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Part 122: Architecture and Construction (REPEAL 11/2013)

Installation and Service: HVAC

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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
Mr. William Harold Jones
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Dr. Sue Matheson
Mrs. Martha "Jackie" Murphy
Ms. Rosetta Richards
Dr. Tom Burnham, State Superintendent of Education

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

Contren Learning Series from the National Center for Construction Education and Research
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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).~~

Installation and Service: Heating, Ventilation, and Air-Conditioning (HVAC) Executive Summary

Program Description

The Installation and Service: HVAC concentration is an instructional program that prepares students for employment or continued education in the occupations of heating, ventilation, and air-conditioning. The curriculum framework for this program was developed in partnership with the Mississippi Construction Education Foundation (MCEF). MCEF is the accredited sponsor for the National Center for Construction Education and Research (NCCER).

Industry Certification

The NCCER developed and published a set of industry standards that are taught nationwide by contractors, associations, construction users, and secondary and postsecondary schools called the **Contren Learning Series.** When developing this set of standards, the NCCER assembled a team of subject matter experts that represented construction companies and schools across the nation. Each committee met several times and combined experts' knowledge and experience to finalize the set of national industry standards.

As a part of the accreditation process, all Mississippi Construction Technology instructors will be required to successfully complete the **Instructor Certification Training Program**. This program ensures that instructors possess a deep knowledge of content of the standards.

This state-of-the-art curriculum is modeled after the eight Mississippi **NCCER Accredited Training and Education Facilities (ATEF)**. In order to become an NCCER ATEF program, school districts must meet a set of guidelines including the following:

1. Use the approved curriculum.
2. All instructors must be NCCER certified.
3. All completed Form 200s and release forms on all student completions are to be forwarded to MCEF for proper approval. MCEF will in turn forward to NCCER for processing.
4. Follow NCCER guidelines on test security and performance profiles.
5. Have an active advisory committee with at least two commercial contractors involved.
6. Follow safety practices and Occupational Safety and Health Administration (OSHA) standards used in the class and lab areas.
7. Involve commercial contractors in class presentations or field trips.
8. All construction programs must be included in the accreditation process.
9. Show active involvement in student leadership development (e.g., VICA and SkillsUSA).
10. Provide demonstrated placement into construction-related occupations, and provide timely reports to MCEF.

Districts will be required to complete a self-evaluation of all programs and host a site visit from industry to ensure proper lab, safety, and instructional procedures are in place.

Assessment

Students will be assessed using the Installation and Service: HVAC 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 Construction and Manufacturing instructional design specialists at the Research and Curriculum Unit at 662.325.2510.

Student Prerequisites

In order for students to be successful in the Installation and Service: HVAC program, the following student prerequisites are in place:

1. C or higher in English (the previous year)
2. C or higher in Math (last course taken or the instructor can specify the math)

or

3. Instructor Approval and TABE Reading Score (eighth grade or higher)

or

4. Instructor Approval

Proposed Applied Academic Credit

Applied Math content from the curriculum was aligned to the 2007 Mississippi Math Framework Revised Academic Benchmarks. It is proposed that upon the completion of this program, students will earn 1/2 Applied Math 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

A 974 educator license is required to teach the Installation and Service: HVAC concentration program. Requirements for the 974 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 earn a passing score on Heating, Ventilation, and Air-Conditioning assessment from National Craft Assessment and Certification Program.
6. Applicant must successfully complete the Contren Instructor Certification.
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 Installation and Service: HVAC 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 974 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.

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, please 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 implement based on student needs and scheduling demands. This curriculum offers a four-Carnegie-unit program.

Option 1

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

Installation and Service I (Course Code: 993002)
Installation and Service II (Course Code: 993003)
Beginning HVAC (Course Code: 993022)
Advanced HVAC (Course Code: 993023)

Course Description: Installation and Service I (Course Code: 993002) includes an introduction to the field as well as fundamentals of safety, math, blueprint reading, and hand and power tools. This is a one-Carnegie-unit course.

Course Description: Installation and Service II (Course Code: 993003) emphasizes an overview of safety and leadership, the lathe theory, and grinding operations. This course gives students real-world, hands-on practice in these areas. This one-Carnegie-unit course should only be taken after students successfully pass Installation and Service, Part A.

Course Description: Beginning HVAC (Course Code: 993022) includes an in-depth study of the heating, ventilation, and air conditioning profession, HVAC math, ferrous metal piping practice, introduction to cooling, and introduction to heating. This course also reinforces safety related to the installation and service of HVAC applications. This one-Carnegie-unit course should only be taken after students successfully pass Installation and Service, Part B.

Course Description: Advanced HVAC (Course Code: 993023) includes an in-depth study of the heating, ventilation, and air conditioning profession, air distribution systems, leak detection evacuation recovery and charging, alternating current, and basic electronics. This course also reinforces safety related to the

installation and service of HVAC applications. This one-Carnegie-unit course should only be taken after students successfully pass Installation and Service II—HVAC, Part A.

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

Installation and Service I (Course Code: 993002)

Unit		Title	Hours
1		Orientation and Safety	50
2		Math, Introduction to Blueprints, and Hand and Power Tools	90
			140

Installation and Service II (Course Code: 993003)

Unit		Title	Hours
3		Orientation to the Trade, Tools of the Trade, Fasteners and Anchors, and Oxy-Fuel Cutting (IM)	70
4		Introduction to HVAC, Tools of the Trade (HVAC), Copper and Plastic Piping, Soldering and Brazing, and Basic Electricity (IM)	70
			140

Beginning HVAC (Course Code: 993022)

Unit		Title	Hours
5		Orientation and Safety (Review and Reinforcement)	20
6		Trade Math, Ferrous Metal Piping Practice, Introduction to Cooling, and Introduction to Heating	120
			140

Advanced HVAC (Course Code: 993023)

Unit		Title	Hours
7		Air Distribution Systems, Leak Detection Evacuation Recovery and Charging, Alternating Current, and Basic Electronics	140
			140

Option 2

Course Description: Installation and Service is a course that students learn about Heating, Ventilation, and Air-Conditioning. Topics include Math, Introduction to Blueprints, Hand and Power Tools, Orientation to the Trade, and Introduction to HVAC. This is a two-Carnegie-unit course.

- Scheduling and operating more than one course in the same classroom/laboratory with the same instructor is not allowed.
- Safety will be reinforced and tested at the beginning of each course.

Course Description: Heating, Ventilation and Air-Conditioning-HVAC is a continuation with the emphasis on Heating, Ventilation, and Air-Conditioning. Topics include employability skills, safety, ferrous metal piping, introduction to cooling, introduction to heating, air distribution, leak detection evacuation recovery and charging, alternating current, and basic electronics. The course should be taken after the student has successfully passed Installation and Service I. This is a two-Carnegie-unit course.

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

Installation and Service (Course Code: 993001)

Unit		Title	Hours
1		Orientation and Safety	45
2		Math, Introduction to Blueprints, and Hand and Power Tools	85
3		Orientation to the Trade, Tools of the Trade, Fasteners and Anchors, and Oxy-Fuel Cutting (IM)	75
4		Introduction to HVAC, Tools of the Trade (HVAC), Copper and Plastic Piping, Soldering and Brazing, and Basic Electricity (IM)	75
			280

Heating, Ventilation and Air-Conditioning-HVAC (Course Code: 993021)

Unit		Title	Hours
5		Orientation and Safety (Review and Reinforcement)	5
6		Trade Math, Ferrous Metal Piping Practice, Introduction to Cooling, and Introduction to Heating	140
7		Air Distribution Systems, Leak Detection Evacuation Recovery and Charging, Alternating Current, and Basic Electronics	135
			280

Research Synopsis

By implementing the National Center for Construction Education and Research in the construction skills standards to the Installation and Service Pathway, students who successfully master the curriculum should have the skills required to enter the workforce or pursue an advanced degree. These skills are based on industry-validated performance indicators. The pathway will include applied instruction designed to articulate with programs offered in Mississippi's community and junior colleges.

Industry Job Data – Employment Projections 2006 to 2016

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

Occupational Title	Employment 2006	Projected Employment 2016	Change 2006–16	
			Number	Percent
Industrial Machinery Mechanics and Maintenance Workers	345,000	368,000	23,000	7%
Industrial Machinery Mechanics	261,000	284,000	24,000	9%
Maintenance and Repair Workers, General	1,391,000	1,513,000	140,000	10%

Industry Comments and Quotes

- A survey of industry representatives provided insight into skills needed for students completing the Installation and Service Pathway.
- Many employers have training programs available to allow employees to advance.
- The expectations of employers primarily center on employability or "soft" skills. Many indicated that dependability is a prime need for employment.
- Employers expect employees to have integrity, a strong work ethic, a good attitude, and customer service skills. They expect employees to be punctual, willing to stick with the job, able to prioritize and organize, and interested in helping people. Maturity level is the key concern.
- Employees should have skills related to safety, blueprints, hand and power tools, and math and measuring.
- Students should be exposed to the general idea of how mechanical, electrical, and hydraulic systems work together to form a complete machine but should also have specialized skills in specific areas such as heating ventilation and air-conditioning.
- Modify Installation and Service to have a year of fundamentals and basic industrial maintenance and HVAC techniques and a year of specialization in a specific area.
- Retain the 2-year individual programs to include fundamentals and a specialized area to include Industrial Maintenance Technician and Heating, Ventilation, and Air-Conditioning.

