools used on a horizontal and vertical mill.
c. Clean and lubricate a horizontal and vertical mill following manufacturer's specifications.
d. Determine the rpm and feed rate.

Suggested Teaching Strategies

- Describe and explain the large variety of cutting tools used on mills. Show the students the actual cutting devices, and then ask students to individually recall the device and its use in the milling operation. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, S1, S2, S3, M1, M2, M3, M4, M5, M6, M7, M8, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Have students look up teacher-assigned cutters and pricing using vendor catalogs. Then have students report both in writing to the teacher and orally to the class about the cost of machine tooling bits. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, M1, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Have students clean the milling machines after use and apply a light coat of oil to proper surfaces. Explain each surface that needs to be lubricated and why. Have the students take notes in their journals about machine lubrication, and ask that they read their notes at the end of class. Ask specific questions that the students should have notes about. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, CS1, CS2, CS3, CS4, CS5
- Demonstrate how to calculate rpm and feed rate for the vertical mill. You may show videos on milling available at the RCU Media Center or videos from other Internet sites (http://youtube.com/watch?v=uAcBU2iqkKE). Have students research the effects of improper rpm and feed rate. Make sure the students keep accurate notes regarding milling rpm and feed rates. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, M1, M2, M7, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6

Suggested Assessment Strategies

- Assign individual students vocabulary words to be defined and be presented orally to the class. The work list should contain technical jargon, mill parts, milling processes, and so forth. The students should define all the terminology in their daily journals but will only report on words the instructor assigns. The entire list will be presented orally by student participants. An example word list, **Sample Milling Word List**, is found at the end of this unit, and it is highly recommended that the instructor add terms deemed pertinent for industry in Mississippi.
- Lay out tooling cutters on a work bench, and have students identify various types and sizes of milling cutters. Then have students use the Internet to research the cost of each type of mill cutter.
- Students should describe the advantages of having a clean work station in their daily journals.
- Give the students an instructor-made test requiring the students to calculate feed rate and rpm.

Competency 3: Perform operations on a milling machine. (DOK 4) SAF, COM, MST, MPT, MPT, L1B, LIL, 1VM, 1DP, 1CM, 2PL, 2CM, GEO4

Suggested Objectives

a. Perform operations on a vertical milling machine.
   i. Perform an end milling operation, side milling, slotting, drilling, reaming, boring, and fly cutting, mounting cutters and cutter holders, and mounting and aligning a swivel vise; mill a key seat, a given angle, and a straight boring operation; align the head square to the table, mill operation with head tilted to 45°, and divide head operations.

Suggested Teaching Strategies

- Demonstrate how to square a block of material to a dimension size. For example, fabricate a 1, 2, 3 block. Let the students perform the operation with the instructor's supervision. Once the demonstration is complete, have the student measure and record the actual dimensions of their workpieces. Let the students determine if their pieces are made to the specifications required. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, M1, M7, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Demonstrate how to cut angled surfaces by using a combination square head or by tilting the vertical milling head. Have students practice the method by referring to their class notes. Form student groups to assess another group's quality. Have students keep a log of how well each group performed. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, S1, S2, S3, M1, M2, M7, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Demonstrate how to align the milling head square to the table or vice. Allow a student volunteer to try and align the head without help from his or her classmates. Once the alignment is complete, let other students check the alignment quality. Record each student's opinion about the volunteer's ability to align the head. Allow peer evaluation to provide feedback for all students about their alignment skills. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, M1, M2, M7, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6

Suggested Assessment Strategies

- Give the students a blueprint in which they are to produce a hex head nut with the dividing head using a horizontal mill.
- Give the students a print in which they are to produce a small cylinder head as used in an engine. Use the vertical mill to bore the cylinder head and hone to precision. The cylinder should slip inside the bore with close tolerance as found in an automotive engine.
- Have the students return the milling head to square (0°) using an indicator.
- Have students work with the shop milling equipment. Do this by having the student's mill and square stock from an angled workpiece.

Standards

21st Century Skills Standards

CS1 Flexibility and Adaptability
CS2 Initiative and Self-direction
CS3 Social and Cross-cultural Skills
CS4 Productivity and Accountability
CS5 Leadership and Responsibility

Mississippi Academic Standards

GEO4 Select and apply various strategies, tools, and formulas to calculate length, surface area, volume, and angle measurements.

ACT College Readiness Standards

E1 Topic Development in Terms of Purpose and Focus
E2 Organization, Unity, and Coherence
E3 Word Choice in Terms of Style, Tone, Clarity, and Economy
E4 Sentence Structure and Formation
E5 Conventions of Usage
E6 Conventions of Punctuation
M1 Basic Operations and Applications
M2 Probability, Statistics, and Data Analysis
M3 Numbers: Concepts and Properties
M4 Expressions, Equations, and Inequalities
M5 Graphical Representations
M6 Properties of Plane Figures
M7 Measurement
M8 Functions
R1 Main Ideas and Author's Approach
R2 Supporting Details
R3 Sequential, Comparative, and Cause–Effect Relationships
R5 Meaning of Words
R6 Generalizations and Conclusions
S1 Interpretation of Data
S2 Scientific Investigation
S3 Evaluation of Models, Inferences, and Experimental Results
W1 Expressing Judgments
W2 Focusing on the Topic
W3 Developing a Position
W4 Organizing Ideas
W5 Using Language

National Industry Standards

SAF - Basic Safety
COM - Basic Communication Skills
MST - Specialty Tools
MPT - Precision Measuring Tools
L1B - Benchwork
LIL - Layout
1VM - Vertical Milling
1DP - Drill Press
1CM - CNC Milling
2PL - Milling – Precision Locations
2CM - CNC Milling

National Educational Technology Standards

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T5 Digital Citizenship
T6 Technology Operations and Concepts

Suggested References

Textbooks

Check, A., Krar, S., & Rapisarda, M. (1998). *Machine tool and manufacturing technology.* Albany, NY: Delmar.

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Suggested Rubrics and Checklists

Milling Cost Assignment Checklist

_____ 1. The student properly described at least three different types of cutters for purchase.

_____ 2. The student indicated the quantity to be purchased on the order form.

_____ 3. The student indicated the unit cost for each item on the order form.

_____ 4. The student correctly calculated the total cost for each line item.

_____ 5. The student correctly calculated the total invoice bill.

_____ 6. The student used up-to-date catalogs or the Internet to research cutter costs.

Qty	Item Description	Unit Cost	Total Cost
Vertical Tool Bits			
		Total Costs for Vertical Bits	
Horizontal Tool Bits			
		Total Costs for Horizontal Bits	

Total Costs for All Bits	

Sample Milling Word List

General Milling Terms
End Milling
Feed
Face Milling
Form Milling
Gang Milling
Knee and Column Milling Machine
Manufacturing Milling Machine (Bed-type)
Milling
Peripheral/Cutting Surface Speed
Peripheral Milling
Plain/Slab Milling
Side Milling
Slitting and Cutting Off
Special Type Milling Machines
Universal Milling Machine
Vertical Milling Machine

Machining Word List
Left-hand (Prefix)
Machine Tool
Machinability
Numerical Control (N/C)
Right-hand (Prefix)

Competency 1: Identify the parts, rules, and care of the metal lathe. (DOK 3) SAF, MAT, HTO, PTO, BLU, MBR, MBL, L1B, LIL, 1TB, 1TC, 1CT, 2TB, 2TC

Suggested Objectives

a. Identify the four major parts of the lathe.
b. Set up a lathe, and determine the rpm and feed rate according to 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 a high-speed steel (hss) turning tool.
    i. Explain the turning of a piece of stock.
    ii. Describe how to chuck a piece of stock.
    iii. Describe facing, center drilling, filing, tapping, and cutoff.

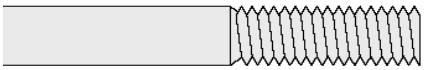
Suggested Teaching Strategies

- Identify, define, explain, and illustrate the safe operation of the major parts of the lathe: head stock, tail stock, carriage, and bed. Have students take notes and make hand-drawn sketches of what each part of the machine looks like in their journals. Then have students discuss among themselves the parts of the machine and what purposes they serve. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5
- Identify and explain the individual parts of the major parts. For example, explain the parts of the carriage: compound rest, cross slide, saddle, and apron. Let the students take notes and discuss their interpretation of what these machine parts do and how important the pieces are to the process. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Identify and explain the individual parts of the working components such as the tool post holder. Explain the half nut lever for thread cutting and graduated micrometer collars on the hand wheels. Allow the students to try the hand wheel and attempt to read the collar setting. R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5
- Demonstrate the proper setup for a lathe project without energizing (turning on) the lathe. Set the lathe in neutral. Demonstrate the proper procedures for setting the feed rate and rpm speed rate according to the specifications for each operation. Make sure the students take good notes on how to set the speeds and feed rate in their journals. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5

Suggested Assessment Strategies

- Divide students into groups, and have students discuss the safe operation of using a lathe. Also, discuss what should not be done when lathing (e.g., leaving the chuck key in the chuck unattended). The students should not use notes or book references to discuss the safety issues. Students are expected to know the safety rules and be able to explain them to other students without the use of notes.
- Using the shop lathe, have students orally identify the four major parts of the lathe and the use of each part. The student should be expected to easily recognize the major parts of the lathe without using notes or book references.
- Get students involved in a real machine shop project. Explain the use of math within the shop. For example, calculate rpm or feed rate. Have students work through the rpm and feed rate to create a 1/2 - 13 in. threaded bolt using the shop lathe. Once the students have

calculated the required measurements, go to the shop equipment and have them set the machine to lathe a bolt. Allow them to actually cut the threads in a piece of round stock using the students' calculated rpm and feed rate. After letting them cut the thread, give the students a 1/2 - 13 in. nut and let them see if the correct thread was made using their figures and their lathing ability. Under close supervision and coaching, the students should calculate the accurate rpm and feed rate for making this project.[R1, W1, M1]



1/2 - 13

- Have students use the Internet or other media source to identify positive and negative attributes of carbide cutting bits. Have students orally describe what carbide bits are used to cut, how long they are expected to last, and what they are not recommended to cut.
- Have students identify the difference between three- and four-jaw chucks. If there are two types in the shop area, have students work in groups. Give the students a length of round bar stock, and let them center the piece in both types of chucks. Have the students demonstrate, without energizing the machine, the process of chucking a workpiece in the lathe. One group can use the three-jaw while the other group uses the four-jaw chuck. Then swap groups on the machines, allowing them to center a workpiece in both types of chucks. The students should then write their experiences in their daily journals for future reference.

Competency 2: Perform procedures for a machining operation. (DOK 3) [SAF, MAT, HTO, PTO, BLU, MBR, MBL, L1B, LIL, 1TB, 1TC, 1CT, 2TB, 2TC, 2CT]

Suggested Objectives

a. Identify terms and procedures for lathe operations.
b. Discuss 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. Complete NIMS turning-chucking Level I project.
m. Complete NIMS turning between centers Level I project.
n. Install a chuck on a lathe.
o. Mount and align a part in a four-jaw chuck on a lathe to instructor's specifications.
p. Turn a taper with a compound rest and a taper attachment.
q. Perform a boring operation.
r. Perform wet and dry cuts.

Suggested Teaching Strategies

- Discuss terminology used when operating a lathe. Have students write down the terminology and definitions for each in their daily journals. The students should start using these terms as soon as possible to reinforce their vocabulary and their understanding of the lathing

operation.[E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5]

- Discuss, review, and relate the proper safety procedures for lathing operations. Have students step through setting up a lathe without powering the machine. The students should write the steps in their journals for future reference. Once the demonstration is complete, allow students to repeat the process. Allow them to use their notes if needed.
- Set up a workpiece out of center. Then use a dial indicator to bring in to concentricity. Explain concentric rings on a four-jaw chuck. Have students take notes and make sketches of the four-jaw chuck for future reference. Allow the student to align an out-of-center workpiece with close supervision. Have the students watch a video on how to center a workpiece (http://youtube.com/watch?v=Hi_s0iQkRFA).[E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5]
- Demonstrate NIMS standards for turning, chucking, and turning between centers. Have students use the Internet to search for NIMS standards and for employers who require the certification for employment (http://www.nims-skills.org/home/index.htm). Then have the students report on what they found regarding the standards.[E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5 T1, T2, T3, T4, T5, T6]
- Demonstrate the removal and installation of a chuck on a lathe. Have a volunteer remove the chuck while others make notes in their journals. Have the student volunteer explain the process to the other students.[E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6]
- Lecture the students on cutting a taper, and then demonstrate how the task is performed. Have students keep well-documented notes for future lab projects.
- Show a video from the RCU, and do a lecture series on boring. Have students make notes as the video progresses. Next, go into the shop area, and demonstrate a boring operation using a standard boring bar.[E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6]

Suggested Assessment Strategies

- Assign individual students vocabulary words to be defined and be presented orally to the class. The work list should contain technical jargon, lathe parts, lathing processes, and so forth. The students should define all the terminology in their daily journals but will only report on words the instructor assigns. The entire list will be presented orally by student participants. An example word list, **General Lathe Terms**, is found at the end of this unit and it is highly recommended that the instructor add terms deemed pertinent for industry in Mississippi.
- Have the students prepare written safety prevention reports for operating the lathe. The students should include accidents that are common in the Manufacturing lathe shop. The report should also include preventative measures used in the Manufacturing shop that are proven to prevent accidents (see the **Written Report Rubric** at the end of this unit).
- Have the students produce a part such as a ball-peen hammer that will encompass all the demonstrated operations for lathing. For example, produce two workpieces, the handle and head. The handle will be turned, knurled, and threaded. The head will be turned, tapered, tapped, and faced.
- Give the students a performance standard for NIMS Level 1 turning between centers. Have the students cut a taper using dimensions listed on an instructor-made blueprint.
- Have the students recall and perform a boring operation using a piece of 3-in. aluminum bar stock. A simple boring operation may be used to produce an aluminum canister. The dimensional measures of the canister should be 3-in. outside diameter, 2 3/4-in. inside diameter, 1/4-in. bottom thickness, and a rounded finished lip. A second part may be added

to the project by fabricating a top for the canister.

Standards

21st Century Skills Standards

CS1 Flexibility and Adaptability
CS2 Initiative and Self-direction
CS3 Social and Cross-cultural Skills
CS4 Productivity and Accountability
CS5 Leadership and Responsibility

ACT College Readiness Standards

E1 Topic Development in Terms of Purpose and Focus
E2 Organization, Unity, and Coherence
E3 Word Choice in Terms of Style, Tone, Clarity, and Economy
E4 Sentence Structure and Formation
E5 Conventions of Usage
E6 Conventions of Punctuation
R1 Main Ideas and Author's Approach
R2 Supporting Details
R3 Sequential, Comparative, and Cause–Effect Relationships
R5 Meaning of Words
R6 Generalizations and Conclusions
W1 Expressing Judgments
W2 Focusing on the Topic
W3 Developing a Position
W4 Organizing Ideas
W5 Using Language

National Industry Standards

SAF - Basic Safety
MAT - Introduction to Construction Math
HTO - Introduction to Hand Tools
PTO - Introduction to Power Tools
BLU - Introduction to Blueprints
MBR - Basic Rigging
MBL - Basic Layout
L1B - Benchwork
LIL - Layout
1TB - Turning – Between Centers
1TC - Turning – Chucking
1CT - CNC Turning
2TB - Turning – Between Centers
2TC - Turning – Chucking

National Educational Technology Standards

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T5 Digital Citizenship
T6 Technology Operations and Concepts

Suggested References

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For additional references, activities, and Web resources, please refer to the Manufacturing Technology B.R.I.D.G.E. Web site: http://www.rcu.blackboard.com (available only to registered users).

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Suggested Rubrics and Checklists

Written Report Rubric

NAME: DATE: PERIOD:

	Exemplary 4 Points	Accomplished 3 Points	Developing 2 Points	Beginning 1 Point	Score
Content	Clear thesis and focus that remain apparent	Thesis and focus that remain apparent	Addresses subject matter with minimal support	Does not focus on topic	
Grammar	Correct and effective use of grammar and mechanics	Occasional errors in use of grammar and mechanics	Problems in use of grammar and mechanics	Repeated errors in use of grammar and mechanics	
Organization	Ideas flow smoothly and logically with clarity and coherence.	Logical order and appropriate sequencing of ideas with adequate transition	Some evidence of an organizational plan or strategy	Lacks organization	
				Total	

Comments:

General Lathe Terms

Automatic Screw Machines
Bed
Bar Parts
Carriage
Chucking Parts
Chucks
Three-jaw Universal Chuck
Four-jaw Independent Chuck
Collet/Chucks
Cross Slide
Engine Lathe
Light-powered Machines
Tool-room Lathes
Standard Lathes
Large Swing or Long-bed Lathes
Face Plate
Feed (Turning)
Follow Rest
Force (Lathes)
Longitudinal Feed Force
Radial Force
Tangential Force
Gibs
Headstock
Lathe Centers
Lathe Dog
Live Center
Mandrel
Quick-change Gear Box
Rocker Tool Post
Shoulder Turning
Spindle/Spindle Nose
Steady Rest
Tailstock
Tool Post/Tool Supports
Turret Lathes

Unit 7: Grinding Theory and Operation

Competency 1: Describe safety, magnetic chuck work, surface grinding operations, and reasons for truing and balancing a grinding wheel. (DOK 3) SAF, MAT, HTO, PTO, MBL, MPT, L1B, LIL, 1SG, 2FA, 2CG

Suggested Objectives

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.

Suggested Teaching Strategies

- Explain that surface grinding is potentially one of the most dangerous working environments in the entire shop because of the magnetic chuck. Parts may become airborne if the part and cutting rate are not properly set. The maximum amount of surface removal is much smaller than what is acceptable when using a milling machine. Have students research using the Internet, or other media, eye injuries due to projectiles and have them report to the class orally. R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, M1, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Demonstrate and explain how to safely chuck and block a workpiece to the grinder bed. Once demonstrated, ask a student to repeat the process you previously illustrated. Allow the student to refer to journal notes. Have other students remark about what should be done in order of importance while the student is setting up the workpiece. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5
- Demonstrate the process involved in grinding a piece of material using the shop grinder (http://www.youtube.com/watch?v=uexMQNUQGQ4). Then allow a student to set up a workpiece on the grinder table. Make sure the student follows all the steps safely. Once the student has set up the machine, allow other students to comment on the quality of work. Have them elaborate on why the setup was performed correctly or incorrectly. R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, M1, M2, M7, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- List and explain the reasons why balancing a grinding wheel is so important. Improper balancing could cause the wheel to shatter. Discuss the properties of the grinding wheel and how the wheel fits on the grinding machine arbor. Have the students research safety issues associated with the grinding machine and report their results in written essays. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, T1, T2, T3, T4, T5, T6
- Demonstrate how to dress a grinding wheel using a diamond dressing tool. Allow students to recite the steps to dress a grinding wheel using their notes or textbooks. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, M1, M2, M7
- Discuss what materials can be ground using a surface grinder and the materials that cannot be ground using a surface grinder (i.e., aluminum and brass will load a grinding wheel ruining the grinding wheel). Discuss the dangers of loading the grinding wheel, and have students take notes regarding types of stones, metals, feed rates, and so forth. Near the end of the period, have students recall the types of metals that can be ground, the stones used to grind, and the safety issues associated with loading the stone. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, M1, M2, M7, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6

Suggested Assessment Strategies

- Assign individual students vocabulary words to be defined and be presented orally to the class. The work list should contain technical jargon, grinding parts, grinding processes, and so forth. Have students define all the terminology in their daily journals but only report on words the instructor assigns. The entire list will be presented orally by student participants. An example word list, **Sample Grinding Word List**, is found at the end of this unit, and it is highly recommended that the instructor add terms deemed pertinent for industry in Mississippi.
- Give students a written essay assignment requiring them to explain why safety is so important around surface grinding machines.
- Have students successfully chuck and block a workpiece on a magnetic bed. Do not allow the students to energize the machine. Have students in the class try to move the workpiece while the magnetic bed is energized.
- After inspecting the students' setup of a workpiece on a magnetic grinding bed, have the students grind down the pieces of stock that they placed on the bed to an instructor-assigned dimension.
- Have students verbally explain why balancing a grinding wheel is important.

Competency 2: Perform maintenance operations to manufacturer's specifications and grinding operations to teacher's specifications. (DOK 4) SAF, MAT, HTO, PTO, BLU, MHT, MBL, MIM, MFS, MIB, MST, MPT, L1B, LIL, 1SG, 2FA, 2CG, GEO3, PRA4

Suggested Objectives

a. Remove and replace a grinding wheel.
b. Dress a wheel flat.
c. Grind a workpiece flat and parallel. Grind a workpiece square, to an angular surface, and to dimension.