Course Outlines

This curriculum framework allows options for local school districts to implement based on student needs and scheduling demands. This curriculum offers a four-Carnegie-unit program.

Option 1

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

Installation and Service, Part A (Course Code: 993002)
Installation and Service, Part B (Course Code: 993003)
Installation and Service II—HVAC, Part A (Course Code: 993022)
Installation and Service II—HVAC, Part B (Course Code: 993023)

Course Description: Installation and Service, Part A (Course Code: 993002) includes an introduction to the field as well as fundamentals of safety, math, blueprint reading, and hand and power tools. This is a one-Carnegie-unit course.

Course Description: Installation and Service, Part B (Course Code: 993003) 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 Installation and Service, Part A.

Course Description: Installation and Service II—HVAC, Part A (Course Code: 993022) includes an in-depth study of the heating, ventilation, and air-conditioning profession; HVAC math; ferrous metal piping practice; introduction to cooling; and introduction to heating. This course also reinforces safety related to the installation and service of HVAC applications. This one-Carnegie-unit course should only be taken after students successfully pass Installation and Service, Part B.

Course Description: Installation and Service II—HVAC, Part B (Course Code: 993023) includes an in-depth study of the heating, ventilation, and air-conditioning profession; air distribution systems; leak detection evacuation recovery and charging; alternating current; and basic electronics. This course also reinforces safety related to the installation and service of HVAC applications. This one-Carnegie-unit course should only be taken after students successfully pass Installation and Service II—HVAC, Part A.

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

~~Installation and Service, Part A (Course Code: 993002)~~

~~Unit~~		~~Title~~	~~Hours~~
~~1~~		~~Orientation and Safety~~	~~50~~
~~2~~		~~Math, Introduction to Blueprints, and Hand and Power Tools~~	~~90~~
			~~**140**~~

~~Installation and Service, Part B (Course Code: 993003)~~

~~Unit~~		~~Title~~	~~Hours~~
~~3~~		~~Orientation to the Trade, Tools of the Trade, Fasteners and Anchors, and Oxy-Fuel Cutting (IM)~~	~~70~~
~~4~~		~~Introduction to HVAC, Tools of the Trade (HVAC), Copper and Plastic Piping, Soldering and Brazing, and Basic Electricity (IM)~~	~~70~~
			~~**140**~~

~~Installation and Service II—HVAC, Part A (Course Code: 993022)~~

~~Unit~~		~~Title~~	~~Hours~~
~~5~~		~~Orientation and Safety (Review and Reinforcement)~~	~~20~~
~~6~~		~~Trade Math, Ferrous Metal Piping Practice, Introduction to Cooling, and Introduction to Heating~~	~~120~~
			~~**140**~~

~~Installation and Service II—HVAC, Part B (Course Code: 993023)~~

~~Unit~~		~~Title~~	~~Hours~~
~~7~~		~~Air Distribution Systems, Leak Detection Evacuation Recovery and Charging, Alternating Current, and Basic Electronics~~	~~140~~
			~~**140**~~

Option 2

Course Description: Installation and Service I is a course in which students learn about heating, ventilation, and air-conditioning. Topics include math, introduction to blueprints, hand and power tools, orientation to the trade, and introduction to HVAC. This is a two-Carnegie-unit course.

- Scheduling and operating more than one course in the same classroom/laboratory with the same instructor is not allowed.
- Safety will be reinforced and tested at the beginning of each course.

Course Description: Installation and Service II—HVAC is a continuation of Installation and Service I with the emphasis on heating, ventilation, and air-conditioning. Topics include employability skills, safety, ferrous metal piping, introduction to cooling, introduction to heating, air distribution, leak detection evacuation recovery and charging, alternating current, and basic electronics. The course should be taken after the student has successfully passed Installation and Service I. This is a two-Carnegie-unit course.

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

Installation and Service I (Course Code: 993001)

Unit		Title	Hours
1		Orientation and Safety	45
2		Math, Introduction to Blueprints, and Hand and Power Tools	85
3		Orientation to the Trade, Tools of the Trade, Fasteners and Anchors, and Oxy-Fuel Cutting (IM)	75
4		Introduction to HVAC, Tools of the Trade (HVAC), Copper and Plastic Piping, Soldering and Brazing, and Basic Electricity (IM)	75
			280

Installation and Service II—HVAC (Course Code: 993021)

Unit		Title	Hours
5		Orientation and Safety (Review and Reinforcement)	5
6		Trade Math, Ferrous Metal Piping Practice, Introduction to Cooling, and Introduction to Heating	140
7		Air Distribution Systems, Leak Detection Evacuation Recovery and Charging, Alternating Current, and Basic Electronics	135
			280

Using This Document

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.

Installation and Service: HVAC

Unit 1: Orientation and Safety

Competency 1: Describe local program and vocational/career technical center policies and procedures. (CONTREN Module: 00107-04 and 00108-04) (DOK 1) COM, EMP

Suggested Enduring Understandings

1. Safety is an integral part of daily life.
2. Rules and regulations are essential to a safe work environment.

Suggested Essential Questions

1. What would happen if there were no rules and regulations?
2. How would we function without rules and regulations?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe local program and vocational/career technical center policies and procedures. (DOK1)	a. Discuss school policy, dress code, attendance, academic requirements, discipline, transportation regulations, 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 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. Once the students have read the syllabus and rules, have students discuss the ramifications of breaking rules and regulations set forth by the school, department, and/or instructor. 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 opinions about the seriousness of the offense and if they think the punishment given by the thespian principal is fair. Make sure to reinforce the school rules and regulations before moving on to another topic. CS3, CS4, CS5, E1, E2, E3, E4	a. The role-play will be evaluated by students answering questions about the topics presented and by using the **Role-Play or Skit Rubric**. Then give an electronic test on local school rules and regulations using the Blackboard class Web site. Have students complete a form verifying that they have received instructions on local school rules and policies. Parents/guardians should also sign to acknowledge rules and policies. This should be kept in a student folder.

Competency 2: Describe employment opportunities and responsibilities of the industrial and HVAC mechanic. (CONTREN Module: 00107-04, 00108-04, and 40101-07 Orientation to the Trade, IM) (DOK 2) COM, EMP, OTT

Suggested Enduring Understandings

1. Employers offer a wide variety of benefit and salary.
2. Employers are looking for specific skills and abilities in employees.
3. Students should know about job opportunities available in the installation and service industry.

Suggested Essential Questions

1. What would our nation and world be like without service technicians?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe employer expectations in the workplace. (DOK2)	a. Relate employment opportunities including the following: • Potential earnings, employee benefits, job availability, place of employment, working conditions, and educational requirements to students' success in a secondary or postsecondary manufacturing curriculum • Describe basic employee responsibilities; demonstrate the ability to follow verbal and written instructions and communicate effectively in on-the-job situations. • Explain the service 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. Afterward, get 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; 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 who the vocational complex is intended to serve (industry needs). Then have students research area job opportunities that are available within the local industry relating to	a. Have students submit the article for a daily grade. Have students write a report on what the former student talked about and how they can use the information to attain a potential job (see **Writing Rubric**).

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. After initially discussing what each student plans to do after graduation, have students perform Internet research on community colleges that offer industrial maintenance and HVAC degrees and certificates. The industrial maintenance and HVAC 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 industrial maintenance and HVAC course relates to postsecondary courses that are available to them at their nearest local community college or university. Overall, encourage the students to pursue industrial maintenance and HVAC careers, and guide them in programs that are offered after high school graduation. Then 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. CS1, CS2, CS3, CS4, CS5, E1

Have former student who works in the industry visit and talk about employment opportunities in the commercial and residential HVAC area, specifically addressing the following: CS2, CS3, CS4, CS5

- Relevancy of the course material to the job
- Working conditions
- Job pay
- Employment benefits
- Problems faced in the HVAC or industrial maintenance area

Competency 3: Explore leadership skills and personal development opportunities provided for students by student organizations to include SkillsUSA. (CONTREN Module: 00107.04 and 00108.04) (DOK 2) COM, EMP

Suggested Enduring Understandings

1. Leadership and team-building skills are needed to be successful in a career.
2. Student involvement in SkillsUSA develops and enhances the skills for which employers are looking.