Suggested Teaching Strategies

- Demonstrate how to select the proper grinding wheel for assigned projects. Then demonstrate how to remove and install a grinding wheel making sure all safety policies are followed. Once the instructor has demonstrated at least twice, allow a student to remove and install a grinding wheel. Have onlooking students remark on safety issues and proper techniques. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5
- Demonstrate how to do a ring test on a grinding wheel to detect cracks. Have each student listen to the ring of the stone during the ring test. Break the students into groups, and have each student in each group attempt the ring test. Have each team report on how well their ring test worked and if the stone is safe to use. CS1, CS2, CS3, CS4, CS5
- Demonstrate how to properly dress a grinding wheel with a diamond dresser until it has a good, flat contact surface. Have a student volunteer dress a grinding wheel. Allow the other students to evaluate the step taken and remark on the quality of workmanship. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, S1, S2, S3, M1, M2, M3, M4, M5, M6, M7, M8, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Review how to grind a workpiece and what is to be expected of the finished project. Assign each student group a piece of metal to grind. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, M1, M2, M7, CS1, CS2, CS3, CS4, CS5

Suggested Assessment Strategies

- Have the students remove and replace a grinding wheel. Also, have the students explain the steps in doing so.
- Have the students dress a grinding wheel until it is ready for use. Have the students explain the steps to dress the wheel and how to determine when the wheel is properly dressed.
- Have the students grind a piece square as assigned by the instructor.
- Have the students grind a piece on an angle using the machinist angle vise.

Standards

21st Century Skills Standards

CS1 Flexibility and Adaptability
CS2 Initiative and Self-direction
CS3 Social and Cross-cultural Skills
CS4 Productivity and Accountability
CS5 Leadership and Responsibility

Mississippi Academic Standards

PRA4 Understand measurable attributes of objects, and apply various formulas in problem-solving situations.
GEO4 Select and apply various strategies, tools, and formulas to calculate length, surface area, volume, and angle measurements.

ACT College Readiness Standards

E1 Topic Development in Terms of Purpose and Focus
E2 Organization, Unity, and Coherence
E3 Word Choice in Terms of Style, Tone, Clarity, and Economy
E4 Sentence Structure and Formation
E5 Conventions of Usage
E6 Conventions of Punctuation
M1 Basic Operations and Applications
M2 Probability, Statistics, and Data Analysis
M7 Measurement
M8 Functions
R1 Main Ideas and Author's Approach
R2 Supporting Details
R3 Sequential, Comparative, and Cause–Effect Relationships
R5 Meaning of Words
R6 Generalizations and Conclusions
S1 Interpretation of Data
S2 Scientific Investigation
S3 Evaluation of Models, Inferences, and Experimental Results
W1 Expressing Judgments
W2 Focusing on the Topic
W3 Developing a Position
W4 Organizing Ideas
W5 Using Language

National Industry Standards

SAF - Basic Safety
MAT - Introduction to Construction Math
HTO - Introduction to Hand Tools

PTO - Introduction to Power Tools
BLU - Introduction to Blueprints
MHT - Millwright Hand Tools
MBL - Basic Layout
MIM - Intermediate Trade Math
MFS - Field Sketching
MIB - Intermediate Blueprint Reading
MST - Specialty Tools
MPT - Precision Measuring Tools
L1B - Benchwork
1SG - Surface Grinding
2FA - Grinding – Flats and Angles
2CG - Cylindrical Grinding
2CM - CNC Milling
2CT - CNC Turning

National Educational Technology Standards

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T5 Digital Citizenship
T6 Technology Operations and Concepts

Suggested References

Textbooks

Check, A., Krar, S., & Rapisarda, M. (1998). *Machine tool and manufacturing technology.* Albany, NY: Delmar.

Jeffus, L. (1999). *Welding principles and applications.* Albany, NY: Delmar.

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Associated Web Sites

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Suggested Rubrics and Checklists

Sample Grinding Word List

General Grinding Terms
Centerless Grinder
Grinding Machine
Grinding Wheel
Surface Grinding

General Terms
Cutting Speed
Cutting Rate
Depth of Cut
Feed
Finish
Finish Failure
Finishing Cut
Loading of the Stone
Parting
Path of Consecutive Cuts
Peripheral Speed
RPM
Stone Life
Work Surface
Feed
Longitudinal Feed Force
Radial Force
Tangential Force
Left-hand (Prefix)
Right-hand (Prefix)

Competency 1: Describe local program and vocational center policies and procedures. (DOK 1) SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, MHT, MFA, MBL, WSS, WOC

Suggested Objectives

a. Describe local program and vocational center policies and procedures including dress code, attendance, academic requirements, discipline, and transportation regulations.

Suggested Teaching Strategies

- Discuss school policy and MS-CPAS2 requirements using the school handbook, and discuss the history of the occupational skill and how it relates to today's technology. Then discuss how the success of the welding program depends on students who are motivated and eager to learn. Let students elaborate on their experiences in Manufacturing I class. R1, R2, R3, R4, R5, R6, W1, W2, W3, CS1, CS2, CS3, CS4, CS5, T1, T2, T3
- Have a student with higher reading ability partner with a student who has lower reading ability, and let them read the welding course syllabus and career center rules. Have them discuss the ramifications of breaking rules and regulations set forth by the school, department, and/or instructor. Also discuss the reasons why the rules are in place, such as safety, attendance, and so forth. R1, R2, R3, R4, R5, R6, W1, W2, W3, CS1, CS2, CS3, CS4, CS5, T1, T2, T3

Suggested Assessment Strategies

- Have the students relate school offenses and the punishment that is given by the administrator, and have students report about the consequences of cutting out or dropping out of school.
- Give the students scenarios that set up a rule violation, and then call on a student to discuss what may happen as a result of the rule breaking.

Competency 2: Describe employment opportunities and responsibilities. (DOK 2) SAF, MAT, COM, EMP, MOT, WSS

Suggested Objectives

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 resume, and complete a job application.

Suggested Teaching Strategies

- Discuss the needs of the welding industry in Mississippi. Tell the students about potential welding employers found throughout the state. Have a guest industry speaker or welding alumnus talk with the students about the expectations of the employers and what employers look for in newly hired employees. R1, R2, R3, W1
- Discuss the proper method for constructing a resume and cover letter. Discuss and provide example job applications found on the Internet and in local newspapers or other media. Have students use the Internet or other media outlets to find job applications and resume sites. Have students report to the class the generalities found in all applications and then the job-

specific qualifications on job applications. Also have students report on the generalities of the resume. What do all resumes have? E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, S1, S2, S3, M1, M2, M3, M4, M5, M6, M7, M8, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6

Suggested Assessment Strategies

- Have students obtain job possibilities from a newspaper or other written media and report orally to the class where the job is and if the job has a pay scale included. Also have students obtain a job application from a local welding company for class discussion.
- Have students research a job in the welding profession using the Internet. Try and obtain payroll, benefit, and retirement information if possible. The student should discuss which companies have better benefits, payroll, job location, type of welding, and quality expectations of new workers.

Competency 3: Demonstrate the ability to follow verbal and written instructions and communicate effectively in on-the-job situations. (DOK 2) SAF, MAT, COM, EMP, MOT, WSS

Suggested Objectives

a. Perform welding projects through written instruction.
b. Perform welding projects through oral instruction.

Suggested Teaching Strategies

- Give the students verbal instructions on an instructor-created project. Have students take notes about the requirements of the project, dimensions, materials to be used, and so forth. Have students discuss among themselves the requirements of the project. After the students have discussed their observations, give them a copy of the written project so they may study what was actually asked by the instructor. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2,CS3, CS4, CS5, T1, T2, T3, T4, T5, T6

Suggested Assessment Strategies

- Break the class into two groups to promote community cooperation. Have one group communicate with the other the required specifications of the project. Allow the students to debate the inconsistency in their notes with the actual job specification sheet.
- Once the students learn more about the welding profession, have them build a project using their written notes taken in lecture. The instructor should describe what is to be built, dimensions, material requirements, and deadlines. This project may be used as a progressive lab that will allow the students to learn progressively as they work toward a goal.

Standards

21st Century Skills Standards

CS1 Flexibility and Adaptability
CS2 Initiative and Self-direction
CS3 Social and Cross-cultural Skills
CS4 Productivity and Accountability
CS5 Leadership and Responsibility

ACT College Readiness Standards

E1 Topic Development in Terms of Purpose and Focus
E2 Organization, Unity, and Coherence
E3 Word Choice in Terms of Style, Tone, Clarity, and Economy
E4 Sentence Structure and Formation
E5 Conventions of Usage
E6 Conventions of Punctuation
M1 Basic Operations and Applications
M2 Probability, Statistics, and Data Analysis
M3 Numbers: Concepts and Properties
M4 Expressions, Equations, and Inequalities
M5 Graphical Representations
M6 Properties of Plane Figures
M7 Measurement
M8 Functions
R1 Main Ideas and Author's Approach
R2 Supporting Details
R3 Sequential, Comparative, and Cause–Effect Relationships
R5 Meaning of Words
R6 Generalizations and Conclusions
S1 Interpretation of Data
S2 Scientific Investigation
S3 Evaluation of Models, Inferences, and Experimental Results
W1 Expressing Judgments
W2 Focusing on the Topic
W3 Developing a Position
W4 Organizing Ideas
W5 Using Language

National Industry Standards

SAF - Basic Safety
MAT - Introduction to Construction Math
HTO - Introduction to Hand Tools
PTO - Introduction to Power Tools
BLU - Introduction to Blueprints

MBR - Basic Rigging
COM - Basic Communication Skills
EMP - Basic Employability Skills
MOT - Orientation to the Trade
MHT - Millwright Hand Tools
MFA - Fasteners and Anchors
MBL - Basic Layout
WSS - Welding Safety
WOC - Oxy-fuel Cutting

National Educational Technology Standards

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T5 Digital Citizenship
T6 Technology Operations and Concepts

Suggested References

Textbooks

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State Board for Community and Junior Colleges. (n.d.). Retrieved December 7, 2007, from http://www.sbcjc.cc.ms.us/

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Vocational Information Center. (n.d.). *Career and technical–vocational education*. Retrieved December 7, 2007, from http://www.khake.com/page50.html

Walter, R. A. (Ed.). (n.d.). *Journal of Industrial Teacher Education*. Retrieved December 7, 2007, from http://scholar.lib.vt.edu/ejournals/JITE/

For additional references, activities, and Web resources, please refer to the Manufacturing Technology B.R.I.D.G.E. Web site: http://www.rcu.blackboard.com (available only to registered users).

Unit 9: Basic Safety (Review and Reinforcement)

Competency 1: Describe general safety rules for working in a shop/lab and industry. (DOK 1) SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, MOT, MHT, MFA, MBL, MGO, WSS, WOC, BMP, SWS, PAC, GFM, TFM, PTM, CPM

Suggested Objectives

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 substances abuse policy and how it relates to safety.
g. Explain the safety procedures when working near pressurized or high temperature.

Suggested Teaching Strategies

- Discuss the need for personal protective equipment (PPE) for the welding environment. Also show the students the PPE that will be used in the shop area. Let students handle the equipment and make visual inspections. Then have students orally tell what they would use the equipment to protect. The following Web site is a good reference for general shop safety, and it also contains welding safety: http://www.envirosafeshop.com/shoprules.htm. R1, W1, CS1, CS2, CS3, CS4, CS5
- Take the students into the shop area, and show them where the PPE and cleanup materials are located. Discuss the dangers of a dirty work area and how daily cleanup is imperative to maintaining a safe work environment. Have students walk through the welding shop taking notes for making safety recommendations based on lecture and what they read from the textbook. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Show the school's evacuation route in case of fire or other threat and also where the tornado shelter is located. Walk the students through the areas so they are familiar with the route. Also, express the importance of having a walkway free of clutter in case of emergency evacuation or bad weather. Take the students through the shop area, and discuss the evacuation routes and if clutter would hinder a timely escape. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5
- If possible, take the students to an actual welding shop in your community. Have the company representative discuss the importance of keeping a clean shop and discuss the company policies regarding substance abuse. R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5

Suggested Assessment Strategies

- Have students locate the shop cleaning materials and, under supervision, have them demonstrate how to clean the shop area. Ask students questions as they work regarding cleanup procedures, chemicals used to clean machines, and where to store used oil and other shop refuse.
- Let the students visit local welding or machining shops and then report on what employers expect of new employees regarding safety rules, cleanliness, and substance abuse. The students should make visual observations about how the industry shops appear (i.e., cluttered, dirty, unkempt machinery, etc.). They should also note the appearance of the workers (i.e., safety glasses; long, loose clothing; unsecured long hair; etc.).

- Have students make posters demonstrating the safety issues related to workplace safety, cleanup, and substance abuse. The poster should include general safety for all welding applications and one specific safety issue about a specific welding application. For example, a student may wish to list the importance of perimeter guards on welding robot cells. The poster should be informative, easy to read, and contain up-to-date graphics on welding.

Competency 2: Identify and apply safety around Manufacturing operations. (DOK 1) SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, MOT, MHT, MFA, MBL, MGO, WSS, WOC, BMP, SWS, PAC, GFM, TFM, PTM, CPM

Suggested Objectives

a. Use proper safety practices when welding or working around Manufacturing operations.
b. Use proper safety practices when welding in or near trenches and excavations.
c. Explain the term "proximity work."

Suggested Teaching Strategies

- Explain and give examples of hazards in the welding shop area, and explain that the work area needs to be free of combustible material such as paper (refer to competency 6). Have students take notes in their journals about the shop hazards for recitation at a later date in the semester. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5
- Discuss the hazards of working in confined spaces such as trenches and excavations. Discuss how flammable gases will settle in a low area such as a dug-out pit where welding may be taking place. Explain that the gases may accumulate and become explosive, which will in turn hurt or kill workers in the confined area. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, S1, S2, S3, M1, M2, M3, M4, M5, M6, M7, M8, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Discuss how large a person's work area should be and the extreme importance of welding in the proximity of hazardous or flammable material. Explain that welding near expensive equipment may burn paint due to weld splatter or cause other aesthetic damage to nearby items resulting in repair costs to the welding company. You may elaborate on how welding over objects will cause them to become showered in weld droppings that may burn or cause abrasive damage to equipment located below the weld zone. Have students make notes in their journals about work proximity. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5

Suggested Assessment Strategies

- Have students set up items around a welding area (floor or tabletop) to determine the area of weld splatter. The items can be plastic, painted metal, cardboard, and so forth. Set up a welder, and perform some welds so that the students can see how far sparks may travel from the immediate weld area. After welding a few pads, have students collect the items, and let them discuss the damage that was caused by welding proximity.

  Note: Make sure the students are a safe distance away so they do not get burned, and also make sure they have eye protection.
- Have students set up a welding area project in the shop. Let them determine if the weld area is safe and if proximity is an issue. You may want to purposefully put items in the area that will cause problems. Allow each student to explain why his or her area is or is not a safe area due to work space proximity.

Competency 3: Identify and explain use of various barriers and confinements. (DOK 2) SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, MOT, MHT, MFA, MBL, MGO, WSS, WOC, BMP, SWS, PAC, GFM, TFM, PTM, CPM

Suggested Objectives

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 personal protective equipment (PPE).

Suggested Teaching Strategies

- Discuss the different types of barricades and why confined space is so dangerous in a welding environment. R1, R2, W1
- Discuss the procedures for lock-out/tag-out. Show the video on lock-out/tag-out available through the RCU video library. Take the students into the shop area, and demonstrate how to apply lock-out/tag-out. Have each student perform the task and write the steps in their journals. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5
- Lay out personal protective equipment (PPE) on a shop table, and discuss what each item is used for. Items for discussion may include welding gloves, pliers, safety glasses, welding shield, and grinding face shield. Have students inspect the equipment and report on the condition of the PPE. Allow students to try on and handle all the equipment so they understand proper use and what the equipment is designed to protect. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, S1, S2, S3

Suggested Assessment Strategies

- Have students set up a welding project in the shop, and then have them explain if the work area is in a confined location or if there is any danger from fire or health hazards. Ask the students to make suggestions about how to fix or clean up the area so work can begin on the project. Do not allow the students to actually begin work before eliminating hazards.
- Give students a piece of personal protective equipment (PPE), such as a face shield, and let them explain how to properly don the device while actually putting it on. Then have the students explain what part of the body the device protects and how it should be used in the welding environment. Also have the students discuss if the PPE is safe to use or if new PPE should be purchased.
- Select an electrical disconnect switch or other device in the shop, and have the students follow the steps to properly lock out the device. Allow students to turn off the power switch and apply the locking device and tag while simultaneously explaining the process steps.

Competency 4: Explain lifting and the use of ladders and scaffolds. (DOK 2) SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, MOT, MHT, MFA, MBL, MGO, WSS, WOC, BMP, SWS, PAC, GFM, TFM, PTM, CPM, ALG4

Suggested Objectives

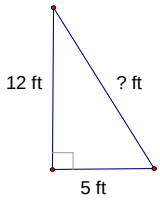
a. Identify and explain the procedures for lifting heavy objects.
b. Inspect and safely work with various ladders and scaffolds.

Suggested Teaching Strategies

- Demonstrate how to lift heavy objects using the legs, not the back, and demonstrate how to team lift heavy objects. Have students research back injuries using the Internet or other media. Students should give an oral or written report on back, arm, and leg injuries caused by improper lifting. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, S1, S2, S3, M1, M2, M3, M4, M5, M6, M7, M8, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6

- Show the students how to properly erect a ladder and/or scaffold in the shop area. Then discuss the dangers of misusing the tools.

- Have students solve for the missing side of a right triangle using the Pythagorean theorem. For example, a construction worker needs a ladder to reach the top of a building that is 12 ft high. The ladder will safely rest on the ground 5 ft from the bottom of the building. How long should the worker let out the ladder?



Suggested Assessment Strategies

- Have students practice, under supervision, how to lift objects. For example, use an empty copy paper box, and watch for proper foot, leg, and back placement. As students lift objects, they should explain what is happening in their bodies and the dangers of improper lifting. For instance, they may feel a tightening in the leg muscles as a heavy box is lifted from the ground to waist level.
- Allow students to set up a ladder/scaffold for use. Then check the equipment to verify that the students properly set the equipment in place correctly. **DO NOT** allow students to climb on unchecked equipment prior to instructor inspection.

Competency 5: Explain the material safety data sheet (MSDS). (DOK 1) SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, MOT, MHT, MFA, MBL, MGO, WSS, WOC, BMP, SWS, PAC, GFM, TFM, PTM, CPM

Suggested Objectives

a. Explain the function of the MSDS.
b. Interpret the requirements of the MSDS.

Suggested Teaching Strategies

- Discuss the legal requirements of employers to keep and maintain an MSDS file of all chemicals used in the workplace. Show the students where to find the MSDS sheet for the shop lab. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Give students an example of an MSDS sheet that is associated with a chemical used in the welding shop such as anti-splatter compound or welding electrodes. Show the students where to find the emergency information and what is recommended in various emergency situations such as ingestion or contact with the eyes. Have students research and orally report on chemical spills and how to perform the proper cleanup. R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Provide the students with emergency contact information such as ambulance service and the American Association of Poison Control Centers.

Suggested Assessment Strategies

- Break the students into groups, and give each group an MSDS sheet. Let them locate the emergency information and what is to be done in the event of an emergency.
- Give the students a selection of MSDS sheets and have them locate the items in the shop, or give the students an item and have them select the MSDS from a selection of documents.

Competency 6: Explain fires. (DOK 2) SAF, MAT, HTO, PTO, BLU, MBR, COM, MOT, MHT, MFA, MBL, MGO, WSS, WOC, BMP, SWS, PAC, GFM, TFM, PTM, CPM

Suggested Objectives

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.

Suggested Teaching Strategies

- Discuss the triangle of fire and the requirements needed to create a fire: fuel, oxygen, and heat. Make sure the students keep these notes in their daily journals. Using the Internet or news media, have the students research and find fires that were caused by a welding operation. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, T1, T2, T3, T4, T5, T6
- Go into the shop, and demonstrate how easily a fire can start. Light an oxy-fuel torch, and heat a small piece of scrap iron such as angle or flat iron. Place the heated piece on a small square of cardboard. Allow the cardboard to begin smoking, possibly letting it ignite, to demonstrate how easily a fire can start in the work area.
- Discuss the types of fires and the fire extinguishers needed to extinguish the relative fire. Have the students note where fire extinguishers are located throughout the school campus and report during class. Have them tell where the extinguisher is located and what type of fire it is intended to be used to extinguish. R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5

Suggested Assessment Strategies

- Allow the students to walk around the school building (instructor supervised) and find fire extinguishers and what types of fires they are used to fight. Give the students a sample fire extinguisher inspection tag (found at the end of this unit). Have the students fill out the tag and report where the fire extinguisher is located.
  WARNING: If your school's administration does not regularly inspect and maintain the fire extinguishers, this may not be a good exercise.
- After returning to the classroom, break the students into two groups. Have students discuss how the firefighting equipment varies from one area to another, if it varies at all. If there is no difference, allow the students to determine what extinguishers might be better to use in the shops.

Competency 7: Explain safety in and around electrical situations. (DOK 3) SAF, MAT, HTO, PTO, BLU, MBR, COM, MOT, MHT, MFA, MBL, MGO, WSS, WOC, BMP, SWS, PAC, GFM, TFM, PTM, CPM

Suggested Objectives

a. Explain injuries when electrical contact occurs.
b. Explain safety around electrical hazards.
c. Explain actions to take when an electrical shock occurs.

Suggested Teaching Strategies

- Show students a safety video on electrical safety. Numerous safety videos are available through the RCU Media Center. Discuss how electrical shock occurs in the welding profession. Discuss how much current is needed to cause death in an individual with average health. Have the students research electrical shock to determine how much current is needed to kill an average-sized person in good health. Then have them report to the class on electrical

shock. R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6

- Discuss how cardiopulmonary resuscitation (CPR) can be used to massage the heart in an electrical shock victim until medics arrive. Also include discussions about electrical burns and how to properly care for those victims. Have students use the Internet to research electrical shock and burns and report on the severity of burns that can occur due to electrical shock or arc blow. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6

Suggested Assessment Strategies

- Have the students research electrical shock using the Internet. Then have students make safety posters illustrating electrical shock prevention. The posters should include metal trade dangers and common electrical hazards on the job. Residential safety is important but not appropriate for this exercise. Hang the posters in the classroom so that each student can see others' views of electrical safety.
- The students should properly hook up the grounds of a welding unit and discuss how electrocution can take place if improper grounds are used or when welding in a wet environment.

Standards

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CS2 Initiative and Self-direction
CS3 Social and Cross-cultural Skills
CS4 Productivity and Accountability
CS5 Leadership and Responsibility

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E2 Organization, Unity, and Coherence
E3 Word Choice in Terms of Style, Tone, Clarity, and Economy
E4 Sentence Structure and Formation
E5 Conventions of Usage
E6 Conventions of Punctuation
M1 Basic Operations and Applications
M2 Probability, Statistics, and Data Analysis
M3 Numbers: Concepts and Properties
M4 Expressions, Equations, and Inequalities
M5 Graphical Representations
M6 Properties of Plane Figures
M7 Measurement
M8 Functions
R1 Main Ideas and Author's Approach
R2 Supporting Details
R3 Sequential, Comparative, and Cause–Effect Relationships
R5 Meaning of Words
R6 Generalizations and Conclusions
S1 Interpretation of Data
S2 Scientific Investigation
S3 Evaluation of Models, Inferences, and Experimental Results
W1 Expressing Judgments
W2 Focusing on the Topic
W3 Developing a Position
W4 Organizing Ideas
W5 Using Language

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EMP - Basic Employability Skills
MOT - Orientation to the Trade
MHT - Millwright Hand Tools
MFA - Fasteners and Anchors
MBL - Basic Layout
MGO - Gaskets and O-rings
WOC - Oxy-fuel Cutting
BMP - Base Metal Preparation
WQT - Weld Quality
SWS - Equipment and Setup (SMAW)
PAC - Plasma Arc Cutting (PAC)
GFM - Equipment and Filler Metals (GMAW and FCAW)
TFM - Equipment and Filler Metals (GTAW)
PTM - Preheating and Post-weld Heat Treatment of Metals
CPM - Physical Characteristics and Mechanical Properties of Metals

National Educational Technology Standards

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T5 Digital Citizenship
T6 Technology Operations and Concepts

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Unit 10: Advanced Lathe Operation

Competency 1: Describe safety precautions, methods for measuring thread pitch diameters, and calculation of dimensions using taper formulas. (DOK 2) SAF, MAT, BLU, COM, MOT, MBL, MIM, MIB, MST, MPT, MRG, MAM

Suggested Objectives

a. Describe safety precautions.
b. Describe methods for measuring thread pitch diameters.
c. Calculate dimensions using taper formulas.

Suggested Teaching Strategies

- The instructor will present a video on the given task. The student will develop several questions and answers from the video. E1
- The instructor will demonstrate identification and interpretation of the specific task concerns. The student will utilize a variety of resources to write a report to identify and interpret task concerns. E1, E2, E3, E5, E8, E9, E10
- Divide the students into groups and assign each group a specific task. Have each group construct a poster listing components and the diagram of the task. E4, E3, E5
- Actual pictures from the lab will be shown and discussed about the specific task. The students will perform each task assigned

Suggested Assessment Strategies

- The questions and answers will be evaluated for content and clarity.
- A report will be presented to the class. A rubric will be used to evaluate the presentation.
- Evaluate the poster for content and clarity.
- A checklist will be used to evaluate the task.

Competency 2: Perform various operations according to specifications. (DOK 2) SAF, MAT, BLU, COM, MOT, MBL, MIM, MIB, MST, MPT, MRG, MAM

Suggested Objectives

a. Perform chamfer, recessing, knurling, drill and recess a hole, align and start a tap using a lathe center, and cutoff.
b. Perform turning a taper with taper attachment, turning a taper with compound, boring, cutting external threads to relief, pick up threads, and cutting internal threads.

Suggested Teaching Strategies

- Perform chamfer, recessing, knurling, drill and recess a hole, align and start a tap using a lathe center, and cutoff.
- Perform turning a taper with taper attachment, turning a taper with compound, boring, cutting external threads to relief, pick up threads, and cutting internal threads.

Suggested Assessment Strategies

- A written test will be given for the terminology.
- A checklist will be used to observe the students while they are performing safety inspections and operation procedures to complete a given task.

Standards

21st Century Skills Standards

CS1 Flexibility and Adaptability
CS2 Initiative and Self-direction
CS3 Social and Cross-cultural Skills
CS4 Productivity and Accountability
CS5 Leadership and Responsibility

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E2 Organization, Unity, and Coherence
E3 Word Choice in Terms of Style, Tone, Clarity, and Economy
E4 Sentence Structure and Formation
E5 Conventions of Usage
E6 Conventions of Punctuation
M1 Basic Operations and Applications
M2 Probability, Statistics, and Data Analysis
M3 Numbers: Concepts and Properties
M4 Expressions, Equations, and Inequalities
M5 Graphical Representations
M6 Properties of Plane Figures
M7 Measurement
M8 Functions
R1 Main Ideas and Author's Approach
R2 Supporting Details
R3 Sequential, Comparative, and Cause–Effect Relationships
R5 Meaning of Words
R6 Generalizations and Conclusions
S1 Interpretation of Data
S2 Scientific Investigation
S3 Evaluation of Models, Inferences, and Experimental Results
W1 Expressing Judgments
W2 Focusing on the Topic
W3 Developing a Position
W4 Organizing Ideas
W5 Using Language

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SAF - Basic Safety
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HTO - Introduction to Hand Tools
PTO - Introduction to Power Tools
BLU - Introduction to Blueprints
MBR - Basic Rigging

COM - Basic Communication Skills
MOT - Orientation to the Trade
MHT - Millwright Hand Tools
MFA - Fasteners and Anchors
MBL - Basic Layout
MGO - Gaskets and O-rings
MIM - Intermediate Trade Math
MFS - Field Sketching
MIB - Intermediate Blueprint Reading
MST - Specialty Tools
MRG - Rigging
MAM - Advanced Trade Math
MPT - Precision Measuring Tools

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Suggested References

Textbooks

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Unit 11: Advanced Milling Operation

Competency 1: Explore vertical milling operations. (DOK 2) SAF, MAT, BLU, COM, MOT, MBL, MIM, MIB, MST, MPT, MRG, MAM

Suggested Objectives

a. Describe and apply safety rules.
b. Identify the types of milling machines and describe the major components.
c. Identify work-holding devices, cutting tools, tool holders, and other attachments.
d. Describe the different types of horizontal milling operations.

Suggested Teaching Strategies

- The instructor will present a video on the given task. The student will develop several questions and answers from the video. E1
- The instructor will demonstrate identification and interpretation of the specific task concerns. The student will utilize a variety of resources to write a report to identify and interpret task concerns. E1, E2, E3, E5, E8, E9, E10
- Divide the students into groups and assign each group a specific task. Have each group construct a poster listing components and the diagram of the task. E4, E3, E5
- Actual pictures from the lab will be shown and discussed about the specific task. The students will perform each task assigned

Suggested Assessment Strategies

- The questions and answers will be evaluated for content and clarity.
- A report will be presented to the class. A rubric will be used to evaluate the presentation.
- Evaluate the poster for content and clarity.
- A checklist will be used to evaluate the task.

Competency 2: Adjust speed and feed rates, clean and lubricate, mount arbors and adjust arbor support bushing, mount a cutter, mill a key-way, and perform selected horizontal operations. (DOK 2) SAF, MAT, BLU, COM, MOT, MBL, MIM, MIB, MST, MPT, MRG, MAM

Suggested Objectives

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.

Suggested Teaching Strategies

- Adjust machine speed and feed rates; clean and lubricate.
- Mount arbors and adjust arbor support bushing and mount a cutter according to specifications
- Perform selected operations according to specifications

Suggested Assessment Strategies

- A written test will be given for the terminology.
- A checklist will be used to observe the students while they are performing safety inspections and operation procedures to complete a given task.

Competency 3: Mount and remove cutters and cutter holders, align a vise using a dial indicator, and perform selected vertical milling and boring operations. (DOK 2) SAF, MAT, BLU, COM, MOT, MBL, MIM, MIB, MST, MPT, MRG

Suggested Objectives

a. Mount and remove cutters and cutter holders; mount and align a vise.
b. Perform selected milling and boring operations according to specifications.

Suggested Teaching Strategies

- Mount and remove cutters and cutter holders; mount and align a vise.
- Perform selected milling and boring operations according to specifications

Suggested Assessment Strategies

- A written test will be given for the terminology.
- A checklist will be used to observe the students while they are performing safety inspections and operation procedures to complete a given task.

Standards

21st Century Skills Standards

CS1 Flexibility and Adaptability
CS2 Initiative and Self-direction
CS3 Social and Cross-cultural Skills
CS4 Productivity and Accountability
CS5 Leadership and Responsibility

ACT College Readiness Standards

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E2 Organization, Unity, and Coherence
E3 Word Choice in Terms of Style, Tone, Clarity, and Economy
E4 Sentence Structure and Formation
E5 Conventions of Usage
E6 Conventions of Punctuation
M1 Basic Operations and Applications
M2 Probability, Statistics, and Data Analysis
M3 Numbers: Concepts and Properties
M4 Expressions, Equations, and Inequalities
M5 Graphical Representations
M6 Properties of Plane Figures
M7 Measurement
M8 Functions
R1 Main Ideas and Author's Approach
R2 Supporting Details
R3 Sequential, Comparative, and Cause–Effect Relationships
R5 Meaning of Words
R6 Generalizations and Conclusions
S1 Interpretation of Data
S2 Scientific Investigation
S3 Evaluation of Models, Inferences, and Experimental Results
W1 Expressing Judgments
W2 Focusing on the Topic
W3 Developing a Position
W4 Organizing Ideas
W5 Using Language

National Industry Standards

SAF - Basic Safety
MAT - Introduction to Construction Math
HTO - Introduction to Hand Tools
PTO - Introduction to Power Tools
BLU - Introduction to Blueprints
MBR - Basic Rigging

COM - Basic Communication Skills
MOT - Orientation to the Trade
MHT - Millwright Hand Tools
MFA - Fasteners and Anchors
MBL - Basic Layout
MGO - Gaskets and O-rings
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MFS - Field Sketching
MIB - Intermediate Blueprint Reading
MST - Specialty Tools
MRG - Rigging
MAM - Advanced Trade Math
MPT - Precision Measuring Tools

National Educational Technology Standards

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T5 Digital Citizenship
T6 Technology Operations and Concepts

Suggested References

Textbooks

Davis, D. (1996). *Practical problems in mathematics for manufacturing*. Albany, NY: Delmar.

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Unit 12: Power Machinery – Computerized Numerical Control

Competency 1: Describe computerized numerical control (CNC), including the codes and the input of a pre-written program. (DOK 2) SAF, MAT, BLU, COM, MOT, MBL, MIM, MIB, MST, MPT, MRG, MAM, PAC

Suggested Objectives

a. Describe the operations of CNC.
b. Describe codes used in a CNC machine.

Suggested Teaching Strategies

- Allow students to search the Internet to find videos on CNC operation. Discuss what the CNC machine is and how it is used in modern machine shops and mass production environments. Let the students research online sites to gain knowledge about CNC operation and safety. The following clip is a good example of what should be researched: http://www.youtube.com/watch?v=2ZqBf-93STg&NR=1. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Discuss the benefits of CNC machining versus manual machining methods. Discuss mass production of parts versus building machined parts one at a time using traditional machining methods. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, S1, S2, S3, M1, M2, M3, M4, M5, M6, M7, M8, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Describe the CNC programming code used in creating a machining program and how to set the machine up for automated machining. Have students go to the Internet and research actual programming code. Have them discuss the programming code and what it was intended to build. Pictures should be required for illustration of the workpiece. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Describe how to set up a CNC machine. Let the student research the CNC code using books or the Internet and then report to the class what the codes are actually used for when machining. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6

Suggested Assessment Strategies

- Ask the students to discuss orally various programming codes. Ask them a particular code, and have them elaborate on what the code means and what the machine will do when the code is executed.
- Have the students give oral discussions on the application of the CNC and its advantages over manual machines. Each student should discuss an advantage that other students have not covered.

Standards

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M5 Graphical Representations
M6 Properties of Plane Figures
M7 Measurement
M8 Functions
R1 Main Ideas and Author's Approach
R2 Supporting Details
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R5 Meaning of Words
R6 Generalizations and Conclusions
S1 Interpretation of Data
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S3 Evaluation of Models, Inferences, and Experimental Results
W1 Expressing Judgments
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MGO - Gaskets and O-rings
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MFS - Field Sketching
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MST - Specialty Tools
MRG - Rigging
MAM - Advanced Trade Math
MPT - Precision Measuring Tools
PAC - Plasma Arc Cutting (PAC)

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Unit 13: Gas Welding/Cutting Processes – Basic Oxy-fuel and Plasma Arc Cutting (PAC)

Competency 1: Identify and describe the basic equipment, setup, and safety rules for proper use of equipment, and prepare base metal for oxy-fuel welding and brazing. (DOK 3) SAF, MAT, HTO, PTO, BLU, MBR, COM, MOT, MHT, MFA, MBL, MGO, MOC, MIM, MFS, MIB, MST, MPT, MRG, WSS, WOC, BMP, JFA, WSY, RWD, PAC, PTM, CPM

Suggested Objectives

a. Identify and explain joint design and considerations.
b. Prepare base metal joints for welding, oxy-fuel welding, and brazing.
c. Properly secure portable gas cylinders and cutting equipment.
d. Set up oxy-fuel equipment.
e. Light and adjust the oxy-fuel cutting torch.
f. Properly shut down oxy-fuel equipment.
g. Perform the different types of cuts using an oxy-fuel torch.
h. Change out empty cylinders.

Suggested Teaching Strategies

- Demonstrate how to set up an oxy-fuel station for cutting and for brazing. Then demonstrate how to light and cut using an oxy-fuel cutting torch. Ask for student volunteers, and under close supervision, allow the students to ignite the torch and adjust the flame for the desired use.
- Demonstrate how to shut off the torch and store the hoses, torch body, striker, and goggles properly. Have a student ignite the torch, adjust the flame, and then demonstrate how to shut off the torch properly. Have students write down explicit directions for lighting and extinguishing the torch. Then have them read their directions aloud in class. After all students have read their instructional materials, allow them to try and light the torch according to their directions. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5
- Demonstrate how to change gas cylinders, where they are to be stored, and the safety issues associated with filled cylinders. Have students roll empty cylinders to get an idea of how to physically handle the large and bulky vessels. Once they have mastered moving empty cylinders, allow them to roll a full bottle of gas.

Suggested Assessment Strategies

- Give the students a regulator, hoses, and a torch body. Have the students retrieve the proper gas cylinders needed for an oxy-acetylene torch and store them safely in the cylinder cart or shop location for cutting. Then have the students attach and set up the proper gauge setting and torch setup for cutting.
- Give the students pieces of metal to be cut, and have the students select the proper cutting tip required to cut the workpieces. Once the tip has been selected, let the students properly ignite, adjust, and shut off the cutting torch. Make sure they check for gas leaks.
- Have the students light and adjust the cutting torch to cut a workpiece. Have the students demonstrate the steps to cut a piece of flat bar using a student-selected cutting tip.

Competency 2: Perform various operations of welding, oxy-fuel welding, and brazing using the proper equipment. (DOK 1) SAF, MAT, HTO, PTO, BLU, MBR, COM, MOT, MHT, MFA, MBL, MGO, MOC, MIM, MFS, MIB, MST, MPT, MRG, WSS, WOC, BMP, JFA, WSY, RWD, PAC, PTM, CPM

Suggested Objectives

a. Oxy-fuel weld in the flat position.

b. Braze in the flat position.

Suggested Teaching Strategies

- Show students different sizes of brazing tips used in the shop. Have students make detailed sketches of each tip with a written description of the size, shape, number of jets, and size of the jet hole. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5
- Demonstrate the proper way of igniting the torch by adjusting the appropriate gases. Then adjust the torch knobs for the desired flame. Also demonstrate the improper way of lighting and shutting off a torch so the students know what not to do. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, S1, S2, S3, M1, M2, M3, M4, M5, M6, M7, M8, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Insert the torch tip to cut a piece of metal using the cutting tip. Demonstrate how to cut horizontally and vertically in a piece of plate steel. Then demonstrate how to cut an angle using the cutting torch so that the angles form a rough 45° angle. Save the piece for a welding demonstration that will require two pieces to be welded at a 90° angle. Also demonstrate how to cut a straight line, piece and slot cuts, bevels, washing, and gouging. While making the cuts, you may want to explain the different types of cutting tips and their uses. Ask for a volunteer to try the predetermined cuts with the torch. Allow other students to observe as the student uses the cutting torch. Have each student write down the proper way to make the angle cuts in his or her journal for future reference. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5
- Insert the torch tip to braze two pieces of metal using the brazing tip. Demonstrate how to braze the pieces lying flat on a work surface. Show the different types of weld joints using examples from within the shop. Allow a student to try the brazing technique. Have all the students make notes of the proper procedure for using a brazing torch. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5

Suggested Assessment Strategies

- Have the students identify the proper tip for brazing a given project. Have students change the torch tips for proper brazing. Have students ignite, adjust, and shut off the flame for brazing.
- Have the students perform a brazing operation in the flat position on two pieces of metal. Have students perform two different brazing joints in a flat position.
- Give the students pieces of flat metal, and let them practice cutting lines, arcs, circles, and other shapes using the oxy-fuel cutting torch. Also, have them use the torch to cut angled bevels and gouges. The students should be required to select the appropriate cutting tip, change the tips, and set the gas regulators to the proper setting before cutting the workpiece.

Competency 3: Explain safety, and identify the major components. (DOK 2) SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, MHT, MFA, MBL, MGO, MOC, MIM, MFS, MIB, MST, MAM, WSS WOC, BMP, WQT, JFA, WSY, RW, PAC, GFM, GFP, TFM, TPW, PTM, CPM

Suggested Objectives

a. Identify and understand plasma arc cutting processes.
b. Identify plasma arc cutting equipment.

Suggested Teaching Strategies

- Identify the shop plasma arc cutting machine and the controls for the machine. The following Web site may be helpful in explaining how the plasma arc cutting gun works internally:

http://uk.youtube.com/watch?v=mJJydOxHwZU. Have students take notes on how to set up and ground the workpiece, start the arc, advance the gun, and end the arc. Have students use the Internet or other forms of media to learn how a plasma arc cutter works, the importance of electricity and air pressure, and about the durability of the machine. Then have students deliver an oral recitation of their research findings. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6

- Demonstrate how to disassemble the cutting torch and service consumable parts. Show the students the parts of the plasma arc cutting torch by disassembling the torch body and identifying each part of the torch. Have students take thorough notes in their daily journals listing how to change consumable parts of the cutting gun. Then have students use their notes to perform routine maintenance on the cutting guns by changing the tips, nozzles, insulators, and o-rings. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5
- Explain the difference between transfer arc and non-transfer arc processes. Have students take notes in their daily journals listing the differences between transfer arc and non-transfer arc processes in plasma arc cutting. Have students discuss what the processes are and how they are used in the welding trade. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5

Suggested Assessment Strategies

- Lay out a manual torch on the shop table, and have the students identify the parts of the plasma arc cutting torch. Require them to explain what each part does when in operation.
- Have the students practice changing the consumable parts on a plasma arc cutting torch.

Competency 4: Set up and perform operations using the plasma arc cutting process. (DOK 4) SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, MHT, MFA, MBL, MGO, MOC, MIM, MFS, MIB, MST, MAM, WSS WOC, BMP, WQT, JFA, WSY, RWD, PAC, GFM, GFP, TFM, TPW, PTM, CPM, GEO4

Suggested Objectives

a. Perform necessary setup.
b. Cut mild steel.

Suggested Teaching Strategies

- Demonstrate how to set up and use the plasma arc cutting machine by cutting 1/4-in. ferrous and nonferrous metal. Have students use the plasma cutter to cut a straight edge, 3-in. circle, and 2-in. square. Allow each student to use the cutter and then compare each student's ability by comparing the quality of cuts. Have students write essays of their experience using a plasma arc cutter in comparison to an oxy-fuel torch. Then have students share with the class their opinions of the two processes. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5
- Demonstrate how to hold the cutting torch safely. Discuss the importance of proper shielding and grounding during the high-voltage cutting process. Let the students practice holding the plasma arc cutting gun, and give feedback on how improper use may negatively affect the quality of the cut.

Suggested Assessment Strategies

- Have the students lay out, set up, and cut an assigned shape from a piece of 1/4-in. carbon steel plate using the plasma arc cutting machine.