Suggested Essential Questions

1. What leadership and team-building skills are necessary for success in any career?
2. What activities does SkillsUSA provide that can prepare you for the world of work?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Demonstrate effective team-building and	a. Use PowerPoint demonstrations and information retrieved from the SkillsUSA Web site, and/or	a. Use the **Writing Rubric** to evaluate student

leadership skills. (DOK2)	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. Have students write a short essay (half-page minimum) about how SkillsUSA is an important organization and how it can benefit the Installation and Service program by preparing students for 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. CS1, CS2, CS3, CS5, T1, T2, R1, R2	writings. Monitor the class for participation.
b. Demonstrate through practice appropriate work ethics. (DOK2)	b. 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. 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 9 weeks to encourage team competition among project groups. Use team-building concepts to create student cooperation and teamwork. 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. CS1, CS2, CS3, CS4, CS5, T1, T2	b. 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.

Competency 4: Describe general safety rules for working in a shop/lab and industry. (CONTREN Module: 00101-04) (DOK 1)[SAF]

Suggested Enduring Understandings

1. Safe use and proper choice of tools is important to safely completing a job.
2. Understanding common safety violations and the consequences of committing unsafe acts is important in the workplace.

Suggested Essential Questions

1. Why do we have safety rules and regulations?
2. How do fires happen, and how do you extinguish a fire?
3. What happens when you choose the improper tool for the job or use a tool in an incorrect manner?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Discuss safety issues and prevention associated with the installation and service shop area. (DOK1)	a. Explain the relationship between housekeeping and safety in reducing on-site accidents; explain the importance of reporting all on-the-job injuries and accidents, evacuation policies, substance abuse policy, and safety around high pressure or high temperature; recognize, explain, inspect, and care for personal protective equipment; identify and explain the procedures for lifting heavy objects; inspect and safely work with various ladders and scaffolds; explain the function of the MSDS; and interpret the MSDS sheet. Use PowerPoint presentations from the Contren Learning Series (NCCER). This should prepare the students for school shop safety and NCCER examinations. Show safety videos such as the Farm Bureau Safety Video. The following Web sites have good safety points: • http://www.woodzone.com/articles/shop_safety.htm • http://www.osha.gov/SLTC/video/constructionsafety/video.html • www.freeoshainfo.com Then discuss the school shop/lab safety rules that pertain to the school premise, 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. Discuss personal protection devices such as safety glasses, face shields, steel-toed boots, lanyards, safety harnesses, gloves, aprons, and so forth. Show proper safety equipment and	a. 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. Explain and demonstrate proper lifting procedures, and explain the importance of safety when lifting tall or long workpieces.

	damaged equipment so that students know what defects look like. 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 and properly interpret an MSDS chemical sheet. 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, eyewash and showers, spill kits, and emergency evacuation routes. CS4, T1, T2, T4	
b. Explain fire safety and prevention. (DOK1)	b. Discuss how fires start, the three things needed to produce a fire, fire suppression practices, and fire prevention of flammable liquids; list and explain the classes of fire extinguishers; identify and explain the use of various barriers and confinements, electrical safety issues, and lockout/tagout safety procedures. Explain the fire triangle—fuel, oxygen, and heat—and then explain what flash point is for various shop materials, and then explain and discuss the various types of fires with students such as wood, grease, electrical, and metal. Explain the classes of fire extinguishers and with what types of fires to use them; then demonstrate the proper use of a fire extinguisher. The following is a great 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. CS1, CS2, CS5, T1, T2, T3, T4 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.	b. Have students walk around the shop and locate safety violations, document the violation, and propose a remedy for the safety issue.

Standards

Industry Standards

CONTREN CORE

SAF Basic Safety
COM Basic Communication Skills
EMP Basic Employability Skills

CONTREN INDUSTRIAL MAINTENANCE LEVEL ONE

OTI Orientation to the Trade

21st Century Learning Standards

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

National Educational Technology Standards for Students

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making

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
R1 Main Ideas and Author's Approach
R2 Supporting Details

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~~Suggested Rubrics and Checklists~~

Interpret MSDS Rubric

NAME: **DATE:** **PERIOD:**

Your instructor will furnish you with the name of a chemical that is commonly used in agricultural and natural resources occupations. You are to conduct a search of the Internet to locate a material safety data sheet (MSDS) for this material and use it to answer the following questions.

1. What was the Web address of the Internet site where you found this information?

2. If you accidentally drank some of this material, what would be the first aid procedure you would do first?

3. What special precautions should be taken in storing this material?

4. What is the flash point of this material?

5. If you spilled a small amount of this product, how would you clean it up?

6. What immediate effects would likely happen if you spilled some of this material on your skin?

Role-Play or Skit Rubric

NAME: **DATE:** **PERIOD:**

Behavior/Skill	Excellent 4	Good 3	Needs Improvement 2	Unacceptable 1	Total Score
ACCURACY	ALL INFORMATION WAS ACCURATE.	ALMOST ALL INFORMATION WAS ACCURATE.	MOST INFORMATION WAS ACCURATE.	VERY LITTLE INFORMATION WAS ACCURATE.	
ROLE	EXCELLENT CHARACTER DEVELOPMENT; STUDENT CONTRIBUTED IN A SIGNIFICANT MANNER.	GOOD CHARACTER DEVELOPMENT; STUDENT CONTRIBUTED IN A COOPERATIVE MANNER.	FAIR CHARACTER DEVELOPMENT; STUDENT MIGHT HAVE CONTRIBUTED.	LITTLE OR NO CHARACTER DEVELOPMENT; STUDENT DID NOT CONTRIBUTE MUCH AT ALL.	
KNOWLEDGE GAINED	CAN CLEARLY EXPLAIN SEVERAL WAYS IN WHICH HIS OR HER CHARACTER "SAW" THINGS DIFFERENTLY THAN OTHER CHARACTERS AND CAN EXPLAIN WHY	CAN CLEARLY EXPLAIN SEVERAL WAYS IN WHICH HIS OR HER CHARACTER "SAW" THINGS DIFFERENTLY THAN OTHER CHARACTERS	CAN CLEARLY EXPLAIN ONE WAY IN WHICH HIS OR HER CHARACTER "SAW" THINGS DIFFERENTLY THAN OTHER CHARACTERS	CANNOT EXPLAIN ANY WAY IN WHICH HIS OR HER CHARACTER "SAW" THINGS DIFFERENTLY THAN OTHER CHARACTERS	
PROPS	USED SEVERAL PROPS AND SHOWED CONSIDERABLE CREATIVITY	USED ONE OR TWO APPROPRIATE PROPS THAT MADE THE PRESENTATION BETTER	USED ONE OR TWO PROPS THAT MADE THE PRESENTATION BETTER	USED NO PROPS TO MAKE THE PRESENTATION BETTER	
REQUIRED ELEMENTS	INCLUDED MORE INFORMATION THAN REQUIRED	INCLUDED ALL REQUIRED INFORMATION	INCLUDED MOST REQUIRED INFORMATION	INCLUDED LESS INFORMATION THAN REQUIRED	

Comments:

Presentation Assessment Rubric

NAME: **DATE:** **PERIOD:**

Behavior/Skill	Excellent 4	Good 3	Needs Improvement 2	Unacceptable 1	Total Score
CONTENT	CLEAR, APPROPRIATE, AND CORRECT	MOSTLY CLEAR, APPROPRIATE, AND CORRECT	SOMEWHAT CONFUSING, INCORRECT, OR FLAWED	CONFUSING, INCORRECT, OR FLAWED	
CLARITY	LOGICAL, INTERESTING SEQUENCE	LOGICAL SEQUENCE	UNCLEAR SEQUENCE	NO SEQUENCE	
PRESENTATION	CLEAR VOICE AND PRECISE PRONUNCIATION	CLEAR VOICE AND MOSTLY CORRECT PRONUNCIATION	LOW VOICE AND INCORRECT PRONUNCIATION	MUMBLING AND INCORRECT PRONUNCIATION	
VISUAL AIDS	ATTRACTIVE, ACCURATE, AND GRAMMATICALLY CORRECT	ADEQUATE, MOSTLY ACCURATE, AND FEW GRAMMATICAL ERRORS	POORLY PLANNED, SOMEWHAT ACCURATE, AND SOME GRAMMATICAL ERRORS	WEAK, INACCURATE, AND MANY GRAMMATICAL ERRORS	
LENGTH	APPROPRIATE LENGTH	SLIGHTLY TOO LONG OR SHORT	MODERATELY TOO LONG OR SHORT	EXTREMELY TOO LONG OR SHORT	
EYE CONTACT	MAINTAINS EYE CONTACT, SELDOM LOOKING AT NOTES	MAINTAINS EYE CONTACT MOST OF TIME BUT FREQUENTLY RETURNS TO NOTES	OCCASIONALLY USES EYE CONTACT BUT READS MOST OF INFORMATION	NO EYE CONTACT BECAUSE READING INFORMATION	
				TOTAL	

Comments:

Safety Review Rubric I

	Scoring Criteria			
The student	Excellent 4	Good 3	Needs Improvement 2	Unacceptable 1
Selects appropriate PPE				
Wears protective clothing and eye protection				
Demonstrates fire extinguisher operation				
Subtotal for safety equipment				
Maintains clean facility				
Cleans area after tasks are complete				
Stores materials properly				
Subtotal for facility cleanliness				
Models appropriate behavior				
Observes safety rules				
Follows written directions				
Follows oral directions				
Observes surroundings				
Subtotal for appropriate behaviors				

Writing Rubric

	4	3	2	1
Writing Structure	Sentences and paragraphs are complete, well constructed, and of varied structure.	All sentences are complete and well constructed (no fragments and no run-ons). Paragraphing is generally done well.	Most sentences are complete and well constructed. Paragraphing needs some work.	There are many sentence fragments or run-on sentences, OR paragraphing needs lots of work.
Content	The writing contains a description of all components of the communication process.	The writing contains a description of three components of the communication process.	The writing contains a description of two components of the communication process.	The writing contains a description of one component of the communication process.
Content Accuracy	The writing contains at least three accurate examples of types of communication.	The writing contains at least two accurate examples of types of communication.	The writing contains at least one accurate example of types of communication.	The writing contains no examples of types of communication.
Content Understanding	Ideas are expressed in a clear and organized fashion.	Ideas are expressed in a pretty clear manner, but the organization could be better.	Ideas are somewhat organized but are not very clear.	The writing seems to be a collection of unrelated sentences.

Name: _____

Date: _____

Period: _____

Work Ethic and Values Rubric

Behavior/Skill	Exemplary 4 Points	Accomplished 3 Points	Developing 2 Points	Beginning 1 Point	Score
Punctuality (arrives on time)					
Preparation (completes pre-assignments and brings necessary materials)					
Respects other students/workers					
Listens to supervisor and follows directions					
Accepts responsibility for actions					
Demonstrates positive personality traits (kindness, trustworthiness, honesty)					
Demonstrates productivity (patience, thoroughness, hard working)					
Demonstrates a concern for others					
Remains on task and allows others to remain on task					
Takes initiative as appropriate					
				Total Score	

Unit 2: Math, Introduction to Blueprints, and Hand and Power Tools

Competency 1: Apply the four basic math skills with whole numbers, fractions, and percents. (CONTREN Module: 00102-04, 00105-04, 40106-07, and 03201-07) (DOK 1) MAT, BLU, TMI, TMH

Suggested Enduring Understandings

1. Math is used daily in industrial maintenance when selecting the properly sized tools, screws, bolts, and other materials.
2. Math is not only an integral part of simple measurement but is also required to select replacement parts and provide service to machinery.

Suggested Essential Questions

1. Can someone be successful as an industrial technician without knowing basic math skills?
2. How is knowledge of basic math skills important throughout life?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Perform mathematic calculations relating to the installation and service trade. (DOK1) SGM1, SGM2, SGM4	a. Demonstrate how to calculate problems and how they relate to job tasks in the installation and service trade. Add, subtract, multiply, and divide whole numbers, decimals, and fractions; convert whole numbers to fractions; convert fractions to whole numbers; convert decimals to percents and percents to decimals; convert fractions to decimals; compare fractions; and convert fractions to percents. 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 who has greater math skills. Have students solve word problems related to industrial maintenance trades. 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? T6, M1, M2, M3, M4, M5, M7, R4, R5 Have students solve word problems related to industrial maintenance trades such as the following. Katie needs to find various lengths of square key stock: 1/2 + 1 1/4, 3/4 + 7/8, + 4 5/16. Convert the sums to mixed numbers so that she will know where to find them on her tape measure. T6, M1, M2, M3, M4, M5, M7, R4, R5 Demonstrate how to convert calculated fractions to use on a tape measure. Give the students several pieces of precut straight	a. 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. 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

	metal bars. Have students give the measurement in 1/4 -, 1/8 -, and 1/16-in. measurements for the same piece of material. The students should learn the relationship between incremental measurements. T6, M1, M2, M3, M4, M5, M7, R4, R5, W1 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. T6, M1, M2, M3, M4, M5, M7, R4, R5	example, a 3/8-in. drill bit will drill a hole that is 12/32nds of an inch, 24/64th 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. Have the students demonstrate how to measure a piece of stock using a tape measure. The students should record the measurement in three different fractional measures: 1/8, 1/16, and decimal equivalent.

Competency 2: Perform basic mathematical calculations related to industrial maintenance shop operations. (CONTREN Module: 00102-04, 00105-04, and 40106-07) (DOK 1) MAT, BLU, TMI

Suggested Enduring Understandings

1. Different measures are used in all areas of mechanical applications.
2. Knowledge of the metric system is important throughout the industrial maintenance and HVAC industry.
3. The student should understand how material is calculated using metric and/or English measurement.

Suggested Essential Questions

1. How do I convert an English measure to the metric equivalent and vice versa?
2. Why are there two different systems of measure?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Use the metric system in industrial maintenance and HVAC applications. (DOK1) SGM1, SGM2, SGM3, SGM4, SGM5, TTA4, TTA5	a. Recognize and use metric units of length, weight, volume, and temperature. Convert metric measurements to English measurements to solve basic linear measures, angles, and sides. Discuss the metric system and its relevance to the global manufacturing market by laying out English and metric	a. 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.

	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. CS1, T1, T4, T6, M1, M3, M4, M5, M7 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, 2-in. square, and 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. T1, T2, M1, M7, R1, W1	Label 20 bolts of various sizes including English and metric measurements installed into a board. 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 correctly sized wrenches they used. Use the following Web site to help reinforce reading measurement devices: http://www.rickyspears.com/rulergame/.
b. Compute distances according to a drawn plan, and then calculate the amount of material for a given project. (DOK1) SGM1, SGM2, SGM3, SGM4, SGM5, TTA4, TTA5	b. Have students create a material list from a given blueprint to calculate the minimum amount of material needed to complete a project. M1, R1, R2, R3, W1,W2, W4, W5 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. M1, M7, R1, R2, R3, W1,W2, W4, W5	b. Have students solve for missing dimensions on a given blueprint, and then 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. Have students use measurement tools to 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: $A^2 + B^2 = C^2$, 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.

Competency 3: Identify and perform functions using various measuring tools and instruments (CONTREN Module: 00102-04, 40106-07, and 03102-07). (DOK 2) MAT, TMI, TMH

Suggested Enduring Understandings

1. Basic measuring skills are a necessity in all areas of installation and service.
2. Identify the different measurements associated with the different trades as in sheet metal gauge and electrical wire gauge.

Suggested Essential Questions

1. What degree of precision should an industrial maintenance technician be able to measure?
2. Why is there more than one standard of measure associated with different trades?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Read a rule and lay out lines to the nearest 1/16 in. (DOK2) SGM3, SGM4, TTA4	a. Demonstrate how to read a rule to the nearest 1/16 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 1 in. 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. M1, M7, R1, W1 Reference the following Web sites to help illustrate how to read a ruler: • http://www.youtube.com/watch?v=lZ3Ec1p93PA&feature=related • http://www.youtube.com/watch?v=Xb3tH9kx7PY&feature=related • http://www.youtube.com/watch?v=ACRA2r03QT4&feature=related • http://www.rickyspears.com/rulergame/ 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. M1, R1, W1	a. Have student's measure lengths of the project assigned by the instructor to determine the length of material to the nearest 1/16 in. Have the students demonstrate how to measure a given piece of stock. The students should measure pieces of varying lengths and accurately read the ruler measurement. Use the **Measurement Rubric** to grade the student's work.

Competency 4: Read, analyze, and design a blueprint. (CONTREN Module: 00105-04) (DOK 2) BLU

Suggested Enduring Understandings

1. The blueprint is the plan designed to attain a goal

Suggested Essential Questions

1. Why are blueprints important in planned

using specific drawings and instructions for completion.

structures and equipment?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Identify and interpret terms and symbols commonly used on blueprints. (DOK2) SGM5, TTA4, TTA5	a. Relate information on prints to real parts/models, describe the information in a title block, and design a blueprint. 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. M1, M7, R1, R2, W1 Bring in an object with multiple parts that can be disassembled, and show how parts align. T1, T2, T3, T4, T5, T6, R1, R2, R3 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. T1, T2, T3, T4, T5, T6, R1, R2, R3, W1 Discuss the parts of the blueprint: legend, title block, border, drawing area, and the revision block. Give students a sample drawing for reference. M1, M7, R1, R2, R3, W1 Explain what the title block and parts list encompass. Explain the scale that applies to the physical part as compared to the paper blueprint. M1, M7, R1, R2, R3, W1 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. M1, M7, R1, R2, R3, W1	a. 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 5: Demonstrate the use and maintenance of various hand and power tools found in the industrial maintenance and HVAC trade. (CONTREN Module: 00101-04, 00103-04, 00104-04, and 40102-07) (DOK 3) SAF, HTO, PTO, TTI

Suggested Enduring Understandings

1. Knowing which tool to use to properly perform the task is important.
2. There are certain tools that are used to perform specific tasks.
3. Proper tools are essential to performing certain tasks.