Standards

21st Century Skills Standards

CS1 Flexibility and Adaptability
CS2 Initiative and Self-direction
CS3 Social and Cross-cultural Skills
CS4 Productivity and Accountability
CS5 Leadership and Responsibility

ACT College Readiness Standards

E1 Topic Development in Terms of Purpose and Focus
E2 Organization, Unity, and Coherence
E3 Word Choice in Terms of Style, Tone, Clarity, and Economy
E4 Sentence Structure and Formation
E5 Conventions of Usage
E6 Conventions of Punctuation
M1 Basic Operations and Applications
M2 Probability, Statistics, and Data Analysis
M3 Numbers: Concepts and Properties
M4 Expressions, Equations, and Inequalities
M5 Graphical Representations
M6 Properties of Plane Figures
M7 Measurement
M8 Functions
R1 Main Ideas and Author's Approach
R2 Supporting Details
R3 Sequential, Comparative, and Cause–Effect Relationships
R5 Meaning of Words
R6 Generalizations and Conclusions
S1 Interpretation of Data
S2 Scientific Investigation
S3 Evaluation of Models, Inferences, and Experimental Results
W1 Expressing Judgments
W2 Focusing on the Topic
W3 Developing a Position
W4 Organizing Ideas
W5 Using Language
W3 Developing a Position
W4 Organizing Ideas
W5 Using Language

National Industry Standards

SAF - Basic Safety
MAT - Introduction to Construction Math
HTO - Introduction to Hand Tools

PTO - Introduction to Power Tools
BLU - Introduction to Blueprints
MBR - Basic Rigging
COM - Basic Communication Skills
EMP - Basic Employability Skills
MOT - Orientation to the Trade
MHT - Millwright Hand Tools
MFA - Fasteners and Anchors
MBL - Basic Layout
MGO - Gaskets and O-rings
MOC - Oxy-fuel Cutting
MIM - Intermediate Trade Math
MFS - Field Sketching
MIB - Intermediate Blueprint Reading
MST - Specialty Tools
MRG - Rigging
MAM - Advanced Trade Math
MPT - Precision Measuring Tools
WSS - Welding Safety
WOC - Oxy-fuel Cutting
BMP - Base Metal Preparation
WQT - Weld Quality
JFA - Joint Fit-up and Alignment
WSY - Welding Symbols
RWD - Reading Welding Detail Drawings
PAC - Plasma Arc Cutting (PAC)
GFM - Equipment and Filler Metals (GMAW and FCAW)
GFP - GMAW and FCAW – Plate
TFM - Equipment and Filler Metals (GTAW)
TPW - Plate (GTAW)
PTM - Preheating and Post-weld Heat Treatment of Metals
CPM - Physical Characteristics and Mechanical Properties of Metals

National Educational Technology Standards

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T5 Digital Citizenship
T6 Technology Operations and Concepts

Suggested References

Textbooks

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Cary, H. (2002). *Modern welding technology* (5th ed.). Upper Saddle River, NJ: Prentice Hall.

Check, A., Krar, S., & Rapisarda, M. (1998). *Machine tool and manufacturing technology.* Albany, NY: Delmar.

Jeffus, L. (1997). *Welding principles and application* (4th ed.). Clifton Park, NY: Thompson Delmar Learning.

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Taylor, D. (1996). *Elementary blueprint reading for machinists* (4th ed.). Albany, NY: Delmar.

Walker, J. (2000). *Modern metalworking.* Tinley Park, IL: Goodheart-Willcox.

Associated Web Sites

Aragon, S. R. (Ed.). (n.d.). *Journal of Vocational Education Research.* Retrieved December 7, 2007, from http://scholar.lib.vt.edu/ejournals/JVER/

Blackboard Academic Suite. (n.d.). Retrieved December 7, 2007, from http://rcu.blackboard.com/webapps/portal/frameset.jsp

Dobbins, T. R. (Ed.). (n.d.). *Journal of Career and Technical Education.* Retrieved December 7, 2007, from http://scholar.lib.vt.edu/ejournals/JCTE/

E-School News. (n.d.). Retrieved December 7, 2007, from http://www.eschoolnews.com/news/top-news/index.cfm?i=50758

How stuff works. (n.d.). Retrieved December 3, 2007, from *http://www.howstuffworks.com/*

Kathy Schrock's guide for educators. (n.d.). In *Discovery Education*. Retrieved December 7, 2007, from http://school.discoveryeducation.com/schrockguide/

Massachusetts Institute of Technology. (n.d.). Introductory MIT courses. In *MIT open courseware*. Retrieved December 7, 2007, from http://ocw.mit.edu/OcwWeb/hs/intro-courses/introcourses/index.htm

Mississippi State University's Agricultural Information Science and Education. (n.d.). Lessons. In *Effective Teaching in Agriculture and Life Sciences*. Retrieved December 7, 2007, from http://www.ais.msstate.edu/TALS/lessons.html

Research and Curriculum Unit. (n.d.). Retrieved December 7, 2007, from http://info.rcu.msstate.edu/

Teacher Vision. (n.d.). Retrieved December 7, 2007, from http://www.teachervision.fen.com/

Tech Learning. (n.d.). Retrieved December 7, 2007, from http://techlearning.com

Walter, R. A. (Ed.). (n.d.). *Journal of Industrial Teacher Education*. Retrieved December 7, 2007, from http://scholar.lib.vt.edu/ejournals/JITE/

Weld Guru. (n.d.). Retrieved January 18, 2008, from http://www.weldguru.com/index.html

For additional references, activities, and Web resources, please refer to the Manufacturing Technology B.R.I.D.G.E. Web site: http://www.rcu.blackboard.com (available only to registered users).

Competency 1: Identify and explain safety, setup, weld cleanup, and maintenance of arc welding equipment. (DOK 3) SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, WSS, WOC, BMP, WQT, SWS, SES, SBF, GWB, JFA, WSY, RWD, PAC, GFM, GFP, PTM, CPM

Suggested Teaching Strategies

- Discuss the differences between the AC/DC welding settings as well as when to use each voltage type (http://uk.youtube.com/watch?v=2FL_WWsn244&feature=related). Show students where to find the AC/DC switch and how to set the machine to weld for either type of current. Using the Internet, assign students to research the uses of AC and DC current types in the welding profession. Have students write essays or give oral presentations about the subject. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, T1, T2, T3, T4, T5, T6
- Demonstrate how to properly set up, use, and maintain SMAW equipment when welding mild steel. Explain how to prepare the metal surfaces for welding when using SMAW. Show the students how to properly ground the workpiece, turn the machine on, set the weld heat, and weld a piece of mild steel. Have students write the steps of setting up and maintaining SMAW equipment in their daily notes so that they may refer to them in lab. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5
- Demonstrate the proper weld cleanup when welding with SMAW equipment. Demonstrate how to remove weld splatter and excess flux.

Suggested Assessment Strategies

- Have students properly set up SMAW welding equipment to weld an instructor-specified project. Then have the students perform various welds. For example, have the students make a butt weld using two pieces of 1/4-in. plate steel. After welding, have the students clean the weld joint of the assigned welding project.
- Have the students perform maintenance on SMAW equipment. For example, have them change out an electrode holder and ground clamp; check leads for breaks, cuts, or nicks in cable insulation; and clean the machine.
- Have the students reload the electrode into the electrode holder.

Competency 2: Identify and use procedures for joint fit-up and alignment. (DOK 1) SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, WSS, WOC, BMP, WQT, SWS, SES, SBF, GWB, JFA, WSY, RWD, PAC, GFM, GFP, PTM, CPM.

Suggested Objectives

a. Identify and explain job code specifications.
b. Use fit-up gauges and measuring devices to check joint fit-up.
c. Use plate fit-up tools to fit up joints.
d. Identify and explain distortion and how it is controlled.
e. Check for joint misalignment and poor fit-up.

Suggested Teaching Strategies

- Have an industry contact share with the class about quality welds and how joint fit affects

joint fit-up. If possible, get the industry representative to bring examples of bad welds. If the industry allows visits, you may be able to take the students to the industry jobsite and have them see quality applications as the industry representative discusses the importance of weld quality. The students should take notes on what the speaker says for future reference and for instructor quizzes. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, S1, S2, S3, M1, M2, M3, M4, M5, M6, M7, M8, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6

- Demonstrate how to use the fit-up devices to show the students how to gauge proper alignment (http://uk.youtube.com/watch?v=5o8e--7T-CE&feature=related). Using two pieces of iron pipe, explain how alignment is critical when welding on pipelines, shafts, and other linear objects. Let groups of two or three student volunteers attempt fitting pieces for tacking. Have them discuss issues with alignment. One of the group members should take notes while the other two align the pieces. Have each group orally present its opinions of fitting the workpieces. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5
- Demonstrate what a bad fit-up is and what is acceptable and what is not an acceptable fit-up. Using a straight piece of pipe or solid shaft, weld the two pieces together so that the two are not perfectly in line. After the piece cools, allow the students to roll the welded piece across the floor or tabletop to illustrate improper alignment of the linear axis. Have students use the Internet to research examples of misalignment in welding projects and the effects of misalignment on mechanical and structural projects. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6

Suggested Assessment Strategies

- Have students recall topics that industry contacts discussed in their visits. Let them discuss in their own words the importance of job performance and weld quality.
- Make some poorly aligned workpieces using an accurate blueprint. Have students inspect bad fit-ups and explain why they are bad fit-ups and what should have been done during the weld process to ensure a higher quality workpiece.
- Have students cut and align two pieces of metal for welding. Allow them to tack the pieces and then check the alignment. After the initial check, have the students completely weld the workpiece and explain if the workpiece is properly aligned. If the piece shrinks or moves due to cooling of the metal, have students explain why the piece did not align properly even though they tacked the sides in place prior to finishing the weld.

Competency 3: Identify and explain filler metal and selection of electrodes. (DOK 1) SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, WSS, WOC, BMP, WQT, SWS, SES, SBF, GWB, JFA, WSY, RWD, PAC, GFM, GFP, PTM, CPM

Suggested Objectives

a. Identify and explain the AWS/ASME filler metal classification system.
b. Explain the storage and control of filler metals.
c. Identify the factors that affect electrode selection.

Suggested Teaching Strategies

- Show students different welding rods, and discuss what the numbering system means. Then discuss the proper storage (moisture and exposure limits) of welding rods. Once you have discussed the types and proper storage of electrodes, explain the effects of contaminates on welding rods. Let students handle new electrodes and then handle contaminated electrodes for comparison. Have students write descriptions of the new versus the contaminated electrodes. They should write brief essays about how to visually determine if the electrodes

are contaminated.[E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5]

- Demonstrate what will happen when an oily welding rod is used in the welding process. Using a contaminated electrode, weld a pad, and allow the students to observe how the welding splatter reacts. Keeping the students at a safe distance from the radical weld splatter, have students observe the welding process while using contaminated electrodes. Then weld with a good electrode, and have students observe the weld splatter again. Before class ends, have students orally report on the variances in weld splatter when using contaminated versus good welding electrodes. Give students time to write notes in their journals about electrode contamination and excessive weld splatter.[E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5]

- Discuss the factors that determine proper electrode selection. Have students take concise notes on how to select the proper electrode for various welding applications. Give the students a welding scenario, and have them select the most appropriate electrode.[E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5]

Suggested Assessment Strategies

- Give the students an instructor-assigned project, and have them select the proper electrode to use. For example, give them a piece of rusted mild steel that must be butt welded. The students must properly prepare the metal and select the required electrode to complete the project.
- Have the students identify contaminated electrodes that are not useable. The electrode may be oily, broken flux, or wet. The students may be allowed to attempt a weld with the unusable electrode to demonstrate how the quality of the weld will be adversely affected by the contaminant.
- Give the students a scenario to decide which electrodes should be used to weld a V-groove 1/2 plate.

Competency 4: Construct various welds using different positions and electrodes. (DOK 4) [SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, WSS, WOC, BMP, WQT, SWS, SES, SBF, GWB, JFA, WSY, RWD, PAC, GFM, GFP, PTM, CPM, GEO4]

Suggested Objectives

a. Weld beads on plate in the flat position using E6010 and E7018 electrodes.
b. Make fillet welds in the horizontal position using E6010 and E7018 electrodes.
c. Make fillet welds in the vertical position using E6010 and E7018 electrodes.
d. Make fillet welds in the overhead position using E6010 and E7018 electrodes.

Suggested Teaching Strategies

- Demonstrate how to weld beads on 1/4-in. mild steel plate in the flat, horizontal position using E6010 and E7018 electrodes, and have students try to strike an arc and then run a short bead. Have students write down the steps for striking the arc, running the bead, and how to end the weld. They should write how the welding process feels and what to look for in a pool. The following links may help demonstrate the processes:[E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, S1, S2, S3, M1, M2, M3, M4, M5, M6, M7, M8, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6]
    - http://uk.youtube.com/watch?v=bpPNDgvXoO4
    - http://uk.youtube.com/watch?v=IqOdCpJOlcM
    - http://uk.youtube.com/watch?v=F3fDbL9MQ-Q&NR=1
    - http://www.youtube.com/watch?v=UU3kxquQATc
- Demonstrate how to make fillet welds on 1/4-in. mild steel plate in the horizontal, vertical,

and overhead positions using E6010 and E7018 electrodes. Allow the students to try welding in different positions. The students should successfully complete at least one weld per position.

Suggested Assessment Strategies

- Have the students perform a weld bead on 1/4-in. mild steel plate of varying contamination in the flat position.
- Have the students perform a weld bead on 1/4-in. mild steel plate of varying contamination in the horizontal, vertical, and overhead positions. You may have the students weld a simple box made of square steel plates. Attach the baseplate on the welding bench, and have the students weld the interior joints using various positions. Do not allow students to move the box while it is being welded.

Competency 5: Identify quality welds, and make various advanced welds in different positions. (DOK 3)
SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, WSS, WOC, BMP, WQT, SWS, SES, SBF, GWB, JFA, WSY, RWD, PAC, GFM, GFP, PTM, CPM, GEO4

Suggested Objectives

a. Identify and explain weld imperfections and their causes.
b. Identify and explain non-destructive examination practices.
c. Identify and explain welder qualification tests.
d. Explain the importance of quality workmanship.
e. Weld plate, V-butt with backing, using E7018 electrodes in the flat position.
f. Weld beads on plate using E7018 electrodes in the horizontal position.
g. Weld plate, V-butt with backing, using E7018 electrodes in the horizontal position.
h. Weld beads on plate using E7018 electrodes in the vertical position.
i. Weld plate, V-butt with backing, using E7018 electrodes in the vertical position.
j. Weld beads on plate using E7018 electrodes in the overhead position.
k. Weld plate, V-butt with backing, using E7018 electrodes in the overhead position.

Suggested Teaching Strategies

- Identify and explain weld imperfections and the causes by showing the students example poor welds in the shop. The following link may provide insight into striking an arc and the imperfections of the weld: http://uk.youtube.com/watch?v=F3fDbL9MQ-Q&NR=1. Use two mild steel plates welded together to illustrate how welding technique can affect quality. Then use the welded plates to demonstrate and explain destructive and non-destructive tests on welded pieces in the shop. Show students test coupons in the shop for weld test examples. Have students research the Internet to find video clips about SMAW welding. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Ask an industry contact to visit the class and discuss the importance of weld quality. Have students prepare questions before the visit. The students should ask good, in-depth questions during the presentation. It may be a good idea to give the questions to the presenter prior to his or her visit to the classroom. The students should then take notes to keep in their daily journals for testing purposes and future reference. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, S1, S2, S3, M1, M2, M3, M4, M5, M6, M7, M8, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Demonstrate welding beads on plate using E7018 electrodes in the flat, horizontal, vertical, and overhead positions. Allow the students to try welding in different positions. The students should try at least one weld per position.
- Demonstrate how to perform a weld on mild plate, V-butt with backing, using E7018

electrodes in the flat, horizontal, vertical, and overhead positions. Allow the students to try welding in different positions. The students should try at least one weld per position.

Suggested Assessment Strategies

- Have students make industry visits or contacts to determine what examination practices are used within the company.
- Have students demonstrate the flat, horizontal, vertical, and overhead weld positions in SMAW applications using an E7018 electrode.
- Use a checklist to observe the students while they are performing safety inspections and operation procedures to complete an assigned task. For example, have them complete a weld according to an instructor-made blueprint.

Competency 6: Weld various plates using various electrodes in different positions. (DOK 4) SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, WSS, WOC, BMP, WQT, SWS, SES, SBF, GWB, JFA, WSY, RWD, PAC, GFM, GFP, PTM, CPM, GEO4

Suggested Objectives

a. Weld plate, open V-butt-joint, using E6010 electrodes in the flat position.
b. Weld beads on plate using E6010 electrodes in the horizontal position.
c. Weld plate, open V-butt-joint, using E6010 electrodes in the horizontal position.
d. Weld beads on plate using E6010 electrodes in the vertical position.
e. Weld plate, open V-butt-joint, using E6010 electrodes in the vertical position.
f. Weld beads on plate using E6010 electrodes in the overhead position.
g. Weld plate, open V-butt-joint, using E6010 electrodes in the overhead position.

Suggested Teaching Strategies

- Demonstrate how to weld a plate, open V-butt-joint, using E6010 electrodes in the flat position. The students should fill out job sheets and take notes as they learn the process. They should note the feel and the "tricks" of starting, running, and ending the bead. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5

- Demonstrate how to weld beads on plate using E6010 electrodes in the horizontal, vertical, and overhead positions. Have the students try welding in different positions. The students should fill out job sheets and take notes as they learn the process. They should note the feel and the "tricks" of starting, running, and ending the bead. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5

- Demonstrate how to weld plate, open V-butt-joint, using E6010 electrodes in the horizontal, vertical, and overhead positions. Have the students try welding in different positions. The students should try at least one weld per position. The students should fill out job sheets and take notes as they learn the process. They should note the feel and the "tricks" of starting, running, and ending the bead. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5

Suggested Assessment Strategies

- On a shop table, have students demonstrate the flat, horizontal, vertical, and overhead weld positions in SMAW applications. The students should lay out, tack the material, and then finish welding the assigned project.
- Give students an instructor-made blueprint, and provide them with material. Allow the students to create the workpiece drawn on the blueprint.

Standards

21st Century Skills Standards

CS1 Flexibility and Adaptability
CS2 Initiative and Self-direction
CS3 Social and Cross-cultural Skills
CS4 Productivity and Accountability
CS5 Leadership and Responsibility

Mississippi Academic Standards

GEO4 Select and apply various strategies, tools, and formulas to calculate length, surface area, volume, and angle measurements.

ACT College Readiness Standards

E1 Topic Development in Terms of Purpose and Focus
E2 Organization, Unity, and Coherence
E3 Word Choice in Terms of Style, Tone, Clarity, and Economy
E4 Sentence Structure and Formation
E5 Conventions of Usage
E6 Conventions of Punctuation
M1 Basic Operations and Applications
M2 Probability, Statistics, and Data Analysis
M3 Numbers: Concepts and Properties
M4 Expressions, Equations, and Inequalities
M5 Graphical Representations
M6 Properties of Plane Figures
M7 Measurement
M8 Functions
R1 Main Ideas and Author's Approach
R2 Supporting Details
R3 Sequential, Comparative, and Cause–Effect Relationships
R5 Meaning of Words
R6 Generalizations and Conclusions
S1 Interpretation of Data
S2 Scientific Investigation
S3 Evaluation of Models, Inferences, and Experimental Results
W1 Expressing Judgments
W2 Focusing on the Topic
W3 Developing a Position
W4 Organizing Ideas
W5 Using Language

National Industry Standards

SAF - Basic Safety

MAT - Introduction to Construction Math
HTO - Introduction to Hand Tools
PTO - Introduction to Power Tools
BLU - Introduction to Blueprints
MBR - Basic Rigging
COM - Basic Communication Skills
EMP - Basic Employability Skills
WSS - Welding Safety
WOC - Oxy-fuel Cutting
BMP - Base Metal Preparation
WQT - Weld Quality
SWS - Equipment and Setup (SMAW)
SES - Electrodes and Selection (SMAW)
SBF - Beads and Fillet Welds (SMAW)
GWB - Groove Welds with Backing (SMAW)
JFA - Joint Fit-up and Alignment
WSY - Welding Symbols
RWD - Reading Welding Detail Drawings
PAC - Plasma Arc Cutting (PAC)
GFM - Equipment and Filler Metals (GMAW AND FCAW)
GFP - GMAW and FCAW – Plate
PTM - Preheating and Post-weld Heat Treatment of Metals
CPM - Physical Characteristics and Mechanical Properties of Metals

National Educational Technology Standards

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T5 Digital Citizenship
T6 Technology Operations and Concepts

Suggested References

Althouse, A., Turnquist, C., Bowditch, W., Bowditch, K., & Bowditch, M. (2003). *Modern welding*. Tinley Park, IL: Goodheart-Willcox.

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Taylor, D. (1996). *Elementary blueprint reading for machinists* (4th ed.). Albany, NY: Delmar.

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Associated Web Sites

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Weld Guru. Retrieved January 18, 2008, from http://www.weldguru.com/index.html

For additional references, activities, and Web resources, please refer to the Manufacturing Technology B.R.I.D.G.E. Web site: http://www.rcu.blackboard.com (available only to registered users).

Unit 15: Gas Welding/Cutting Processes – Gas Metal Arc Welding (GMAW) and Flux Core Arc Welding (FCAW)

Competency 1: Demonstrate and discuss safety procedures, applications, and the advantages and limitations, and identify the machine controls for GMAW and FCAW. (DOK 2) SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, MGO, MOC, MPT, MRG, WSS, WOC, BMP, WQT, JFA, WSY, RWD, PAC, GFM, GFP, PTM, CPM

Suggested Teaching Strategies

- Present videos on GMAW and FCAW welding procedures. Some videos may be obtained from the RCU Media Center or from Internet sources. The following links are excellent examples of GMAW and FCAW welding procedures: http://uk.youtube.com/watch?v=6B_5p4fIhbU&NR=1 and http://uk.youtube.com/watch?v=9iMNEZvGfNQ&feature=related. Have students make notes about how to use GMAW while viewing the videos and Internet links. Have students compare notes and discuss the proper method for this type of welding. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Demonstrate the proper setup of GMAW and FCAW welding machines, changing tips, nozzles, o-rings, and insulators. Have students take thorough notes in their daily journals listing how to change consumable parts of the welding gun. Then allow the students to use their notes to perform routine maintenance on the welding guns by changing the tips, nozzles, insulators, and o-rings. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Explain proper gas selection for welding various types of metals, and demonstrate how to change gas cylinders and properly adjust the flowmeter. The following links discuss proper gas selection and issues associated with gas flow and weld quality: http://uk.youtube.com/watch?v=kZZQU_6zSpk&NR=1 and http://uk.youtube.com/watch?v=MprZbIZO3OM&feature=related. Have students search for other welding video clips on the Internet, document the Web addresses, and share with the class. Have students write short paragraphs about the types of shielding gases used in GMAW and FCAW welding applications. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Discuss and demonstrate reversing polarity on the GMAW and FCAW welding machines. Allow students to handle different types of welding machines so they get a grasp of the variation in name brands, sizes, and so forth. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5,
- Explain the types of filler metals used in GMAW and FCAW welding applications. Have students call local vendors and acquire pricing quotes for GMAW and FCAW welding electrodes. Then have students research and discuss what types of filler materials are used to weld in the automotive industry. Have students write essays about how filler materials are used, where they are used, and what types of parent metals are used in welding with GMAW and FCAW. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6

Suggested Assessment Strategies

- Have students set up GMAW and FCAW welding machines for assigned projects. For example, assign students a project to weld two pieces using GMAW or FCAW processes.
- Have students set the proper gas flow rate and select proper filler metal for an assigned welding project.
- Use the **Written Report Rubric** to evaluate student reports.

Competency 2: Perform various welds according to specifications. (DOK 4) SAF, MAT, HTO, PTO, BLU, MBR, COM EMP, MGO, MOC, MPT, MRG, WSS, WOC, BMP, WQT, JFA, WSY, RWD, PAC, GFM, GFP, PTM, CPM, GEO4

Suggested Objectives

a. Perform GMAW welds (in the flat position).
   i. Fabricate a butt-joint weld.
   ii. Fabricate a lap-joint fillet weld.
   iii. Fabricate a T-joint fillet weld.
   iv. Fabricate a V-groove butt-joint weld in the flat and horizontal positions (vertical and overhead optional) according to specifications.

b. Perform FCAW welds.
   i. Fabricate a multi-pass fillet weld (vertical and overhead optional) according to specifications.
   ii. Fabricate a V-grooved butt-joint weld in the flat and horizontal positions (vertical and overhead optional) according to specifications.

Suggested Teaching Strategies

- Demonstrate how to fabricate a butt-joint, lap-joint, T-joint, and V-groove weld using GMAW and FCAW machines. As you demonstrate one type of joint, allow the students to try and weld the same. Have students take notes and write about their experience in their daily journals. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5
- Demonstrate how to fabricate a V-groove butt-joint weld in the flat and horizontal positions (vertical and overhead optional) according to specifications using GMAW and FCAW machines. Let the students attempt the welds as demonstrated. Have students take notes and write about their experience in their daily journals. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5
- Demonstrate how to fabricate a multi-pass fillet weld (vertical and overhead optional) according to specifications using GMAW and FCAW machines. Let the students attempt the welds as demonstrated. Have students take notes and write about their experience in their daily journals. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5

Suggested Assessment Strategies

- Have students construct a square box out of 1/4-in. mild steel plate to be welded solid. The box should be built on a table and not allowed to be moved during construction so that all positions must be used during the welding process. Hydrostatically check the box to find leaks. The correct weldment should not leak. This project will encompass horizontal, vertical, and overhead welds.
- Have students perform a pad weld for all positions using GMAW and FCAW machines. Require students to build a welded pad with at least three overlays on a piece of mild flat steel.

Standards

21st Century Skills Standards

CS1 Flexibility and Adaptability
CS2 Initiative and Self-direction
CS3 Social and Cross-cultural Skills
CS4 Productivity and Accountability
CS5 Leadership and Responsibility

Mississippi Academic Standards

GEO4 Select and apply various strategies, tools, and formulas to calculate length, surface area, volume, and angle measurements.

ACT College Readiness Standards

E1 Topic Development in Terms of Purpose and Focus
E2 Organization, Unity, and Coherence
E3 Word Choice in Terms of Style, Tone, Clarity, and Economy
E4 Sentence Structure and Formation
E5 Conventions of Usage
E6 Conventions of Punctuation
R1 Main Ideas and Author's Approach
R2 Supporting Details
R3 Sequential, Comparative, and Cause–Effect Relationships
R5 Meaning of Words
R6 Generalizations and Conclusions
W1 Expressing Judgments
W2 Focusing on the Topic
W3 Developing a Position
W4 Organizing Ideas
W5 Using Language

National Industry Standards

SAF - Basic Safety
MAT - Introduction to Construction Math
HTO - Introduction to Hand Tools
PTO - Introduction to Power Tools
BLU - Introduction to Blueprints
MBR - Basic Rigging
COM - Basic Communication Skills
EMP - Basic Employability Skills
MGO - Gaskets and O-rings
MOC - Oxy-fuel Cutting
MRG - Rigging
MPT - Precision Measuring Tools

WSS - Welding Safety
WOC - Oxy-fuel Cutting
BMP - Base Metal Preparation
WQT - Weld Quality
JFA - Joint Fit-up and Alignment
WSY - Welding Symbols
RWD - Reading Welding Detail Drawings
PAC - Plasma Arc Cutting (PAC)
GFM - Equipment and Filler Metals (GMAW and FCAW)
GFP - GMAW and FCAW – Plate
PTM - Preheating and Post-weld Heat Treatment of Metals
CPM - Physical Characteristics and Mechanical Properties of Metals

National Educational Technology Standards

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T5 Digital Citizenship
T6 Technology Operations and Concepts

Suggested References

Althouse, A., Turnquist, C., Bowditch, W., Bowditch, K., & Bowditch, M. (2003). *Modern welding*. Tinley Park, IL: Goodheart-Willcox.

Cary, H. (2002). *Modern welding technology* (5th ed.). Upper Saddle River, NJ: Prentice Hall.

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Associated Web Sites

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Walter, R. A. (Ed.). *Journal of Industrial Teacher Education*. Retrieved December 7, 2007, from http://scholar.lib.vt.edu/ejournals/JITE/

Weld Guru. Retrieved January 18, 2008, from http://www.weldguru.com/index.html

For additional references, activities, and Web resources, please refer to the Manufacturing Technology B.R.I.D.G.E. Web site: http://www.rcu.blackboard.com (available only to registered users).

Suggested Rubrics and Checklists

Written Report Rubric

NAME: DATE: PERIOD:

	Exemplary 4 Points	Accomplished 3 Points	Developing 2 Points	Beginning 1 Point	Score
Content	Clear thesis and focus that remain apparent	Thesis and focus that remain apparent	Addresses subject matter with minimal support	Does not focus on topic	
Grammar	Correct and effective use of grammar and mechanics	Occasional errors in use of grammar and mechanics	Problems in use of grammar and mechanics	Repeated errors in use of grammar and mechanics	
Organization	Ideas flow smoothly and logically with clarity and coherence.	Logical order and appropriate sequencing of ideas with adequate transition	Some evidence of an organizational plan or strategy	Lacks organization	
				Total	

Comments:

Competency 1: Identify proper safety procedures, principles, and parts; and perform a setup. (DOK 2)
SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, WSS, WOC, BMP, WQT, JFA, WSY, RWD, PAC, TFM, TPW, PTM, CPM

Suggested Objectives

a. Describe the different types of tungsten electrodes.
b. Identify the major controls on a machine.
c. Identify the parts of a torch and the functions of each.
d. Identify the different types of cups and the application of each.

Suggested Teaching Strategies

- Show videos attained from the RCU Media Center or from the Internet about GTAW welding procedures and machines. The following links are excellent examples of GTAW welding procedures: http://uk.youtube.com/watch?v=OfOqyqKR0IU&NR=1 and http://uk.youtube.com/watch?v=8y5WfhrDlbE. Have students make notes about how to use GTAW while viewing the videos and Internet links. Have students compare notes and discuss the proper method for this type of welding. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Take the students to the shop, and show them the control knobs and switches on the machines on the shop floor. Discuss why GTAW applications may be better than other methods of welding. Have students take thorough notes in their daily journals listing where the controls are and what purposes they serve. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5
- Show students the parts of the GTAW torch by disassembling the torch body and identifying each part of the torch. Have students take thorough notes in their daily journals listing how to change consumable parts of the welding gun. Then allow the students to use their notes to perform routine maintenance on the welding guns by changing the tips, nozzles, insulators, and o-rings. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5
- Identify and explain the use of GTAW shielding gases. Using the Internet, have students research the types of gases used in GTAW, the cost of the gases, and the types of parent metals these gases are used on. Have students make posters that depict gas requirements, uses, and so forth to be displayed in the classroom and shop area. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5, S1, S2, S3, M1, M2, M3, M4, M5, M6, M7, M8, CS1, CS2, CS3, CS4, CS5, T1, T2, T3, T4, T5, T6
- Set up the GTAW equipment in the shop, and demonstrate how to weld a single pad across a piece of mild steel. Allow a student volunteer to try and operate the GTAW machine to weld a straight pad across a workpiece.

Suggested Assessment Strategies

- Ask the students to recall important facts mentioned in the video presentation.
- Label the GTAW control panel using letters or numbers on sticky notes. Attach the letters to the knobs and switches of the machine. Ask the students to identify the parts of the GTAW control panel.
- Have students verbally explain why GTAW is used rather than other methods of welding.
- Take the torch body apart, and display the parts on a table. Have students identify each piece verbally and explain what the piece does.
- With a disassembled torch, have students properly assemble a GTAW torch explaining what each part does as they assemble the torch.

Competency 2: Perform various welds on plate steel. (DOK 4) SAF, MAT, HTO, PTO, BLU, MBR, COM, EMP, WSS, WOC, BMP, WQT, JFA, WSY, RWD, PAC, TFM, TPW, PTM, CPM, GEO4

Suggested Objectives

a. Run stringer beads in the flat and horizontal positions.
b. Fabricate a square groove butt-weld in the flat and horizontal positions.
c. Fabricate a T-joint fillet weld in the flat and horizontal positions.

Suggested Teaching Strategies

- Demonstrate stringer beads in various welding positions using a piece of flat mild steel. Have students watch the process while the welding operation is taking place. Have students take notes on how to set up the parent metals, start the arc, feed the filler metal (if applicable), and end the bead. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5
- Demonstrate welding beads with and without filler metal using GTAW on a piece of flat mild steel. Explain each step of the process as students watch. Students should take clear, thorough notes in their daily journals for future reference. The students should make sure they note the differences between welding with filler material and without filler material. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5
- Demonstrate a square groove butt-weld using two pieces of flat mild steel. Let the students attempt the welds as demonstrated. Have students take notes and write about their experience in their daily journals. E1, E2, E3, E4, E5, E6, R1, R2, R3, R4, R5, R6, W1, W2, W3, W4, W5

Suggested Assessment Strategies

- Administer a multiple-choice test using the Blackboard Learning System.
- Have students perform an open root V-groove weld with filler metal in the flat and horizontal positions.
- Have students perform a fusion weld without using filler metal on lap joints in the flat and horizontal positions.

Standards

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CS1 Flexibility and Adaptability
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CS5 Leadership and Responsibility

Mississippi Academic Standards

GEO4 Select and apply various strategies, tools, and formulas to calculate length, surface area, volume, and angle measurements.

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E3 Word Choice in Terms of Style, Tone, Clarity, and Economy
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E5 Conventions of Usage
E6 Conventions of Punctuation
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R3 Sequential, Comparative, and Cause–Effect Relationships
R5 Meaning of Words
R6 Generalizations and Conclusions
S1 Interpretation of Data
S2 Scientific Investigation
S3 Evaluation of Models, Inferences, and Experimental Results
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W3 Developing a Position
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BMP - Base Metal Preparation
WQT - Weld Quality
JFA - Joint Fit-up and Alignment
WSY - Welding Symbols
RWD - Reading Welding Detail Drawings
PAC - Plasma Arc Cutting (PAC)
TFM - Equipment and Filler Metals (GTAW)
TPW - Plate (GTAW)
PTM - Preheating and Post-weld Heat Treatment of Metals
CPM - Physical Characteristics and Mechanical Properties of Metals

National Educational Technology Standards

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T5 Digital Citizenship
T6 Technology Operations and Concepts

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For additional references, activities, and Web resources, please refer to the Manufacturing Technology B.R.I.D.G.E. Web site: http://www.rcu.blackboard.com (available only to registered users).

Student Competency Profile for Metal Fabrication

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 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 vocational/career technical center policies and procedures. (DOK 1)
	2	Describe employment opportunities and responsibilities. (DOK 2)
	3	Explore leadership skills and personal development opportunities provided for students by student organizations to include SkillsUSA. (DOK 2)
	4	Describe general safety rules for working in a shop/lab and industry. (DOK 1)
	5	Identify and apply safety around Manufacturing operations. (DOK 1)
	6	Explain lifting. (DOK 3)
	7	Explain the material safety data sheet (MSDS). (DOK 2)
	8	Explain fires. (DOK 1)
	9	Explain safety in and around Manufacturing and electrical situations. (DOK 2)
Unit 2: Math, Measuring Tools, and Instruments		
	1	Apply the four basic math skills with whole numbers, fractions, and percents. (DOK 1)
	2	Perform basic mathematical calculations related to machine shop operations. (DOK 1)
	3	Identify and perform functions using various measuring tools and instruments (micrometers, dial indicators, height gauge, and digital caliper). (DOK 2)
Unit 3: Introduction to Blueprints and Hand and Power Tools		
	1	Read, analyze, and design a blueprint. (DOK 2)
	2	Demonstrate the use and maintenance of various hand and power tools. (DOK 3)
Unit 4: Drill Press and Band Saw Theory and Operation		
	1	Identify and describe the safe operation of the types of power saws. (DOK 2)
	2	Identify and describe the types of drilling machines, including hand powered and drill press, and the rules for safe operation of each. (DOK 2)
Unit 5: Milling Machine Theory and Operation		
	1	Differentiate between the types of milling machines. (DOK 2)
	2	Identify the parts, cutting tools, and basic maintenance of a vertical milling machine. (DOK 2)

	3	Perform operations on a milling machine. (DOK 4)
Unit 6: Lathe Theory and Operation		
	1	Identify the parts, rules, and care of the metal lathe. (DOK 3)
	2	Perform procedures for a machining operation. (DOK 3)
Unit 7: Grinding Theory and Operation		
	1	Describe safety, magnetic chuck work, surface grinding operations, and reasons for truing and balancing a grinding wheel. (DOK 3)
	2	Perform maintenance operations to manufacturer's specifications and grinding operations to teacher's specifications. (DOK 4)
Unit 8: Orientation, Advanced Leadership, and Employability Skills		
	1	Describe local program and vocational center policies and procedures. (DOK 1)
	2	Describe employment opportunities and responsibilities. (DOK 2)
	3	Demonstrate the ability to follow verbal and written instructions and communicate effectively in on-the-job situations. (DOK 2)
Unit 9: Basic Safety (Review and Reinforcement)		
	1	Describe general safety rules for working in a shop/lab and industry. (DOK 1)
	2	Identify and apply safety around Manufacturing operations. (DOK 1)
	3	Identify and explain the use of various barriers and confinements. (DOK 2)
	4	Explain lifting and the use of ladders and scaffolds. (DOK 2)
	5	Explain the material safety data sheet (MSDS). (DOK 1)
	6	Explain fires. (DOK 2)
	7	Explain safety in and around electrical situations. (DOK 3)
Unit 10: Advanced Lathe Operation		
	1	Describe safety precautions, methods for measuring thread pitch diameters, and calculation of dimensions using taper formulas. (DOK 2)
	2	Perform various operations according to specifications. (DOK 2)
Unit 11: Advanced Milling Operation		
	1	Explore vertical milling operations.
	2	Adjust speed and feed rates, clean and lubricate, mount arbors and adjust arbor support bushing, mount a cutter, mill a key-way, and perform selected horizontal operations. (DOK 2)
	3	Mount and remove cutters and cutter holders, align a vise using a dial indicator, and perform selected vertical milling and boring operations. (DOK 2)
Unit 12: Power Machinery – Computerized Numerical Control		
	1	Describe computerized numerical control (CNC), including the codes and the input of a pre-written program. (DOK 2)

Unit 13: Gas Welding/Cutting Processes – Basic Oxy-fuel Cutting and Plasma Arc Cutting (PAC)		
	1	Identify and describe the basic equipment, setup, and safety rules for proper use of equipment, and prepare base metal for oxy-fuel welding and brazing. (DOK 3)
	2	Perform various operations of welding, oxy-fuel welding, and brazing using the proper equipment. (DOK 1)
	3	Explain safety, and identify the major components. (DOK 2)
	4	Set up and perform operations using the plasma arc cutting process. (DOK 4)
Unit 14: Gas Welding/Cutting Processes – Shielded Metal Arc Welding (SMAW)		
	1	Identify and explain safety, setup, weld cleanup, and maintenance of arc welding equipment. (DOK 3)
	2	Identify and use procedures for joint fit-up and alignment. (DOK 1)
	3	Identify and explain filler metal and selection of electrodes. (DOK 1)
	4	Construct various welds using different positions and electrodes. (DOK 4)
	5	Identify quality welds, and make various advanced welds in different positions. (DOK 3)
	6	Weld various plates using various electrodes in different positions. (DOK 4)
Unit 15: Gas Welding/Cutting Processes – Gas Metal Arc Welding (GMAW) and Flux Core Arc Welding (FCAW)		
	1	Demonstrate and discuss safety procedures, applications, and the advantages and limitations, and identify the machine controls for GMAW and FCAW. (DOK 2)
	2	Perform various welds according to specifications. (DOK 4)
Unit 16: Gas Welding/Cutting Processes – Introduction to Gas Tungsten Arc Welding (GTAW)		
	1	Identify proper safety procedures, principles, and parts; and perform a setup. (DOK 2)
	2	Perform various welds on plate steel. (DOK 4)

Recommended Tools and Equipment

First Year

Capitalized Items

Metal Fabrication Fundamentals

1. Boring bars set with holders: small, medium, and large (1)
2. 14-in. lathes with accessories (6)
3. Vernier caliper, 8 in. (1)
4. Vertical milling machines with vises (3)
5. Height gauge (1)
6. Gauge blocks (1 set)
7. Machinist's level (1)
8. Surface grinders (2)
9. Horizontal band saw (1)
10. Vertical band saw (1)
11. Hydraulic press, minimum 25 T (1)
12. Dividing head with tailstock (1)
13. Rotary table for milling machine (1)
14. Sander, belt (1)
15. Reamer, tapered, set, 5/8 in.–1 in. (1)
16. Reamer set, adjustable (6)
17. Sander, disk (1)
18. Micrometers, 0 in.–6 in. (1 set)
19. Drill, taper, set 5/8 in.–1 in. (1)
20. Drill press and mill tools (2)
21. Thread holder bars (4)

Non-capitalized Items

Metal Fabrication Fundamentals

1. Dial caliper, 8 in. (4)
2. Thread micrometer, 0 in.–2 in. (1)
3. Machinist rules, 6 in. (12)
4. Gauges, center, and edge combination (6)
5. Hook rule, 6 in. (6)
6. Edge finder (1)
7. Hole punches (1 set)
8. Drill bits, numbers, letters, fractions (1 set)
9. Transfer punches (1 set)
10. V blocks (1 set)
11. Parallels, 1 in.–3/8 in. (1 set)
12. Tap and die, English sets, include most common sizes in taper, plug, and bottom in NC and NF (2)
13. Tap and die, metric sets, include most common sizes in taper plug and bottom (2)

14. Oil cans (8)
15. Reamer, shell, set (1)
16. Scales, 12 in. (6)
17. Locking grip pliers (6)
18. Wrench, pipe, set, 6 in., 10 in., and 12 in. (1)
19. Hammers, ball-peen set, small, medium, and large (4)
20. Hammer, sledge, 10 lb (1)
21. Sets, counter (6)
22. Calipers, inside (6)
23. Calipers, outside (6)
24. Micrometers, 0 in.–1 in. (4)
25. Micrometers, digital (2)
26. Calipers, digital (2)
27. Dial indicators with magnetic base, graduated for 0.001 in., range 2 in. (2)
28. Depth micrometer, 0 in.–6 in. (1)
29. Angle blocks, 4 in., 6 in. (1)
30. Thread pitch gauge (1)
31. Carbide tool holders
    a) Turning (4)
    b) Threading (4)
    c) Facing (4)