Suggested Essential Questions

1. How do I determine which tool is used for a specific job?
2. Why are specific tools important in the industrial trades?
3. What is the difference between power tools and hand tools?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Identify and discuss the proper safe use of common hand and power tools. (DOK1)	a. 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	a. Label and identify tools found in the shop. The students should give the proper name and slang name, if applicable. Grade the students on the number of correct responses.

	~~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 device at a later date. Let students practice using PPE and also locating the items in the shop storage area.~~ ~~E1, R1, R2, W1, W2~~ ~~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~~	~~While students are using an oxy-fuel torch, grade them on the use of personal protection equipment such as face shields, goggles, leather gloves, proper clothing, and so forth.~~ ~~Have the students evaluate hand tools that have safety hazards such as frayed cords, cut or nicked wiring, ladders with cracked rails, chisels with mushroomed heads, and screwdrivers with chipped tips. Have the students select a drill for drilling holes in concrete. The students should justify why they suggest a particular drill, how much the drill costs, and where the tool can be bought.~~ ~~Have the students perform a drilling project. The students should select the proper drill size for a 1/4-in. hole, the proper drill speed, and type of bit used. The students should also be graded on the safe use of the handheld power drill.~~

	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	
b. Select and demonstrate the use of tools, and explain the procedures for maintaining hand and power tools. (DOK3)	b. Lay out an assortment of tools on a work bench. Demonstrate how to select the proper tool to accomplish a given task. Demonstrate how to clean and oil tools as well as tool storage. E1, R1, R2, R3, W1	b. Lay out dirty hand tools on the work bench. Have the students properly clean and store the hand tools.

Standards

Industry Standards

CONTREN CORE

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

CONTREN INDUSTRIAL MAINTENANCE LEVEL ONE

TTI Tools of the Trade
TMI Craft-Related Mathematics

CONTREN HVAC LEVEL ONE

TMH Trade Mathematics

Applied Academic Credit 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.
SGM2 Develop and apply the basic operations of rational numbers to algebraic and numerical tasks. Create and apply algebraic expressions and equations.
SGM3 Apply geometric relationships of angles, two- and three-dimensional shapes, and transformations.
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.
SGM5 Organize and interpret data. Analyze data to make predictions.

TRANSITION TO ALGEBRA

TTA4 Demonstrate and apply various formulas in problem-solving situations.
TTA5 Interpret data.

21st Century Learning Standards

CS1 Flexibility and Adaptability

National Educational Technology Standards for Students

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

ACT College Readiness Standards

M1 Basic Operations and Applications
M2 Probability, Statistics, and Data Analysis
M3 Numbers: Concepts and Properties
M4 Expressions, Equations, and Inequalities

~~M5 Graphical Representations~~
~~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~~
~~W4 Organizing Ideas~~
~~W5 Using Language~~

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~~Suggested Rubrics and Checklists~~

Name: _____

Date: _____

Period: _____

Measurement Rubric

Object to be measured: _____

Measuring instrument: _____
Record measurements below (length, depth, width, internal, external, etc.):

Rate the ability of the student to perform measurement tasks shown below using the following scale:

4 Proficient – Can perform consistently and independently with proficiency of an incumbent worker
3 Intermediate – Can perform the task but may require further practice to become as proficient as an incumbent worker
2 Introductory – Can perform the task, but some coaching and further training are required.
1 Limited – Can perform the task with extensive coaching. Further training and practice are required.

Task	**Rating**
Safety procedures	
Uses proper measuring instrument	
Understands how to measure	
Records proper measurements	
Total Score	

Comments:

Name: _____

Date: _____

Period: _____

Teamwork Rubric

Behavior/Skill	**Accomplished 3 Points**	**Developing 2 Points**	**Beginning 1 Point**	**Total Score**
Sharing	Shared ideas with others	Occasionally shared ideas with others	Seldom shared ideas with others	
Listening	Always listened to peers	Occasionally listened to peers	Ignored ideas of peers	
Respecting	Interacted with, encouraged, and supported ideas of others	Occasionally encouraged and supported others	Seldom encouraged and supported others	
Participating	Shared task equally with group members	Did most of the task	Did very little of the task	

Comments:

Unit 3: Orientation to the Trade, Tools of the Trade, Fasteners and Anchors, and Oxy-Fuel Cutting (IM)

Competency 1: The student will research and distinguish job opportunities in the industrial maintenance field and then reflect upon the importance of the industrial maintenance mechanic's role in the modern manufacturing and service industry (CONTREN: 00108-04 and 40101-07) (DOK 2) EMP, OTI

Suggested Enduring Understandings

1. The student will understand that specific fasteners have specifications and limits of use.
2. The student will understand how to properly select and use the fastener needed for a particular job.

Suggested Essential Questions

1. Where are fasteners used?
2. Why are fasteners so important in the installation and service industry?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe employment opportunities in the industrial maintenance profession. (DOK2)	a. Describe employment opportunities including potential earnings, employee benefits, job availability, place of employment, working conditions, educational requirements, and basic employee responsibilities; and demonstrate and practice effective team-building and leadership skills and appropriate work ethics. Explain the employment opportunities in the local area and surrounding communities. Describe types of jobs that industrial technicians can attain and the financial benefits that could possibly be earned in the trade. 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; 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 who the vocational complex is intended to serve (industry needs). Then 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. The students should visit the local WIN Job Center and discuss job opportunities that are available in the area and the benefits offered by local industry. CS1, CS2, CS3, CS4, CS5, E1	a. Have the students give oral presentations about the results of their visit to the WIN Job Center. Ask questions during the presentation such as the following: • How many jobs are available in the area that relate to industrial maintenance and HVAC? • How much can a person starting out expect to earn in payroll? • How many companies in the area offer retirement, insurance, and other financial benefit packages to employees?

Competency 2: Identify and use tools found in the industrial maintenance trade, describe how each is used, and discuss proper care and maintenance of the tools. (CONTREN: 00103-04, 00104-04, and 40102-07) (DOK 2) HTO, PTO, TTI

Suggested Enduring Understandings

1. The student will understand that specific fasteners have specifications and limits of use.
2. The student will understand how to properly select and use the fastener needed for a particular job.

Suggested Essential Questions

1. Where are fasteners used?
2. Why are fasteners so important in the installation and service industry?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Illustrate the use of tools used in the industrial maintenance profession. (DOK2) SGM1, TTA3, TTA4	a. Describe and explain the purpose of each of the tools commonly used by industrial maintenance craft workers and how to maintain each of the tools used by industrial maintenance craft workers, and demonstrate the proper use and basic maintenance of selected industrial maintenance tools and the use and maintenance of hand and power tools. Lay out common hand tools on a work bench such as screwdrivers, pliers, saws, wrenches, and hammers. Discuss and demonstrate how each tool is safely used in the industrial maintenance and HVAC area. Use the Internet to search for sites depicting misuse of hand tools such as the following: • http://findarticles.com/p/articles/mi_hb5645/is_/ai_n23674427 • http://www.ncbi.nlm.nih.gov/pubmed/8899580 • http://www.safetytoolboxtalks.com/index.php?option=com_content&task=view&id=105&Itemid=2 Divide students into groups, and give each group a scenario or case study (written or on video) involving an accident. Have each group identify safety mistakes in each situation; determine correct procedures; and present the scenario, mistakes found, and procedures that should have been used to the class. For example, never use a slotted screwdriver as a chisel. This is a common misuse of hand tools found in the real-world industrial setting. T1, T3, T4, T6, E1, M7	a. Evaluate the case study for content.
b. Identify and use common hand and power tools used in the industrial maintenance trade. (DOK2) SGM1, TTA3, TTA4	b. Select and demonstrate and explain the safe use of tools and the procedures for maintenance. Discuss types and sizes of screwdrivers, and demonstrate how to properly use hand screw driving devices. This can be reinforced by setting up a lab table with various sizes and shapes of screwdrivers. The following suggestions may aid in explaining what various screwdrivers are used for and where they are applied.	b. Assign each student a specific set of tools (i.e., hammers, power saws, wrenches, etc.). Have students use the Internet to research and write or type (if technology resources are

	• Locate screws that require various sizes of screwdrivers such as a slotted screw head in 3/16 in., 1/4 in., 5/16 in., and 3/8 in. • Locate screws that require the use of a No. 1, No. 2, and No. 3 Phillips head screwdriver. • Locate equipment that requires tools of various shank lengths to demonstrate the use of 3 in., 4 in., 6 in., and 8 in. shank lengths. T1, T3, T4, T6, E1, M7	available) a report on the proper procedures for maintenance of the assigned set of tools.

Competency 3: Identify various fasteners and anchors found in the industrial and HVAC trade, how to install and remove fasteners and anchors, and how to select the correct fastener or anchor for an application (CONTREN Module: 40103-07 Fasteners and Anchors). (DOK2) FAN

Suggested Enduring Understandings

1. Understanding that specific fasteners have specifications and limits of use is important.
2. Understanding how to properly select and use the fastener needed for a particular job is crucial to the industrial maintenance trade.

Suggested Essential Questions

1. Where are fasteners used?
2. Why are fasteners so important in the installation and service industry?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Identify and install threaded fasteners, non-threaded fasteners, and anchors. (DOK2) SGM1	a. Lay out various fasteners such as 1/4-20 cap head bolt, socket head bolt, various washers and nuts, carriage bolt, shoulder bolt, lag bolts, No. 8 pan head sheet metal screw, and No. 8, No. 10, and No. 12 flat-head brass wood screws. The students are to select, explain the use of, and install threaded fasteners, non-threaded fasteners, and anchors. Let the students reference the Internet to determine what the bolts are and how they are used. You may reference http://www.boltdepot.com/Fastener-Information/Type-Chart.aspx. Explain each fastener's use, its weaknesses, and its strengths. Make sure to use various drivers such as flat, Phillips, torx, hex, and Allen head styles. T3, T6, M3, M6, M7, R2, R3, R4, R5, W1 • http://www.boltdepot.com/Fastener-Information/Printable-Tools/Type-Chart.pdf • http://www.boltdepot.com/Fastener-Information/Printable-Tools/Default.aspx • http://www.nutsandbolts.com/videos.html	a. Have the student verbally identify the proper grade bolt for use in a specific application in which the bolt or screw can be used.
b. Identify various grades of bolt hardness. (DOK1) SGM1	b. Demonstrate how to determine various grades of bolts and where they are used. Lay out various grades of bolts on a workbench, and discuss the thread, shoulder, head, diameter, and length of the bolts. The following Web sites may be useful in explaining bolt hardness and tensile strength: T3, T6, M3, M6, M7, R2, R3, R4, R5, W1	b. Give the student a set of bolts in various sizes and thread types, and have them visually determine what grade bolt they are.

- http://www.bikernet.com/garage/fastenertech.asp
- http://home.jtan.com/~joe/KIAT/kiat_2.htm
- http://www.precisionscrewandbolt.com/hardness.htm
- http://www.boltdepot.com/
- http://store.nutsandbolts.com/fastener-information.html
- http://www.nutsandbolts.com/videos.html
- http://www.boltscience.com/pages/glossary.htm

Competency 4: Identify and describe the basic equipment, setup, and safety rules for proper use of equipment, and prepare base metal for oxy-fuel welding. (CONTREN Module: 40104-07 Oxy-Fuel Cutting) (DOK 2) OXC

Suggested Enduring Understandings

1. Typical applications of oxy-fuel welding and brazing are important.
2. Safety procedures must be followed in oxy-fuel cutting.

Suggested Essential Questions

1. What is oxy-fuel equipment used for?
2. Where is oxy-fuel used in the industrial maintenance area?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Identify and explain the use of oxy-fuel cutting equipment. (DOK1)	a. Using oxy-fuel cutting equipment, provide the students with a list of safety rules stating the safety precautions for using oxy-fuel equipment. Have the students discuss the rules and quiz each other in preparation for the safety test. Provide the students with a list of written safety rules involved in oxy-fuel cutting. Provide the students with an illustration or diagram of the components of the oxy-fuel equipment. Following discussion and demonstration of the parts, the students will label the parts of the illustration. T6, E2, E3 • http://www.virginia.edu/art/studio/safety/sculpture/mstools/oxyactelyene.htm • http://ezinearticles.com/?Acetylene-and-Oxygen-Cutting-Torch---OSHA-Says-Oxyfuel-Safety-is-Part-of-Welding-Safety&id=1253287	a. Using a teacher assessment, test the students on the safety rules associated with oxy-fuel cutting. Provide an unlabeled diagram of the oxy-fuel equipment, and ensure the students correctly identify the components of the equipment. Each student should present his or her diagram to the class and explain the parts of the diagram. Use the **Presentation Assessment Rubric** to grade the students' work.
b. Demonstrate how to use an oxy-fuel torch. (DOK2)	b. Set up oxy-fuel cutting equipment, light and adjust an oxy-fuel torch, shut down oxy-fuel cutting equipment, disassemble oxy-fuel cutting equipment, and change an empty cylinder.	b. Have students demonstrate the assembly, operation, and disassembly of the

	Demonstrate and discuss the assembly, operation, and disassembly of the oxy-fuel equipment. Following discussion of flames, demonstrate the various flame types, flashbacks, and backfires resulting from improper adjustment of the torch. Following the demonstration, have students perform the entire exercise individually. These Web sites may prove useful in demonstrating and discussing properly using oxy-fuel equipment: T6, E2 • http://www.virginia.edu/art/studio/safety/sculpture/mstools/oxyactelyene.htm • http://www.wikihow.com/Use-a-Cutting-Torch • http://ezinearticles.com/?Acetylene-and-Oxygen-Cutting-Torch---OSHA-Says-Oxyfuel-Safety-is-Part-of-Welding-Safety&id=1253287	oxy-fuel equipment. Have students demonstrate neutral, oxidizing, and carbonizing flames.
c. Perform oxy-fuel cutting (DOK2): • Straight line and square shapes • Piercing and slot cutting • Bevels • Washing	c. Explain and demonstrate how to cut straight lines and square shapes, piercing, and slot cutting. Using a coffee can, framing square, and soapstone, have the students trace a square and circle with soapstone on a piece of flat, hot rolled steel. • The students should use a framing square and soapstone to draw a 5-in. by 5-in. square blank. The students should practice properly cutting out blank pieces of steel before proceeding with the circle project. • Next, using the coffee can bottom, the students should outline and cut out a circle making sure to keep within 1/16 in. from the drawn line. Following this class activity, the students will practice performing the operations (http://www.wikihow.com/Use-a-Cutting-Torch). T6, E2	c. Have students demonstrate how to cut shapes that include straight lines, squares, piercing, and slots.

Standards

Industry Standards

CONTREN CORE

HTO Introduction to Hand Tools
PTO Introduction to Power Tools
EMP Basic Employability Skills

CONTREN INDUSTRIAL MAINTENANCE LEVEL ONE

OTI Orientation to the Trade
TTI Tools of the Trade
FAN Fasteners and Anchors
OXC Oxy-Fuel Cutting

Applied Academic Credit 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.

TRANSITION TO ALGEBRA

TTA3 Understand geometric principles of polygons, angles, and figures.
TTA4 Demonstrate and apply various formulas in problem-solving situations.

21st Century Learning Standards

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

National Educational Technology Standards for Students

T1 Creativity and Innovation
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T6 Technology Operations and Concepts

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
M3 Numbers: Concepts and Properties
M6 Properties of Plane Figures
M7 Measurement
R2 Supporting Details
R3 Sequential, Comparative, and Cause–Effect Relationships
R4 Meaning of Words
R5 Generalizations and Conclusions
W1 Expressing Judgments

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~~Suggested Rubrics and Checklists~~

Name: _____

Date: _____

Period: _____

Presentation Assessment Rubric

Behavior/Skill	Exemplary 4 Points	Accomplished 3 Points	Developing 2 Points	Beginning 1 Point	Score
Content	Clear, appropriate, and correct	Mostly clear, appropriate, and correct	Somewhat confusing, incorrect, or flawed	Confusing, incorrect, or flawed	
Clarity	Logical, interesting sequence	Logical sequence	Unclear sequence	No sequence	
Presentation	Clear voice and precise pronunciation	Clear voice and mostly correct pronunciation	Low voice and incorrect pronunciation	Mumbling and incorrect pronunciation	
Visual Aids	Attractive, accurate, and grammatically correct	Adequate, mostly accurate, and few grammatical errors	Poorly planned, somewhat accurate, and some grammatical errors	Weak, inaccurate, and many grammatical errors	
Length	Appropriate length	Slightly too long or short	Moderately too long or short	Extremely too long or short	
Eye Contact	Maintains eye contact, seldom looking at notes	Maintains eye contact most of time but frequently returns to notes	Occasionally uses eye contact but reads most of information	No eye contact because reading information	
				TOTAL	

Comments:

Unit 4: Introduction to HVAC, Tools of the Trade (HVAC), Copper and Plastic Piping, Soldering and Brazing, and Basic Electricity (IM)

Competency 1: Identify and explain heating, ventilation, and air-conditioning systems, HVAC environmental law, and job opportunities that are available in the HVAC profession. (CONTREN Module: 03101-07 Introduction to HVAC) (DOK 2)[INT]

Suggested Enduring Understandings

1. Understanding where HVAC systems are used in modern residential and commercial application is important.
2. Being able to describe the basic components of the cooling system is important for the HVAC profession.