Second Year

Capitalized Items

Gas Welding/Cutting Processes

1. Work bench with medium-duty vises (4)
2. Oxy-fuel burning table with dross pan and replaceable slats (4 ft by 8 ft by 31 in.) (1)
3. Exhaust system (1)
4. Guided bend testing machine (1)
5. Compressed air supply and accessories (minimum delivery 80 psi @ 8 cfm per station) (1)
6. Plasma arc cutting device with minimum 1/2 cutting depth (2)
7. Shielded metal arc welding machines (AC/DC—constant current 300 amp @ 60%) with cables and accessories (6)
8. Gas tungsten arc welding machine (AC/DC—constant current 300 amp @ 60%) with cables and accessories (1)
9. Gas metal arc welding machines (spray and short circuit) (DC—constant voltage 300 amp @ 100%) with cables, gun, and accessories (4)
10. Flux cored arc welding machine (DC—constant voltage 300 amp @ 100%) with cables, gun, and accessories (2)
11. Oxy-fuel gas cutting equipment with regulators, hoses, torch, tips, cart, and accessories (2 sets)
12. Machine oxy-fuel gas cutting equipment with regulators, hoses, torch, tips, rails or track, and accessories (1 set)
13. Safety glasses with side shields and a sanitizing cabinet (1 set)
14. Ironworker (1)

15. Pedestal grinders (2)
16. Large drill press (1)
17. Small drill press (1)
18. Portable handheld band saw (1)
19. Horizontal band saw, power cutoff (1)
20. Vertical band saw (1)

Non-capitalized Items

Gas Welding/Cutting Processes

1. First-aid kit (1)
2. Emergency eye wash station (1)
3. 8-in. C-clamps (10)
4. 4 1/2-in. right angle grinder (6)
5. 9-in. right angle grinder (2)
6. Work area protective screens (as required)
7. Framing squares, 24 in. by 18 in. (6)
8. Compressed air hoses, 50 in., with retractable reel (2)
9. Compressed air regulator (1)
10. Male and female quick couples and adaptors (as required)
11. Hose repair kit with crimping tool for oxy-fuel (1)
12. Leather jacket, cape, sleeves, or apron (6 sets)
13. Leather gloves (1 pair per student)
14. Burning goggles or face shields (5)
15. No. 5 filter plate/lens (5)
16. Clear cover plate/lens (5)
17. Welding helmets (10)
18. Welding lenses to match helmet, No. 10 shaded filter plate/lens (10)
19. Clear cover plate/lens (10)
20. Stainless steel wire brushes, 1 for every 2 students (10)
21. 16-oz ball-peen hammers (4)
22. Electric hand drill, 3/8-in. and 1/2-in. chuck (4)
23. Center punches (2 sets)
24. Metal scribes (12)
25. Steel dividers, radius maker, minimum 6 in. (12)
26. Steel tapes, minimum 10 ft (12)
27. Combination square sets (8)
28. English/metric steel bench rules (minimum 12 in.) (6)
29. Chipping hammers (12)
30. 10-in. mill files, half round bastard cut (10)
31. Cold chisels (1 set)
32. Adjustable wrenches, 12 in., 10 in., 8 in., 6 in. (1 set)
33. Tank wrenches (2)
34. 10-in. groove or slip-joint pliers (8)
35. 6-in. side or diagonal cutting pliers (4)
36. 6-in. needle-nose pliers (2)
37. 10-in. vise grips (4)

38. 10-in. vise grip clamps (4)
39. Allen or hex wrenches, up to 3/8 in. (6 sets)
40. Screwdrivers, flat head (1 set)
41. Screwdrivers, Phillips head (1 set)
42. Oxy-fuel friction lighters, with flints and tip cleaners (4)
43. Fillet gauges (4 sets)
44. Welding clamps (6)
45. Clamps, C, set (4 in.–12 in.) (2)

Recommended Instructional Aids

It is recommended that instructors have access to the following items:

1. Scientific calculator (1)
2. Cart, AV, for overhead projector (1)
3. Video/audio data projector (1)
4. Laptop computer (1)
5. Digital camera (1)
6. Digital scanner with optical character recognition (OCR) (1)
7. Interactive display board (1)

Appendix A: 21st Century Skills Standards[1]

CLS1 Flexibility and Adaptability
CLS2 Initiative and Self-direction
CLS3 Social and Cross-cultural Skills
CLS4 Productivity and Accountability
CLS5 Leadership and Responsibility

Today's life and work environments require far more than thinking skills and content knowledge. The ability to navigate the complex life and work environments in the globally competitive information age requires students to pay rigorous attention to developing adequate life and career skills.

CS 1 Flexibility and Adaptability

- Adapting to varied roles and responsibilities
- Working effectively in a climate of ambiguity and changing priorities

CS 2 Initiative and Self-Direction

- Monitoring one's own understanding and learning needs
- Going beyond basic mastery of skills and/or curriculum to explore and expand one's own learning and opportunities to gain expertise
- Demonstrating initiative to advance skill levels toward a professional level
- Defining, prioritizing, and completing tasks without direct oversight
- Utilizing time efficiently and managing workload
- Demonstrating commitment to learning as a lifelong process

CS 3 Social and Cross-Cultural Skills

- Working appropriately and productively with others
- Leveraging the collective intelligence of groups when appropriate
- Bridging cultural differences and using differing perspectives to increase innovation and the quality of work

CS 4 Productivity and Accountability

- Setting and meeting high standards and goals for delivering quality work on time
- Demonstrating diligence and a positive work ethic (e.g., being punctual and reliable)

CS 5 Leadership and Responsibility

- Using interpersonal and problem-solving skills to influence and guide others toward a goal
- Leveraging strengths of others to accomplish a common goal
- Demonstrating integrity and ethical behavior
- Acting responsibly with the interests of the larger community in mind

[1] *21st Century Skills.* (n.d.). Washington, DC: Partnership for 21st Century Skills.

Appendix B: Mississippi Academic Standards

SEVENTH-GRADE MATH

SGM1. Apply concepts of rational numbers and perform basic operations emphasizing the concepts of ratio, proportion, and percent with and without the use of calculators.

a. Use the order of operations to simplify and/or evaluate whole numbers (including exponents and grouping symbols). (DOK 1)
b. Solve problems involving addition, subtraction, multiplication, and division of rational numbers. Express answers in simplest form. (DOK 2)
c. Convert among decimals, fractions, mixed numbers, and percents. (DOK 1)
d. Evaluate and estimate powers and square roots of real numbers. (DOK 2)
e. Explain the relationship between standard form and scientific notation. (DOK 1)
f. Multiply and divide numbers written in scientific notation. (DOK 1)
g. Solve real-life problems involving unit price, unit rate, sales price, sales tax, discount, simple interest, commission, and rates of commission. (DOK 1)
h. Solve contextual problems requiring the comparison, ordering, and application of integers. (DOK 2)
i. Develop a logical argument to demonstrate the 'denseness' of rational numbers. (DOK 3)

SGM2. Develop and apply the basic operations of rational numbers to algebraic and numerical tasks. Create and apply algebraic expressions and equations.

a. Recognize, describe, and state the rule of generalized numerical and geometric patterns using tables, graphs, words, and symbols. (DOK 2)
b. Solve equations that represent algebraic and real-world problems using multiple methods including the real number properties. (DOK 1)
c. Formulate algebraic expressions, equations, and inequalities to reflect a given situation and vice versa. (DOK 2)
d. Complete a function table based on a given rule and vice versa. (DOK 1)
e. Identify the following properties using variables, and apply them in solving problems: (DOK 1)
    - Zero property of multiplication
    - Inverse properties of addition/subtraction and multiplication/division
    - Commutative and associative properties of addition and multiplication
    - Identity properties of addition and multiplication
    - Distributive properties of multiplication over addition and subtraction
f. Predict the shape of a graph from a function table. (DOK 2)

SGM3. Apply geometric relationships of angles, two- and three-dimensional shapes, and transformations.

a. Classify and compare three-dimensional shapes using their properties. (DOK 1)
b. Construct two-dimensional representations of three-dimensional objects. (DOK 2)
c. Justify the congruency or symmetry of two figures. (DOK 2)

d. Perform transformations (rigid and non-rigid motions) on two-dimensional figures using the coordinate plane. (DOK 2)
e. Create an argument using the Pythagorean theorem principles to show that a triangle is a right triangle. (DOK 2)
f. Construct and classify angles. (DOK 2)

SGM4. Apply appropriate techniques, tools, and formulas to determine measurements with a focus on real-world problems. Recognize that formulas in mathematics are generalized statements about rules, equations, principles, or other logical mathematical relationships.

a. Convert from one unit to another, perform basic operations, and solve real-world problems using standard (English and metric) measurements within the same system. (DOK 2)
b. Use formulas and strategies, such as decomposition, to compute the perimeter and area of triangles, parallelograms, and trapezoids and the circumference and area of circles and to find the area of more complex shapes. (DOK 2)
c. Develop and justify geometric formulas for volume and surface area of cylinders, pyramids, and prisms. (DOK 3)
d. Solve problems involving scale factors using ratios and proportions. (DOK 2)

SGM5. Organize and interpret data. Analyze data to make predictions.

a. Use proportions, estimates, and percentages to construct, interpret, and make predictions about a population based on histograms or circle graph representations of data from a sample. (DOK 2)
b. Determine how outliers affect mean, median, mode, or range. (DOK 2)
c. Construct and interpret line graphs, frequency tables, circle graphs, box-and-whisker plots, and scatterplots to generalize trends from given data. (DOK 2)
d. Determine probabilities through experimentation, simulation, or calculation. (Note: Make and test conjectures and predictions by calculating the probability of an event.) (DOK 2)

PRE-ALGEBRA

PRA1. Apply concepts and perform basic operations using real numbers in real-world contexts.

a. Define, classify, and order rational and irrational numbers and their subsets. (DOK 1)
b. Formulate and solve standard and real-life problems involving addition, subtraction, multiplication, and division of rational numbers. (DOK 2)
c. Apply the concepts of greatest common factor (GCF) and least common multiple (LCM) to monomials with variables. (DOK 2)
d. Simplify and evaluate expressions using order of operations, and use real number properties to justify solutions. (DOK 2)
e. Explain the rules of exponents related to multiplication and division of terms with exponents. (DOK 2)
f. Recognize and appropriately use exponential and scientific notation. (DOK 1)
g. Explain and use the inverse relationship between square roots and squares. (DOK 2)

PRA2. Apply properties to simplify algebraic expressions, solve linear equations and inequalities, and apply principles of graphing.

a. Simplify and evaluate numerical and algebraic expressions. (DOK 1)
b. Apply properties of real numbers with an emphasis on the distributive properties of multiplication over addition and subtraction. (DOK 1)
c. Solve and check equations and inequalities using one variable. (DOK 2)
d. Model inequalities (and their solutions) on a number line. (DOK 1)
e. Graph linear equations and non-linear equations ($y = x^2$) using multiple methods including t-tables and slope–intercept. (DOK 2)
f. Given a linear graph, identify its slope as positive, negative, undefined, or zero, and interpret slope as rate of change. (DOK 2)
g. Determine slope, x-intercept, and y-intercept from a graph and/or equation in slope-intercept or standard form. (DOK 1)
h. Add, subtract, and multiply monomials and binomials. (DOK 1)
i. Predict characteristics of a graph given an equation or t-table. (DOK 2)

PRA3. Identify and apply geometric principles to polygons, angles, and two- and three-dimensional figures.

a. Locate and identify angles formed by parallel lines cut by a transversal(s) (e.g., adjacent, vertical, complementary, supplementary, corresponding, alternate interior, and alternate exterior). (DOK 1)
b. Find missing angle measurements for parallel lines cut by a transversal(s) and for a vertex of a polygon. (DOK 1)
c. Explain the Pythagorean theorem, and apply it to solve routine and non-routine problems. (DOK 3)
d. Solve real-world and non-routine problems involving congruent and similar figures. (DOK 3)
e. Use two-dimensional representations (nets) of three-dimensional objects to describe objects from various perspectives. (DOK 2)

PRA4. Understand measurable attributes of objects, and apply various formulas in problem-solving situations.

a. Solve real-world application problems that include length, area, perimeter, and circumference using standard measurements. (DOK 2)
b. Develop, analyze, and explain methods for solving problems involving proportions, such as scaling and finding equivalent ratios. (DOK 3)
c. Use formulas and/or appropriate measuring tools to find length and angle measures (to appropriate levels of precision), perimeter, area, volume, and surface area of polygons, circles, spheres, cones, pyramids, and composite or irregular figures. (DOK 1)

PRA5. Interpret, organize, and make predictions about a variety of data using concepts of probability.

a. Use a given mean, mode, median, and range to summarize and compare data sets including investigation of the different effects that changes in data values have on these measures. (DOK 2)
b. Select the appropriate measures of central tendency for a particular purpose. (DOK 2)
c. Make and list conjectures by calculating probability for experimental or simulated contexts. (DOK 3)

d. Construct and interpret scatterplots to generalize trends from given data sets. (DOK 3)

TRANSITION TO ALGEBRA

TTA1. Understand relationships between numbers and their properties, and perform operations fluently.

a. Compare and contrast the subsets of real numbers. (DOK 1)
b. Simplify and evaluate expressions using order of operations, and use real number properties to justify solutions. (DOK 2)
c. Express, interpret, and compute numbers using scientific notation in meaningful contexts. (DOK 1)
d. Apply the concept of greatest common factor (GCF) and least common multiple (LCM) to monomials with variables. (DOK 2)
e. Use the inverse relationship to develop the concept of roots and perfect squares. (DOK 2)

TTA2. Understand, represent, and analyze patterns, relations, and functions.

a. Given a literal equation, solve for a specified variable of degree one. (DOK 1)
b. Explain and illustrate how changes in one variable may result in a change in another variable. (DOK 2)
c. Solve and check multistep equations and inequalities, including distributive property, variables on both sides, and rational coefficients. (DOK 2)
d. Use real-world data to express slope as a rate of change. (DOK 2)
e. Graph solutions to linear inequalities. (DOK 2)
f. Write linear equations given slope and y-intercept or two points. (DOK 2)
g. Identify domain, range, slope, and intercepts of functions. (DOK 1)
h. Develop generalizations to characterize the behaviors of graphs (linear, quadratic, and absolute value). (DOK 2)
i. Classify and determine degree of a polynomial and arrange polynomials in ascending or descending order of a variable. (DOK 1)
j. Apply ratios and use proportional reasoning to solve real-world algebraic problems. (DOK 2)
k. Add, subtract, multiply, and divide polynomial expressions. (DOK 1)
l. Analyze the relationship between *x* and *y* values, and determine whether a relation is a function. (DOK 2)

TTA3. Understand geometric principles of polygons, angles, and figures.

a. Apply the Pythagorean theorem to solve problems. (DOK 2)
b. Apply proportional reasoning to determine similar figures and find unknown measures. (DOK 2)

TTA4. Demonstrate and apply various formulas in problem-solving situations.

a. Solve real-world problems involving measurements (i.e., circumference, perimeter, area, volume, distance, temperature, etc.). (DOK 2)
b. Explain and apply the appropriate formula to determine length, midpoint, and slope of a segment in a coordinate plane (i.e., distance formula and Pythagorean theorem). (DOK 2)

TTA5. Interpret data.

a. Construct graphs, make predictions, and draw conclusions from tables, line graphs, and scatterplots. (DOK 3)

b. Use a given mean, mode, median, and range to summarize and compare data sets including investigation of the different effects that changes in data have on these measures of central tendency, and select the appropriate measures of central tendency for a given purpose. (DOK 2)
c. Calculate basic probability of experiments and simulations to make and test conjectures about results. (DOK 3)

ALGEBRA I

ALG1-1. Understand relationships between numbers and their properties, and perform operations fluently.

a. Apply properties of real numbers to simplify algebraic expressions, including polynomials. (DOK 1)
b. Use matrices to solve mathematical situations and contextual problems. (DOK 2)

ALG1-2. Understand, represent, and analyze patterns, relations, and functions.

a. Solve, check, and graph multistep linear equations and inequalities in one variable, including rational coefficients in mathematical and real-world situations. (DOK 2)
b. Solve and graph absolute value equations and inequalities in one variable. (DOK 2)
c. Analyze the relationship between *x* and *y* values, determine whether a relation is a function, and identify domain and range. (DOK 2)
d. Explain and illustrate how a change in one variable may result in a change in another variable and apply to the relationships between independent and dependent variables. (DOK 2)
e. Graph and analyze linear functions. (DOK 2)
f. Use algebraic and graphical methods to solve systems of linear equations and inequalities in mathematical and real-world situations. (DOK 2)
g. Add, subtract, multiply, and divide polynomial expressions. (DOK 1)
h. Factor polynomials by using greatest common factor (GCF), and factor quadratics that have only rational roots. (DOK 1)
i. Determine the solutions to quadratic equations by using graphing, tables, completing the square, the quadratic formula, and factoring. (DOK 1)
j. Justify why some polynomials are prime over the rational number system. (DOK 2)
k. Graph and analyze absolute value and quadratic functions. (DOK 2)
l. Write, graph, and analyze inequalities in two variables. (DOK 2)

ALG1-3. Understand how algebra and geometric representations interconnect and build on one another.

a. Apply the concept of slope to determine if lines in a plane are parallel or perpendicular. (DOK 2)
b. Solve problems that involve interpreting slope as a rate of change. (DOK 2)

ALG1-4. Demonstrate and apply various formulas in problem-solving situations.

a. Solve real-world problems involving formulas for perimeter, area, distance, and rate. (DOK 2)
b. Explain and apply the appropriate formula to determine length, midpoint, and slope of a segment in a coordinate plane. (i.e., distance formula and Pythagorean theorem). (DOK 2)
c. Represent polynomial operations with area models. (DOK 2)

ALG1-5. Represent, analyze, and make inferences based on data with and without the use of technology.

a. Draw conclusions and make predictions from scatterplots. (DOK 3)
b. Use linear regression to find the line-of-best fit from a given set of data. (DOK 3)

Appendix C: ACT College Readiness Standards

English

E1 Topic Development in Terms of Purpose and Focus

- Identify the basic purpose or role of a specified phrase or sentence.
- Delete a clause or sentence because it is obviously irrelevant to the essay.
- Identify the central idea or main topic of a straightforward piece of writing.
- Determine relevancy when presented with a variety of sentence-level details.
- Identify the focus of a simple essay, applying that knowledge to add a sentence that sharpens the focus or to determine if an essay has met a specified goal.
- Delete material primarily because it disturbs the flow and development of the paragraph.
- Add a sentence to accomplish a fairly straightforward purpose such as illustrating a given statement.
- Apply an awareness of the focus and purpose of a fairly involved essay to determine the rhetorical effect and suitability of an existing phrase or sentence or to determine the need to delete plausible but irrelevant material.
- Add a sentence to accomplish a subtle rhetorical purpose such as to emphasize, to add supporting detail, or to express meaning through connotation.
- Determine whether a complex essay has accomplished a specific purpose.
- Add a phrase or sentence to accomplish a complex purpose, often expressed in terms of the main focus of the essay.

E2 Organization, Unity, and Coherence

- Use conjunctive adverbs or phrases to show time relationship in simple narrative essays (e.g., then, this time, etc.).
- Select the most logical place to add a sentence in a paragraph.
- Use conjunctive adverbs or phrases to express straightforward logical relationships (e.g., first, afterward, and in response).
- Decide the most logical place to add a sentence in an essay.
- Add a sentence that introduces a simple paragraph.
- Determine the need for conjunctive adverbs or phrases to create subtle logical connections between sentences (e.g., therefore, however, and in addition).
- Rearrange the sentences in a fairly uncomplicated paragraph for the sake of logic.
- Add a sentence to introduce or conclude the essay or to provide a transition between paragraphs when the essay is fairly straightforward.
- Make sophisticated distinctions concerning the logical use of conjunctive adverbs or phrases, particularly when signaling a shift between paragraphs.
- Rearrange sentences to improve the logic and coherence of a complex paragraph.
- Add a sentence to introduce or conclude a fairly complex paragraph.

- Consider the need for introductory sentences or transitions, basing decisions on a thorough understanding of both the logic and rhetorical effect of the paragraph and essay.

E3 Word Choice in Terms of Style, Tone, Clarity, and Economy

- Revise sentences to correct awkward and confusing arrangements of sentence elements.
- Revise vague nouns and pronouns that create obvious logic problems.
- Delete obviously synonymous and wordy material in a sentence.
- Revise expressions that deviate from the style of an essay.
- Delete redundant material when information is repeated in different parts of speech (e.g., alarmingly startled).
- Use the word or phrase most consistent with the style and tone of a fairly straightforward essay.
- Determine the clearest and most logical conjunction to link clauses.
- Revise a phrase that is redundant in terms of the meaning and logic of the entire sentence.
- Identify and correct ambiguous pronoun references.
- Use the word or phrase most appropriate in terms of the content of the sentence and tone of the essay.
- Correct redundant material that involves sophisticated vocabulary and sounds acceptable as conversational English (e.g., “an aesthetic viewpoint” versus “the outlook of an aesthetic viewpoint”).
- Correct vague and wordy or clumsy and confusing writing containing sophisticated language.
- Delete redundant material that involves subtle concepts or that is redundant in terms of the paragraph as a whole.