Suggested Essential Questions

1. What can a person expect to make working in the HVAC industry?
2. What size are HVAC systems that are found in commercial buildings?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Explain the basic principles of heating, ventilating, and air-conditioning. (DOK2)	a. Identify career opportunities available to people in the HVAC trade, and explain the purpose and objectives of an apprentice training program. Gather the following items for the demonstration: an infrared thermometer gun, glass of ice water, 4-in. length of 1/2-in. copper pipe capped on one end, 4-in. length of 1/2-in. plastic pipe capped on one end, and a sheet of paper. Using the infrared thermometer, test the glass of ice water, copper tube, and plastic tube. Log the temperatures on a sheet of paper in the students' notebooks. Next, make a funnel by rolling up the sheet of paper into a tight roll. The funnel should be large at the top and small at the bottom. Pour the copper pipe and plastic full of ice water. Let stand 2 minutes. Finally, take another temperature measurement of the copper and plastic pipe. Explain to the students about BTU transfer and why copper piping is such a good thermal conductor. Have the students reflect on the temperature conducting differences between the copper and plastic pipes. This Web site may be useful in illustrating how an HVAC system works: http://home.howstuffworks.com/how-to-repair-central-air-conditioners.htm. T4, T6, E1, E2, M3, M7, R3	a. Form paired groups of students. Using the infrared thermometer, have the students log the air temperature at the return register and registers nearest the unit and the register at the end of the duct run. The students should also check objects within the shop area or classroom such as tables and chairs. The student pair should log the temperature differences found in the shop or classroom area. The students should verbally report on temperature differences between each item tested. Use the **Team-**

		Building and Participation Skills Rubric to grade the students' participation and teamwork.
b. Describe what the Clean Air Act means to the HVAC trade. (DOK1)	b. Describe the types of regulatory codes encountered in the HVAC trade. Using the Internet and a data projector, display the federal Clean Air Act at http://www.epa.gov/air/caa/. Explain the history of the HVAC law and how changes in the law reflect society's need for HVAC and environmental concerns generated by refrigerants used in residential and commercial applications. T4, T6, E1, E2, M3, M7, R3	b. Have students use the Internet to look up the federal Clean Air Act at http://www.epa.gov/air/ caa/. After the students have researched the contents of the Clean Air Act, have them create a pictorial poster that depicts Title I through Title VI. The photos should illustrate what each section of the law relates to. The students should explain what the law means to an HVAC technician.
c. Identify the types of schedules/ drawings used in the HVAC trade. (DOK1)	c. Using a dry erase board with colors of black, red, green, blue, and any other colors available, demonstrate how to draw a bird's-eye view of an HVAC schematic of a three-bedroom house with one bath, kitchen, dining, and living area. The drawing should include equipment location, duct, and register locations. Use various colors to illustrate where the return is located, room registers, duct runs, and air handler. T4, T6, E1, E2, M3, M7, R3	c. Using the assessment in Section A, have the student pair create a schematic of the shop or classroom HVAC system. The students should draw the schematic illustrating the HVAC system and the temperature values taken at locations as mentioned above. The students'

schematic should also encompass the elements of the HVAC drawing.

Competency 2: Demonstrate the safe use and routine maintenance of hand and power tools used in the HVAC trade. (CONTREN Module: 00103-04, 00104-04, & 040102-07) (DOK2). HTO, PTO, TTI

Suggested Enduring Understandings

1. The proper use, maintenance, and safety of tools improve job efficiency and develop confidence.

Suggested Essential Questions

1. What are the specialized tools used in HVAC?
2. Why are there specialized tools in HVAC?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Demonstrate the safe use and maintenance of hand and power tools used in HVAC. (DOK2)	a. Identify, discuss, properly select, and demonstrate how to use a vacuum pump, manifold gauges, and recovery equipment. Using a 4-in. piece of PVC pipe 3 ft long, glue an adapter in one end for a 1/4-in. female threaded outlet and insert a vacuum gauge. On the other end of the pipe, insert an adapter to attach an HVAC vacuum pump. Using the shop vacuum pump, create a vacuum in the pipe and allow the students to watch the vacuum gauge during the process. T6, E1, E2, M1, M3, M5, M7, R1, R2, R3, R4, R5, W1, W2	a. Lay out HVAC tools on a workbench. Have the students verbally explain what each tool is used for. Have the students recover refrigerant from a unit (window unit), replace or repair the failed component, pull vacuum on the system, and recharge the system.

Competency 3: Identify and discuss the tools used in the piping trade, discuss the materials and methods of connecting piping systems, and perform copper and plastic piping tasks found in the industrial maintenance and HVAC environment. (CONTREN Module: 03103-07 Copper and Plastic Piping) (DOK 2) CPP

Suggested Enduring Understandings

1. Understanding the differences in types of pipe is important.
2. Understanding the different methods for joining pipes is important.

Suggested Essential Questions

1. Why are certain types of pipe used in certain applications?
2. Which specific methods of joining pipes are used versus other methods?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Discuss and demonstrate how to use copper tubing in HVAC. (DOK2)	a. State the precautions that must be taken when installing refrigerant piping, select the right tubing for a job, cut and bend copper tubing, safely join tubing by using flare and compression fittings, determine the kinds of hangers and supports needed for refrigerant piping, and state the basic safety requirements for pressure testing a system once it has been installed. Demonstrate how to properly measure, cut, and bend copper tubing; select tubing; utilize fittings; and hang and support refrigeration piping. Reference Internet Web sites for instructional support such as the following: • http://www.ehow.com/video_4418767_cutting-copper-pipes.html • http://www.copper.org/publications/pub_list/pdf/copper_tube_handbook.pdf • http://www.diyfixit.co.uk/diy/plumbing/copper_bend/copper_bend.html • http://www.diydata.com/techniques/plumbing/bending.php Demonstrate proper pressure testing an HVAC system. Assemble a 4-ft length of copper pipe that contains couplings and unions. Using the shop air compressor, pressurize the pipe to 30 psi. Demonstrate how to detect a leak by brushing soapy water across each fitting. Demonstrate the pressure test with all the union fittings seated so that there is no leak. Next, demonstrate the pressure test with one union cracked open so that the students can view soap bubbles forming on the union fitting. T6, E1, E2, M7, W1,W2, W5	a. Have the students demonstrate cutting, bending, and flaring of copper tubing. Once the tubing is fitted, pressure test the connection and leak test using soapy water. Leaking connectors should be noted and repaired by the students.
b. Discuss and demonstrate how to use plastic tubing in HVAC. (DOK2)	b. Identify types of plastic pipe, state their uses, and cut and join lengths of plastic pipe. Discuss the uses of plastic pipe, types of glued and threaded fittings, types of PVC glues and solvents, Teflon tape, and how all these are used to create a plastic piping system. Demonstrate how to properly measure, cut, and glue plastic piping and install fittings. These Web sites are useful in illustrating how to glue PVC piping: T6, E1, E2, M7, W1,W2, W5 • http://www.askthebuilder.com/How_To_Glue_PVC_Pipe_Video.shtml • http://www.pvcworkshop.com/cut&glue. htm • http://www.thisoldhouse.com/toh/skill-builder/0,,1194353,00.html • http://www.johndeerelandscapes.com/_Professional_R_S/_Articles/Arti_pvc_glue.asp	b. Have the students build a 12-in. square shape from 3/4-in. PVC pipe with a tee fitting that can be hydro pressure tested.

Competency 4: Prepare and solder copper piping systems in various industrial and HVAC applications and properly clean, install fittings, and braze piping (silver solder). (CONTREN Module: 40104-07 and 03104-07) (DOK2) OXC, SBR

Suggested Enduring Understandings

1. Understanding tools and materials used in soldering low-pressure copper piping is important in industrial maintenance trades.
2. Understanding tools and materials used in brazing high-pressure copper piping is important in industrial maintenance trades.
3. Understanding the types of torches and their applications in soldering and brazing applications is important in industrial maintenance trades.

Suggested Essential Questions

1. What is the difference between soldering and brazing?
2. What types of solder and/or fluxes should be used in various applications?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Solder copper pipe in HVAC. (DOK2)	a. Assemble and operate the tools used for soldering, prepare tubing and fittings for soldering, identify the purposes and uses of solder and solder fluxes, and solder copper tubing and fittings. Demonstrate and explain the proper technique for preparing copper for soldering. Using copper piping and fittings, practice soldering the fittings onto the pipe with solder using oxy-fuel torch equipment (http://video.google.com/videoplay?docid=6607591589472663 85). T6, M7, W1	a. Using four 12-in. lengths of copper tubing and copper fittings, the students should practice soldering fitting onto lengths of copper tubing.
b. Braze copper pipe in HVAC. (DOK2)	b. Assemble and operate the tools used for brazing, prepare tubing and fittings for brazing, identify the purposes and uses of filler metals and fluxes used for brazing, braze copper tubing and fittings, and identify the inert gases that can be used safely to purge tubing when brazing. Demonstrate and explain the proper technique for preparing copper for brazing, which includes fit-up and pressure test. Explain the difference between soldering and brazing. Using copper pipe and fittings brazing material and oxy-fuel torch equipment, demonstrate how to braze the copper pipes together. T6, M7, W1	b. Using four 12-in. lengths of copper tubing and copper fittings, the students should practice brazing fitting onto lengths of tubing.