E4 Sentence Structure and Formation

- Use conjunctions or punctuation to join simple clauses.
- Revise shifts in verb tense between simple clauses in a sentence or between simple adjoining sentences.
- Determine the need for punctuation and conjunctions to avoid awkward-sounding sentence fragments and fused sentences.
- Decide the appropriate verb tense and voice by considering the meaning of the entire sentence.
- Recognize and correct marked disturbances of sentence flow and structure (e.g., participial phrase fragments, missing or incorrect relative pronouns, or dangling or misplaced modifiers).
- Revise to avoid faulty placement of phrases and faulty coordination and subordination of clauses in sentences with subtle structural problems.
- Maintain consistent verb tense and pronoun person on the basis of the preceding clause or sentence.
- Use sentence-combining techniques, effectively avoiding problematic comma splices, run-on sentences, and sentence fragments, especially in sentences containing compound subjects or verbs.
- Maintain a consistent and logical use of verb tense and pronoun person on the basis of information in the paragraph or essay as a whole.
- Work comfortably with long sentences and complex clausal relationships within sentences, avoiding weak conjunctions between independent clauses and maintaining parallel structure between clauses.

E5 Conventions of Usage

- Solve such basic grammatical problems as how to form the past and past participle of irregular but commonly used verbs and how to form comparative and superlative adjectives.
- Solve such grammatical problems as whether to use an adverb or adjective form, how to ensure straightforward subject–verb and pronoun–antecedent agreement, and which preposition to use in simple contexts.
- Recognize and use the appropriate word in frequently confused pairs such as there and their, past and passed, and led and lead.
- Use idiomatically appropriate prepositions, especially in combination with verbs (e.g., long for and appeal to).
- Ensure that a verb agrees with its subject when there is some text between the two.
- Ensure that a pronoun agrees with its antecedent when the two occur in separate clauses or sentences.
- Identify the correct past and past participle forms of irregular and infrequently used verbs, and form present-perfect verbs by using “have” rather than “of.”
- Correctly use reflexive pronouns, the possessive pronouns “its” and “your,” and the relative pronouns “who” and “whom.”
- Ensure that a verb agrees with its subject in unusual situations (e.g., when the subject–verb order is inverted or when the subject is an indefinite pronoun).
- Provide idiomatically and contextually appropriate prepositions following verbs in situations involving sophisticated language or ideas.
- Ensure that a verb agrees with its subject when a phrase or clause between the two suggests a different number for the verb.

E6 Conventions of Punctuation

- Delete commas that create basic sense problems (e.g., between verb and direct object).
- Provide appropriate punctuation in straightforward situations (e.g., items in a series).
- Delete commas that disturb the sentence flow (e.g., between modifier and modified element).
- Use commas to set off simple parenthetical phrases.
- Delete unnecessary commas when an incorrect reading of the sentence suggests a pause that should be punctuated (e.g., between verb and direct object clause).
- Use punctuation to set off complex parenthetical phrases.
- Recognize and delete unnecessary commas based on a careful reading of a complicated sentence (e.g., between the elements of a compound subject or compound verb joined by “and”).
- Use apostrophes to indicate simple possessive nouns.
- Recognize inappropriate uses of colons and semicolons.
- Use commas to set off a nonessential/nonrestrictive appositive or clause.
- Deal with multiple punctuation problems (e.g., compound sentences containing unnecessary commas and phrases that may or may not be parenthetical).
- Use an apostrophe to show possession, especially with irregular plural nouns.
- Use a semicolon to indicate a relationship between closely related independent clauses.
- Use a colon to introduce an example or an elaboration.

Math

M1 Basic Operations and Applications

- Perform one-operation computation with whole numbers and decimals.
- Solve problems in one or two steps using whole numbers.
- Perform common conversions (e.g., inches to feet or hours to minutes).
- Solve routine one-step arithmetic problems (using whole numbers, fractions, and decimals) such as single-step percent.
- Solve some routine two-step arithmetic problems.
- Solve routine two-step or three-step arithmetic problems involving concepts such as rate and proportion, tax added, percentage off, and computing with a given average.
- Solve multi-step arithmetic problems that involve planning or converting units of measure (e.g., feet per second to miles per hour).
- Solve word problems containing several rates, proportions, or percentages.
- Solve complex arithmetic problems involving percent of increase or decrease and problems requiring integration of several concepts from pre-algebra and/or pre-geometry (e.g., comparing percentages or averages, using several ratios, and finding ratios in geometry settings).

M2 Probability, Statistics, and Data Analysis

- Calculate the average of a list of positive whole numbers.
- Perform a single computation using information from a table or chart.
- Calculate the average of a list of numbers.
- Calculate the average, given the number of data values and the sum of the data values.
- Read tables and graphs.
- Perform computations on data from tables and graphs.
- Use the relationship between the probability of an event and the probability of its complement.
- Calculate the missing data value, given the average and all data values but one.
- Translate from one representation of data to another (e.g., a bar graph to a circle graph).
- Determine the probability of a simple event.
- Exhibit knowledge of simple counting techniques.*
- Calculate the average, given the frequency counts of all the data values.
- Manipulate data from tables and graphs.
- Compute straightforward probabilities for common situations.
- Use Venn diagrams in counting.*
- Calculate or use a weighted average.
- Interpret and use information from figures, tables, and graphs.
- Apply counting techniques.
- Compute a probability when the event and/or sample space is not given or obvious.
- Distinguish between mean, median, and mode for a list of numbers.
- Analyze and draw conclusions based on information from figures, tables, and graphs.
- Exhibit knowledge of conditional and joint probability.

M3 Numbers: Concepts and Properties

- Recognize equivalent fractions and fractions in lowest terms.
- Recognize one-digit factors of a number.
- Identify a digit's place value.

- Exhibit knowledge of elementary number concepts including rounding, the ordering of decimals, pattern identification, absolute value, primes, and greatest common factor.
- Find and use the least common multiple.
- Order fractions.
- Work with numerical factors.
- Work with scientific notation.
- Work with squares and square roots of numbers.
- Work problems involving positive integer exponents.*
- Work with cubes and cube roots of numbers.*
- Determine when an expression is undefined.*
- Exhibit some knowledge of the complex numbers.†
- Apply number properties involving prime factorization.
- Apply number properties involving even/odd numbers and factors/multiples.
- Apply number properties involving positive/negative numbers.
- Apply rules of exponents.
- Multiply two complex numbers.†
- Draw conclusions based on number concepts, algebraic properties, and/or relationships between expressions and numbers.
- Exhibit knowledge of logarithms and geometric sequences.
- Apply properties of complex numbers.

M4 Expressions, Equations, and Inequalities

- Exhibit knowledge of basic expressions (e.g., identify an expression for a total as b + g).
- Solve equations in the form x + a = b, where a and b are whole numbers or decimals.
- Substitute whole numbers for unknown quantities to evaluate expressions.
- Solve one-step equations having integer or decimal answers.
- Combine like terms (e.g., 2x + 5x).
- Evaluate algebraic expressions by substituting integers for unknown quantities.
- Add and subtract simple algebraic expressions.
- Solve routine first-degree equations.
- Perform straightforward word-to-symbol translations.
- Multiply two binomials.*
- Solve real-world problems using first-degree equations.
- Write expressions, equations, or inequalities with a single variable for common pre-algebra settings (e.g., rate and distance problems and problems that can be solved by using proportions).
- Identify solutions to simple quadratic equations.
- Add, subtract, and multiply polynomials.*
- Factor simple quadratics (e.g., the difference of squares and perfect square trinomials).*
- Solve first-degree inequalities that do not require reversing the inequality sign.*
- Manipulate expressions and equations.
- Write expressions, equations, and inequalities for common algebra settings.
- Solve linear inequalities that require reversing the inequality sign.
- Solve absolute value equations.
- Solve quadratic equations.
- Find solutions to systems of linear equations.
- Write expressions that require planning and/or manipulating to model a situation accurately.

- Write equations and inequalities that require planning, manipulating, and/or solving.
- Solve simple absolute value inequalities.

M5 Graphical Representations

- Identify the location of a point with a positive coordinate on the number line.
- Locate points on the number line and in the first quadrant.
- Locate points in the coordinate plane.
- Comprehend the concept of length on the number line.*
- Exhibit knowledge of slope.*
- Identify the graph of a linear inequality on the number line.*
- Determine the slope of a line from points or equations.*
- Match linear graphs with their equations.*
- Find the midpoint of a line segment.*
- Interpret and use information from graphs in the coordinate plane.
- Match number line graphs with solution sets of linear inequalities.
- Use the distance formula.
- Use properties of parallel and perpendicular lines to determine an equation of a line or coordinates of a point.
- Recognize special characteristics of parabolas and circles (e.g., the vertex of a parabola and the center or radius of a circle).†
- Match number line graphs with solution sets of simple quadratic inequalities.
- Identify characteristics of graphs based on a set of conditions or on a general equation such as $y = ax2 + c$.
- Solve problems integrating multiple algebraic and/or geometric concepts.
- Analyze and draw conclusions based on information from graphs in the coordinate plane.

M6 Properties of Plane Figures

- Exhibit some knowledge of the angles associated with parallel lines.
- Find the measure of an angle using properties of parallel lines.
- Exhibit knowledge of basic angle properties and special sums of angle measures (e.g., 90°, 180°, and 360°).
- Use several angle properties to find an unknown angle measure.
- Recognize Pythagorean triples.*
- Use properties of isosceles triangles.*
- Apply properties of 30°-60°-90°, 45°-45°-90°, similar, and congruent triangles.
- Use the Pythagorean theorem.
- Draw conclusions based on a set of conditions.
- Solve multi-step geometry problems that involve integrating concepts, planning, visualization, and/or making connections with other content areas.
- Use relationships among angles, arcs, and distances in a circle.

M7 Measurement

- Estimate or calculate the length of a line segment based on other lengths given on a geometric figure.
- Compute the perimeter of polygons when all side lengths are given.
- Compute the area of rectangles when whole number dimensions are given.
- Compute the area and perimeter of triangles and rectangles in simple problems.

- Use geometric formulas when all necessary information is given.
- Compute the area of triangles and rectangles when one or more additional simple steps are required.
- Compute the area and circumference of circles after identifying necessary information.
- Compute the perimeter of simple composite geometric figures with unknown side lengths.*
- Use relationships involving area, perimeter, and volume of geometric figures to compute another measure.
- Use scale factors to determine the magnitude of a size change.
- Compute the area of composite geometric figures when planning or visualization is required.

M8 Functions

- Evaluate quadratic functions, expressed in function notation, at integer values.
- Evaluate polynomial functions, expressed in function notation, at integer values.†
- Express the sine, cosine, and tangent of an angle in a right triangle as a ratio of given side lengths.†
- Evaluate composite functions at integer values.†
- Apply basic trigonometric ratios to solve right-triangle problems.†
- Write an expression for the composite of two simple functions.†
- Use trigonometric concepts and basic identities to solve problems.†
- Exhibit knowledge of unit circle trigonometry.†
- Match graphs of basic trigonometric functions with their equations.

Notes

- Students who score in the 1–12 range are most likely beginning to develop the knowledge and skills assessed in the other ranges.
- Standards followed by an asterisk (*) apply to the PLAN and ACT mathematics tests only.
- Standards followed by a dagger (†) apply to the ACT mathematics test only.

Reading

R1 Main Ideas and Author's Approach

- Recognize a clear intent of an author or narrator in uncomplicated literary narratives.
- Identify a clear main idea or purpose of straightforward paragraphs in uncomplicated literary narratives.
- Infer the main idea or purpose of straightforward paragraphs in uncomplicated literary narratives.
- Understand the overall approach taken by an author or narrator (e.g., point of view and kinds of evidence used) in uncomplicated passages.
- Identify a clear main idea or purpose of any paragraph or paragraphs in uncomplicated passages.
- Infer the main idea or purpose of straightforward paragraphs in more challenging passages.
- Summarize basic events and ideas in more challenging passages.
- Understand the overall approach taken by an author or narrator (e.g., point of view and kinds of evidence used) in more challenging passages.
- Infer the main idea or purpose of more challenging passages or their paragraphs.
- Summarize events and ideas in virtually any passage.

- Understand the overall approach taken by an author or narrator (e.g., point of view and kinds of evidence used) in virtually any passage.
- Identify clear main ideas or purposes of complex passages or their paragraphs.

R2 Supporting Details

- Locate basic facts (e.g., names, dates, and events) clearly stated in a passage.
- Locate simple details at the sentence and paragraph level in uncomplicated passages.
- Recognize a clear function of a part of an uncomplicated passage.
- Locate important details in uncomplicated passages.
- Make simple inferences about how details are used in passages.
- Locate important details in more challenging passages.
- Locate and interpret minor or subtly stated details in uncomplicated passages.
- Discern which details, though they may appear in different sections throughout a passage, support important points in more challenging passages.
- Locate and interpret minor or subtly stated details in more challenging passages.
- Use details from different sections of some complex informational passages to support a specific point or argument.
- Locate and interpret details in complex passages.
- Understand the function of a part of a passage when the function is subtle or complex.

R3 Sequential, Comparative, and Cause–Effect Relationships

- Determine when (e.g., first, last, before, or after) or if an event occurred in uncomplicated passages.
- Recognize clear cause–effect relationships described within a single sentence in a passage.
- Identify relationships between main characters in uncomplicated literary narratives.
- Recognize clear cause–effect relationships within a single paragraph in uncomplicated literary narratives.
- Order simple sequences of events in uncomplicated literary narratives.
- Identify clear relationships between people, ideas, and so forth in uncomplicated passages.
- Identify clear cause–effect relationships in uncomplicated passages.
- Order sequences of events in uncomplicated passages.
- Understand relationships between people, ideas, and so forth in uncomplicated passages.
- Identify clear relationships between characters, ideas, and so forth in more challenging literary narratives.
- Understand implied or subtly stated cause–effect relationships in uncomplicated passages.
- Identify clear cause–effect relationships in more challenging passages.
- Order sequences of events in more challenging passages.
- Understand the dynamics between people, ideas, and so forth in more challenging passages.
- Understand implied or subtly stated cause–effect relationships in more challenging passages.
- Order sequences of events in complex passages.
- Understand the subtleties in relationships between people, ideas, and so forth in virtually any passage.
- Understand implied, subtle, or complex cause–effect relationships in virtually any passage.

R4 Meaning of Words

- Understand the implication of a familiar word or phrase and of simple descriptive language.
- Use context to understand basic figurative language.

- Use context to determine the appropriate meaning of some figurative and nonfigurative words, phrases, and statements in uncomplicated passages.
- Use context to determine the appropriate meaning of virtually any word, phrase, or statement in uncomplicated passages.
- Use context to determine the appropriate meaning of some figurative and nonfigurative words, phrases, and statements in more challenging passages.
- Determine the appropriate meaning of words, phrases, or statements from figurative or somewhat technical contexts.
- Determine, even when the language is richly figurative and the vocabulary is difficult, the appropriate meaning of context-dependent words, phrases, or statements in virtually any passage.

R5 Generalizations and Conclusions

- Draw simple generalizations and conclusions about the main characters in uncomplicated literary narratives.
- Draw simple generalizations and conclusions about people, ideas, and so forth in uncomplicated passages.
- Draw generalizations and conclusions about people, ideas, and so forth in uncomplicated passages.
- Draw simple generalizations and conclusions using details that support the main points of more challenging passages.
- Draw subtle generalizations and conclusions about characters, ideas, and so forth in uncomplicated literary narratives.
- Draw generalizations and conclusions about people, ideas, and so forth in more challenging passages.
- Use information from one or more sections of a more challenging passage to draw generalizations and conclusions about people, ideas, and so forth.
- Draw complex or subtle generalizations and conclusions about people, ideas, and so forth, often by synthesizing information from different portions of the passage.
- Understand and generalize about portions of a complex literary narrative.

Science

S1 Interpretation of Data

- Select a single piece of data (numerical or non-numerical) from a simple data presentation (e.g., a table or graph with two or three variables or a food web diagram).
- Identify basic features of a table, graph, or diagram (e.g., headings, units of measurement, or axis labels).
- Select two or more pieces of data from a simple data presentation.
- Understand basic scientific terminology.
- Find basic information in a brief body of text.
- Determine how the value of one variable changes as the value of another variable changes in a simple data presentation.
- Select data from a complex data presentation (e.g., a table or graph with more than three variables or a phase diagram).
- Compare or combine data from a simple data presentation (e.g., order or sum data from a table).

- Translate information into a table, graph, or diagram.
- Compare or combine data from two or more simple data presentations (e.g., categorize data from a table using a scale from another table).
- Compare or combine data from a complex data presentation.
- Interpolate between data points in a table or graph.
- Determine how the value of one variable changes as the value of another variable changes in a complex data presentation.
- Identify and/or use a simple (e.g., linear) mathematical relationship between data.
- Analyze given information when presented with new, simple information.
- Compare or combine data from a simple data presentation with data from a complex data presentation.
- Identify and/or use a complex (e.g., nonlinear) mathematical relationship between data.
- Extrapolate from data points in a table or graph.
- Compare or combine data from two or more complex data presentations.
- Analyze given information when presented with new, complex information.

S2 Scientific Investigation

- Understand the methods and tools used in a simple experiment.
- Understand the methods and tools used in a moderately complex experiment.
- Understand a simple experimental design.
- Identify a control in an experiment.
- Identify similarities and differences between experiments.
- Understand the methods and tools used in a complex experiment.
- Understand a complex experimental design.
- Predict the results of an additional trial or measurement in an experiment.
- Determine the experimental conditions that would produce specified results.
- Determine the hypothesis for an experiment.
- Identify an alternate method for testing a hypothesis.
- Understand precision and accuracy issues.
- Predict how modifying the design or methods of an experiment will affect results.
- Identify an additional trial or experiment that could be performed to enhance or evaluate experimental results.

S3 Evaluation of Models, Inferences, and Experimental Results

- Select a simple hypothesis, prediction, or conclusion that is supported by a data presentation or a model.
- Identify key issues or assumptions in a model.
- Select a simple hypothesis, prediction, or conclusion that is supported by two or more data presentations or models.
- Determine whether given information supports or contradicts a simple hypothesis or conclusion and why.
- Identify strengths and weaknesses in one or more models.
- Identify similarities and differences between models.
- Determine which model(s) is/are supported or weakened by new information.
- Select a data presentation or a model that supports or contradicts a hypothesis, prediction, or conclusion.

- Select a complex hypothesis, prediction, or conclusion that is supported by a data presentation or model.
- Determine whether new information supports or weakens a model and why.
- Use new information to make a prediction based on a model.
- Select a complex hypothesis, prediction, or conclusion that is supported by two or more data presentations or models.
- Determine whether given information supports or contradicts a complex hypothesis or conclusion and why.

Writing

W1 Expressing Judgments

- Show a little understanding of the persuasive purpose of the task, but neglect to take or to maintain a position on the issue in the prompt.
- Show limited recognition of the complexity of the issue in the prompt.
- Show a basic understanding of the persuasive purpose of the task by taking a position on the issue in the prompt, but do not maintain that position.
- Show a little recognition of the complexity of the issue in the prompt by acknowledging, but only briefly describing, a counterargument to the writer's position.
- Show understanding of the persuasive purpose of the task by taking a position on the issue in the prompt.
- Show some recognition of the complexity of the issue in the prompt by doing the following:
    - Acknowledging counterarguments to the writer's position
    - Providing some response to counterarguments to the writer's position
- Show clear understanding of the persuasive purpose of the task by taking a position on the specific issue in the prompt and offering a broad context for discussion.
- Show recognition of the complexity of the issue in the prompt by doing the following:
    - Partially evaluating implications and/or complications of the issue
    - Posing and partially responding to counterarguments to the writer's position
- Show clear understanding of the persuasive purpose of the task by taking a position on the specific issue in the prompt and offering a critical context for discussion.
- Show understanding of the complexity of the issue in the prompt by doing the following:
    - Examining different perspectives
    - Evaluating implications or complications of the issue
    - Posing and fully discussing counterarguments to the writer's position

W2 Focusing on the Topic

- Maintain a focus on the general topic in the prompt through most of the essay.
- Maintain a focus on the general topic in the prompt throughout the essay.
- Maintain a focus on the general topic in the prompt throughout the essay, and attempt a focus on the specific issue in the prompt.
- Present a thesis that establishes focus on the topic.
- Maintain a focus on discussion of the specific topic and issue in the prompt throughout the essay.
- Present a thesis that establishes a focus on the writer's position on the issue.
- Maintain a clear focus on discussion of the specific topic and issue in the prompt throughout the essay.

- Present a critical thesis that clearly establishes the focus on the writer's position on the issue.

W3 Developing a Position

- Offer a little development, with one or two ideas; if examples are given, they are general and may not be clearly relevant; resort often to merely repeating ideas.
- Show little or no movement between general and specific ideas and examples.
- Offer limited development of ideas using a few general examples; resort sometimes to merely repeating ideas.
- Show little movement between general and specific ideas and examples.
- Develop ideas by using some specific reasons, details, and examples.
- Show some movement between general and specific ideas and examples.
- Develop most ideas fully, using some specific and relevant reasons, details, and examples.
- Show clear movement between general and specific ideas and examples.
- Develop several ideas fully, using specific and relevant reasons, details, and examples.
- Show effective movement between general and specific ideas and examples.

W4 Organizing Ideas

- Provide a discernible organization with some logical grouping of ideas in parts of the essay.
- Use a few simple and obvious transitions.
- Present a discernible, though minimally developed, introduction and conclusion.
- Provide a simple organization with logical grouping of ideas in parts of the essay.
- Use some simple and obvious transitional words, though they may at times be inappropriate or misleading.
- Present a discernible, though underdeveloped, introduction and conclusion.
- Provide an adequate but simple organization with logical grouping of ideas in parts of the essay but with little evidence of logical progression of ideas.
- Use some simple and obvious, but appropriate, transitional words and phrases.
- Present a discernible introduction and conclusion with little development.
- Provide unity and coherence throughout the essay, sometimes with a logical progression of ideas.
- Use relevant, though at times simple and obvious, transitional words and phrases to convey logical relationships between ideas.
- Present a somewhat developed introduction and conclusion.
- Provide unity and coherence throughout the essay, often with a logical progression of ideas.
- Use relevant transitional words, phrases, and sentences to convey logical relationships between ideas.
- Present a well-developed introduction and conclusion.

W5 Using Language

- Show limited control of language by doing the following:
    - Correctly employing some of the conventions of standard English grammar, usage, and mechanics but with distracting errors that sometimes significantly impede understanding
    - Using simple vocabulary
    - Using simple sentence structure
    - Correctly employing some of the conventions of standard English grammar, usage, and mechanics but with distracting errors that sometimes impede understanding

- Using simple but appropriate vocabulary
- Using a little sentence variety, though most sentences are simple in structure
- Correctly employing many of the conventions of standard English grammar, usage, and mechanics but with some distracting errors that may occasionally impede understanding
- Using appropriate vocabulary
- Using some varied kinds of sentence structures to vary pace
- Correctly employing most conventions of standard English grammar, usage, and mechanics, with a few distracting errors but none that impede understanding
- Using some precise and varied vocabulary
- Using several kinds of sentence structures to vary pace and to support meaning
- Correctly employing most conventions of standard English grammar, usage, and mechanics, with just a few, if any, errors
- Using precise and varied vocabulary
- Using a variety of sentence structures to vary pace and to support meaning

Appendix D: National Industry Standards

CONTREN CORE

SAF - Basic Safety

- Explain the role that safety plays in the construction crafts.
- Describe the meaning of jobsite safety.
- Describe the characteristics of a competent person and a qualified person.
- Explain the appropriate safety precautions to take around common jobsite hazards.
- Demonstrate the use and care of appropriate personal protective equipment (PPE).
- Properly don and remove personal protective equipment (safety goggles, hard hat, and personal fall protection).
- Follow the safety procedures required for lifting heavy objects.
- Describe safe behavior on and around ladders and scaffolds.
- Explain the importance of Hazard Communications (HazCom) and material safety data sheets (MSDSs).
- Describe fire prevention and firefighting techniques.
- Define safe work procedures to use around electrical hazards.

MAT - Introduction to Construction Math

- Add, subtract, multiply, and divide whole numbers, with and without a calculator.
- Use a standard ruler and a metric ruler to measure.
- Add, subtract, multiply, and divide fractions.
- Add, subtract, multiply, and divide decimals, with and without a calculator.
- Convert decimals to percentages and percentages to decimals.
- Convert fractions to decimals and decimals to fractions.
- Explain what the metric system is and how it is important in the construction trade.
- Recognize and use metric units of length, weight, volume, and temperature.
- Recognize some of the basic shapes used in the construction industry, and apply basic geometry to measure them.

HTO - Introduction to Hand Tools

- Recognize and identify some of the basic hand tools used in the construction trade.
- Use hand tools safely.
- Describe the basic procedures for taking care of hand tools.

PTO - Introduction to Power Tools

- Identify power tools commonly used in the construction trades.
- Use power tools safely.
- Explain how to maintain power tools properly.

BLU - Introduction to Blueprints

- Recognize and identify basic blueprint terms, components, and symbols.
- Relate information on blueprints to actual locations on the print.
- Recognize different classifications of drawings.
- Interpret and use drawing dimensions.

MBR - Basic Rigging

- Identify and describe the use of slings and common rigging hardware.
- Describe basic inspection techniques and rejection criteria used for slings and hardware.
- Describe basic hitch configurations and their proper connections.
- Describe basic load-handling safety practices.
- Demonstrate proper use of American National Standards Institute (ANSI) hand signals.

COM - Basic Communication Skills

- Demonstrate the ability to interpret information and instructions presented in both written and verbal form.
- Demonstrate the ability to communicate effectively in on-the-job situations using written and verbal skills.

EMP - Basic Employability Skills

- Explain the construction industry, the role of the companies that make up the industry, and the role of individual professionals in the industry.
- Demonstrate critical-thinking skills and the ability to solve problems using those skills.
- Demonstrate knowledge of computer systems, and explain common uses for computers in the construction industry.
- Demonstrate effective relationship skills with teammates and supervisors, the ability to work on a team, and appropriate leadership skills.
- Be aware of workplace issues such as sexual harassment, stress, and substance abuse.

CONTREN METAL TRADES—FIRST YEAR - MACHINING

MOT - Orientation to the Trade

- Describe the types of work performed by millwrights.
- Identify career opportunities available to millwrights.
- Explain the purpose and objectives of an apprentice training program.
- Explain the responsibilities of a millwright.
- Explain the importance of safety in relation to millwrights.
- Explain the role of NCCER in the training process.

MHT - Millwright Hand Tools

- Explain the purpose of each of the tools commonly used by millwrights.
- Describe how to maintain each of the tools used by millwrights.
- Demonstrate the proper use of selected millwright tools.

MFA - Fasteners and Anchors

- Identify and explain the use of threaded fasteners.
- Identify and explain the use of non-threaded fasteners.
- Identify and explain the use of anchors.
- Select the correct fasteners and anchors for given applications.
- Install fasteners and anchors.

MBL - Basic Layout

- Identify layout tools, and explain their uses.
- Lay out baselines using the arc method.
- Lay out baselines using the 3-4-5 method.
- Scribe straight lines.
- Scribe perpendicular lines to baselines using a square.
- Scribe perpendicular lines to an edge using a combination square.
- Scribe angled lines using a combination square and a protractor.
- Scribe circles using dividers and trammel points.
- Scribe perpendicular lines from baselines using dividers and reference points.
- Bisect lines using dividers.
- Divide a line into equal parts.
- Divide a circle into equal parts.
- Lay out equipment locations.

MGO - Gaskets and O-rings

- Identify the various types of gaskets, and explain their uses.
- Identify the various types of gasket materials, and explain their applications.
- Lay out, cut, and install a flange gasket.
- Describe the use of O-rings.
- Explain the importance of selecting the correct O-ring for an application.
- Select an O-ring for a given application, and install it.

MOC - Oxy-fuel Cutting

- Identify and explain the use of oxy-fuel cutting equipment.
- Set up oxy-fuel cutting equipment.
- Light and adjust an oxy-fuel torch.
- Shut down oxy-fuel cutting equipment.
- Disassemble oxy-fuel cutting equipment.
- Change empty cylinders.

- Perform oxy-fuel cutting.
    - Straight line and square shapes
    - Piercing and slot cutting
    - Bevels
    - Washing
- Operate a motorized, portable oxy-fuel gas cutting machine.

MIM - Intermediate Trade Math

- Use ratios and proportions.
- Solve basic algebra problems.
- Solve area problems.
- Solve volume problems.
- Solve circumference problems.
- Solve circular speed problems.
- Use tables.

MFS - Field Sketching

- Sketch straight lines.
- Sketch angles.
- Sketch arcs and circles.
- Sketch ellipses.
- Sketch dimensions.
- Make orthographic sketches.
- Make pictorial sketches.

MIB - Intermediate Blueprint Reading

- Explain orthographic projection.
- Interpret schematic drawings.
- Interpret isometric drawings.

MST - Specialty Tools

- Use torque multipliers.
- Use cable cutters.
- Use nut splitters.
- Use keyseat rules.
- Use depth gauges.
- Use bevels.
- Use telescoping gauges.
- Use radius gauges.
- Use drill gauges.
- Use thickness gauge stock.

- Use a plasti-gauge.
- Explain hardness testers.
- Explain surface roughness testers.

MPT - Power Tools

- Explain power tool safety.
- Use and care for drill presses.
- Use and care for hydraulic presses.
- Use and care for pipe threading machines.
- Use and care for nibblers.
- Use and care for band saws.
- Identify and explain belt sanders.
- Identify and explain Woodruff keyseaters.
- Identify and explain key broaches.
- Use and care for bearing heaters.
- Use and care for drills.
- Perform precision drilling.

MRG - Rigging

- Identify and describe the uses of common rigging hardware and equipment.
- Inspect common rigging equipment.
- Select, use, and maintain special rigging equipment, including the following:
    - Chain hoists
    - Come-alongs
    - Jacks
    - Tugger
- Tie knots used in rigging.
- Use and understand the correct hand signals to guide a crane operator.
- Identify basic rigging and crane safety procedures.
- Explain load balancing.

MAM - Advanced Trade Math

- Use right triangle trigonometry.
- Solve acute right triangles.

MPT - Precision Measuring Tools

- Use levels.
- Use feeler gauges.
- Use calipers.
- Use micrometers.
- Use dial indicators.

- Use protractors.
- Use parallels and gauge blocks.
- Use trammels.
- Use precision straightedges.
- Use speed measurement tools.
- Use pyrometers.

CONTREN METAL TRADES—SECOND YEAR - WELDING

WSS - Welding Safety

- Identify some common hazards in welding.
- Explain and identify proper personal protection equipment used in welding.
- Demonstrate how to avoid welding fumes.
- Explain some of the causes of accidents.
- Identify and explain uses for material safety data sheets (MSDSs).
- Demonstrate safety techniques for storing and handling cylinders.
- Explain how to avoid electric shock when welding.
- Demonstrate proper material handling methods.

WOC - Oxy-fuel Cutting

- Identify and explain the use of oxy-fuel cutting equipment.
- Set up oxy-fuel equipment.
- Light and adjust an oxy-fuel torch.
- Shut down oxy-fuel cutting equipment.
- Disassemble oxy-fuel equipment.
- Change empty cylinders.
- Perform oxy-fuel cutting.
    - Straight line and square shapes
    - Piercing and slot cutting
    - Bevels
    - Washing
    - Gouging
- Operate a motorized, portable oxy-fuel gas cutting machine.

BMP - Base Metal Preparation

- Clean base metal for welding or cutting.
- Identify and explain joint design.
- Explain joint design considerations.
- Using a nibbler, cutter, or grinder, mechanically prepare the edge of a mild steel plate 1⁄4-in. to 3⁄4-in. thick at 221⁄2° (or 30° depending on equipment available).

- Using a nibbler, cutter, or grinder, mechanically prepare the end of a pipe with a 30° or 37 1⁄2° bevel (depending on equipment available) and a 3⁄32-in. land. Use 6-in., 8-in., or 10-in. Schedule 40 or Schedule 80 mild steel pipe.
- Select the proper joint design based on a welding procedure specification (WPS) or instructor direction.

WQT - Weld Quality

- Identify and explain codes governing welding.
- Identify and explain weld imperfections and their causes.
- Identify and explain nondestructive examination practices.
- Identify and explain welder qualification tests.
- Explain the importance of quality workmanship.
- Identify common destructive testing methods.

SWS - Equipment and Setup (SMAW)

- Identify and explain shielded metal arc welding (SMAW) safety.
- Identify and explain welding electrical current.
- Identify and explain arc welding machines.
- Explain setting up arc welding equipment.
- Set up a machine for welding.
- Identify and explain tools for weld cleaning.

SES - Electrodes and Selection (SMAW)

- Identify factors that affect electrode selection.
- Explain the American Welding Society (AWS) and the American Society of Mechanical Engineers (ASME) filler metal classification system.
- Identify different types of filler metals.
- Explain the storage and control of filler metals.
- Explain filler metal traceability requirements and how to use applicable code requirements.
- Identify and select the proper electrode for an identified welding task.

SBF - Beads and Fillet Welds (SMAW)

- Set up shielded metal arc welding (SMAW) equipment.
- Describe methods of striking an arc.
- Properly strike and extinguish an arc.
- Describe causes of arc blow and wander.
- Make stringer, weave, and overlapping beads.
- Make fillet welds in the following positions:
    - Horizontal (2F) position
    - Vertical (3F) position
    - Overhead (4F) position

GWB - Groove Welds with Backing (SMAW)

- Identify and explain groove welds.
- Identify and explain groove welds with backing.
- Set up shielded metal arc welding (SMAW) equipment for making V-groove welds.
- Perform SMAW for V-groove welds with backing in the following positions:
    - Flat (1G) position
    - Horizontal (2G) position
    - Vertical (3G) position
    - Overhead (4G) position

JFA - Joint Fit-up and Alignment

- Identify and explain job code specifications.
- Use fit-up gauges and measuring devices to check joint fit-up.
- Identify and explain distortion and how it is controlled.
- Fit up joints using plate and pipe fit-up tools.
- Check for joint misalignment and poor fit-up before and after welding.

WSY - Welding Symbols

- Identify and explain the various parts of a welding symbol.
- Identify and explain fillet and groove weld symbols.
- Read welding symbols on drawings, specifications, and welding procedure specifications.
- Interpret welding symbols from a print.
- Draw welding symbols based on the observation of actual welds.

RWD - Reading Welding Detail Drawings

- Identify and explain a welding detail drawing.
- Identify and explain lines, material fills, and sections.
- Identify and explain object views.
- Identify and explain dimensioning.
- Identify and explain notes and bill of materials.
- Interpret basic elements of a welding detail drawing.
- Develop basic welding drawings.

PAC - Plasma Arc Cutting (PAC)

- Identify and understand plasma arc cutting processes.
- Identify plasma arc cutting equipment.
- Prepare and set up plasma arc cutting equipment.
- Use plasma arc cutting equipment to make various types of cuts.
- Properly store equipment and clean the work area after use.

GFM - Equipment and Filler Metals (GMAW and FCAW)

- Explain gas metal arc welding (GMAW) and flux cored arc welding (FCAW) safety.
- Explain the characteristics of welding current and power sources.
- Identify and explain the use of GMAW and FCAW equipment.
    - Spray transfer
    - Globular
    - Short circuiting
    - Pulse
- Identify and explain the use of GMAW and FCAW shielding gases and filler metals.
- Set up GMAW and FCAW equipment, and identify tools for weld cleaning.

GFP - GMAW and FCAW – PLATE

- Perform GMAW multiple-pass fillet welds on plate, using solid or composite wire and shielding gas in multiple positions.
- Perform GMAW multiple-pass open-root V-groove welds on plate, using solid or composite wire and shielding gas, in multiple positions.
- Perform GMAW spray fillet and open-root V-groove welds on plate, using solid or composite wire and shielding gas, in flat and horizontal positions.
- Perform FCAW multiple-pass fillet welds on plate in multiple positions using flux cored wire and, if required, shielding gas.
- Perform FCAW multiple-pass open-root V-groove welds on plate in multiple positions using flux cored wire and, if required, shielding gas.

TFM - Equipment and Filler Metals (GTAW)

- Explain gas tungsten arc welding (GTAW) safety.
- Identify and explain the use of GTAW equipment.
- Identify and explain the use of GTAW filler metals.
- Identify and explain the use of GTAW shielding gases.
- Set up GTAW equipment.

TPW - Plate (GTAW)

- Build a pad in the flat position with stringer beads using GTAW and carbon steel filler metal.
- Make multiple-pass open-root V-groove welds on carbon steel plate in the 1G (flat) position using GTAW and carbon steel filler metal.
- Make multiple-pass open-root V-groove welds on carbon steel plate in the 2G (horizontal) position using GTAW and carbon steel filler metal.
- Make multiple-pass open-root V-groove welds on carbon steel plate in the 3G (vertical) position using GTAW and carbon steel filler metal.
- Make multiple-pass open-root V-groove welds on carbon steel plate in the 4G (overhead) position using GTAW and carbon steel filler metal.

PTM - Preheating and Post-weld Heat Treatment of Metals

- Explain how to preheat metals.
- Describe maintaining interpass temperature.
- Explain post-weld heat treatment of metals.
- Identify and explain the effects of welding on metals.
    - Heat-affected zone (HAZ)
    - Cracking
    - Face changes/grain structure

CPM - Physical Characteristics and Mechanical Properties of Metals

- Identify and explain the composition and classification of base metals.
- Explain and demonstrate field identification methods for base metals.
- Identify and explain the physical characteristics and mechanical properties of metals.
- Identify and explain forms and shapes of structural metals.
- Explain metallurgical considerations for welding metals.

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

L1B - Benchwork
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
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

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
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
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
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
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
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).
Accuracy Level: Match the requirements of the part print and 63 Ra microinch finish.

1CT - CNC Turning
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).
Accuracy Level: Match the requirements of the part print.

NIMS Machining Level II
2TB - Turning – Between Centers
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 two straight diameters within +/- 0.001 and an appropriate taper at each end of the part, and it should require a reversal of the part end for end.
Accuracy Level: +/- 0.015 on all fractions and+/- 0.005 on all decimals unless otherwise specified on the part print. Diameters are to be concentric within 0.001 TIR.
Surface finish of 63 Ra microinches or better

2TC - Turning – Chucking
Given a print detailing a part requiring milling, drilling, turning, and grinding, verbal instructions, and appropriate references, formulate a set of strategies to manufacture the part, and write a detailed process plan including a quality plan for that part. Provide sketches as needed. Make a presentation explaining each of the process plan steps to be taken; identify all major components and functions of the machine tools, all major hand tools, measuring tools, tools and fixtures, and work materials; and provide the rationale for the speeds and feeds selected.

2PL - Milling – Precision Locations
Produce three bores to specification. The holes will be between 0.75 and 1.5, and their locations are to be held within +/- 0.001 and hold diameters within +/- 0.0005. One hole is to be counterbored to a decimal depth holding +/- 0.002 and counterbore diameter within +/- 0.005.
Accuracy Level: +/- 0.005 on all decimals unless otherwise specified on the part print and 63 microinch finish

2FA - Grinding – Flats and Angles
Given a block roughed out on a mill, a process plan, 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 and grind the specified radii and angled surfaces to a finish matching the process plan and the part print specifications using appropriate trade techniques. The part specified will be in the semi-finished state having been roughed out. Finishing the part will require the precision finishing of the specified surfaces of the block to tolerances common to precision grinding for squareness, size, and surface finish characteristics.
Accuracy Level: +/- 0.0005 on all decimals unless otherwise specified on the part print
Square within 0.0001 over 1 in. Angles are to be held within +/- 15'. Radii +/- 001

2CG - Cylindrical Grinding
Dress the wheel. Given a part rough finished on three diameters, mount the part between centers and grind the required diameters to finish.
Accuracy Level: +/- 0.005 on decimals, +/- 0.0005 on ground diameters

2CM - CNC Milling
Given a CNC mill, create a qualified CNC program, set up and operate the mill, change tool values as necessary, and replace and qualify tooling as necessary.
Accuracy Level: Match the requirements of the part print and 63 Ra microinch finish.

2CT - CNC Turning
Given a CNC lathe, create a qualified CNC program, set up and operate the lathe, change tool values as necessary, and replace and qualify tooling as necessary.
Accuracy Level: Match the requirements of the part print and 63 Ra microinch finish.

Appendix E: National Educational Technology Standards for Students[2]

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T5 Digital Citizenship
T6 Technology Operations and Concepts

T1 Creativity and Innovation

Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. Students do the following:

a. Apply existing knowledge to generate new ideas, products, or processes
b. Create original works as a means of personal or group expression
c. Use models and simulations to explore complex systems and issues
d. Identify trends and forecast possibilities

T2 Communication and Collaboration

Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others. Students do the following:

a. Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media
b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats
c. Develop cultural understanding and global awareness by engaging with learners of other cultures
d. Contribute to project teams to produce original works or solve problems

T3 Research and Information Fluency

Students apply digital tools to gather, evaluate, and use information. Students do the following:

a. Plan strategies to guide inquiry
b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media
c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks
d. Process data and report results

T4 Critical Thinking, Problem Solving, and Decision Making

Students use critical-thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources. Students do the following:

[2] International Society for Technology in Education. (2000). *National educational technology standards for students (NETS).* Retrieved February 27, 2008, from http://www.iste.org/

a. Identify and define authentic problems and significant questions for investigation
b. Plan and manage activities to develop a solution or complete a project
c. Collect and analyze data to identify solutions and/or make informed decisions
d. Use multiple processes and diverse perspectives to explore alternative solutions

T5 Digital Citizenship

Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior. Students do the following:

a. Advocate and practice safe, legal, and responsible use of information and technology
b. Exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity
c. Demonstrate personal responsibility for lifelong learning
d. Exhibit leadership for digital citizenship

T6 Technology Operations and Concepts

Students demonstrate a sound understanding of technology concepts, systems, and operations. Students do the following:

a. Understand and use technology systems
b. Select and use applications effectively and productively
c. Troubleshoot systems and applications
d. Transfer current knowledge to learning of new technologies