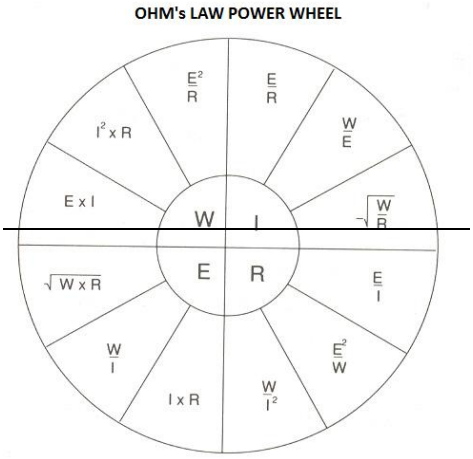
Competency 5: Identify electrical safety hazards, demonstrate safety around circuits and equipment, describe basic electricity laws, interpret electrical drawings and schematics, and demonstrate wiring basic electrical circuits. (CONTREN Module: 03106-07, 40203-08, 03206-07, and 03207-07) (DOK 2) BEL, ETO, ALT, BAE

Suggested Enduring Understandings

1. Understanding basic electrical principles is essential to industrial maintenance trades.
2. Understand how basic circuitry works is crucial to industrial maintenance trades.

Suggested Essential Questions

1. What is the difference between AC and DC?
2. What is the difference between low and high voltage?
3. Who invented electricity?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe how voltage, current, resistance, and power are mathematically related. (DOK2) PRA1, PRA2, TTA4, TTA5, ALG2	a. Use Ohm's law to calculate the current, voltage, and resistance in a circuit; use the power formula to calculate how much power is consumed by a circuit. Using the class dry erase board or chalkboard, give work sample problems and describe the inverse relationship between current flow and resistance. The following example may be used with the Ohm's law formula V=IE. Given: 10 V applied to a circuit that has 10 Ω of resistance present. What is the current flow in this circuit? Answer: 1 A. Using the same circuit, change the resistance to 20 Ω. What is the current flow in this circuit? Answer: 1/2 A. Therefore, if voltage remains constant, as resistance increases, current decreases and vice versa. T6, M7, W1 OHM's LAW POWER WHEEL  	a. Have the students work through the Leviton Web site module and print the certificate at the end of the module: http://ezlearn.leviton.com/el_front/.
b. Describe the difference between series and parallel circuits, and calculate loads in each. (DOK2) PRA1, PRA2, TTA4, TTA5, ALG2	b. State how electrical power is distributed in a series and a parallel circuit. Explain the components of the electrical circuit. The instructor should explain the power supply, circuitry, and load of a circuit. Calculate and determine the proper size of a power supply needed to deliver the required current for a circuit that is comprised of a 10-A, 12-A, and 5-A parallel load rated at 220 VAC. The calculations should be used to determine minimum power supply size, conductor size, and current protection devices. T2, T4, E1, E2, M1, M3, M7, W1, W2, W3, W4, W5	b. Have students draw a schematic and build a basic electrical circuit that will power a lightbulb.
c. Describe the purpose and	c. State and demonstrate the safety precautions	c. Draw a schematic, and wire

~~operation of the various electrical components used in equipment. (DOK2)~~ ~~PRA1, PRA2, TTA4, TTA5, ALG2~~	~~that must be followed when working on electrical equipment and make voltage, current, and resistance measurements using electrical test equipment while reading and interpreting common electrical symbols. Demonstrate electrical power distribution and the difference between series and parallel loads.~~ ~~Explain and demonstrate how transformers operate, and demonstrate how to wire a step-down transformer to operate a doorbell circuit.~~ ~~T2, T4,E1, E2, M1, M3, M7, W1,W2, W3, W4, W5~~	~~various electrical circuits including series and parallel loads.~~ ~~Have the students hook up a doorbell circuit with a simple normally open circuit so that when the button is pushed the doorbell will ring.~~

Standards

Industry Standards

CONTREN CORE

HTO Introduction to Hand Tools
PTO Introduction to Power Tools

CONTREN INDUSTRIAL MAINTENANCE LEVEL ONE

TTI Tools of the Trade
OXC Oxy-Fuel Cutting

CONTREN INDUSTRIAL MAINTENANCE LEVEL TWO

ETO Electrical Theory
ALT Alternating Current

CONTREN HVAC LEVEL ONE

INT Introduction to HVAC
CP Copper and Plastic Piping Practices
SBR Soldering and Brazing
BEL Basic Electricity

CONTREN HVAC LEVEL TWO

ALT Alternating Current
BAE Basic Electronics

Applied Academic Credit Standards

PRE-ALGEBRA

PRA1 Apply concepts and perform basic operations using real numbers in real-world contexts.
PRA2 Apply properties to simplify algebraic expressions, solve linear equations and inequalities, and apply principles of graphing.

TRANSITION TO ALGEBRA

TTA4 Demonstrate and apply various formulas in problem-solving situations.
TTA5 Interpret data.

ALGEBRA I

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

National Educational Technology Standards for Students

T4 Critical Thinking, Problem Solving, and Decision Making
T6 Technology Operations and Concepts

ACT College Readiness Standards

E1 Topic Development in Terms of Purpose and Focus
E2 Organization, Unity, and Coherence
M1 Basic Operations and Applications
M3 Numbers: Concepts and Properties
M5 Graphical Representations
M7 Measurement

~~R1 Main Ideas and Author's Approach~~
~~R2 Supporting Details~~
~~R3 Sequential, Comparative, and Cause–Effect Relationships~~
~~R4 Meaning of Words~~
~~R5 Generalizations and Conclusions~~
~~W1 Expressing Judgments~~
~~W2 Focusing on the Topic~~
~~W5 Using Language~~

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~~Suggested Rubrics and Checklists~~

Name: _____

Date: _____

Period: _____

Team-Building and Participation Skills Rubric

The student	Exemplary 4 Points	Accomplished 3 Points	Developing 2 Points	Beginning 1 Point	Score
Actively participates in team discussions and activities.					
Encourages other team members to participate in discussions and activities.					
Works with other members to keep the activity on schedule and task.					
Shares ideas and thoughts.					
Offers constructive recommendations.					
Credits others for their contributions and ideas.					
Empathizes with other members.					
Requests input from others to reach an agreement.					
Expresses ideas and thoughts.					
Actively listens to other team members.					
				Total	

Notes:

Unit 5: Orientation and Safety (Review and Reinforcement)

Competency 1: Describe local program and vocational/career technical center policies and procedures. (CONTREN Modules: 00107-04 and 00108-04) (DOK 1) COM, EMP

Suggested Enduring Understandings

1. Safety is an integral part of daily life.
2. Rules and regulations are essential to a safe work environment.

Suggested Essential Questions

1. What would happen if there were no rules and regulations?
2. How would we function without rules and regulations?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe local program and vocational/career technical center policies and procedures. (DOK1)	a. 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 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. Once the students have read the syllabus and rules, have students discuss the ramifications of breaking rules and regulations set forth by the school, department, and/or instructor. 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 opinions 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. CS1, CS2, CS3, CS4, CS5, T1, T2, T3, R1, R2, R3, R4, R5, W1, W2, W3	a. The role-play will be evaluated by students answering questions about the topics presented and by using the **Role-Play or Skit Rubric**. Then give an electronic test on local school rules and regulations using the Blackboard class Web site. Have students complete a form verifying that they have received instructions on local school rules and policies. Parents/guardians should also sign to acknowledge rules and policies. This should be kept in a student folder.

Competency 2: Describe employment opportunities and responsibilities of the industrial and HVAC mechanic. (CONTREN Modules: 00108-04, 40101-07, and 03103-07) (DOK 2) EMP, OTI, INT

Suggested Enduring Understandings

1. Employers offer a wide variety of benefits.
2. Employers are looking for specific skills in employees.

Suggested Essential Questions

1. What do you already know about industrial maintenance and HVAC repair?
2. What would our nation and world be like without service technicians?
3. What are the businesses in your area that provide industrial repair services?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe employer expectations in the workplace. (DOK2)	a. Ask 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; 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 who the vocational complex is intended to serve (industry needs). Then 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. CS2, T1, T2, T3, T4, T5, T6, R1, R2, R3, R4, R5, W1	a. After initially discussing what each student plans to do after graduation, have students perform Internet research on community colleges that offer industrial maintenance and HVAC degrees and certificates. The industrial maintenance and HVAC 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.

		Then 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.

Competency 3: Explore leadership skills and personal development opportunities provided for students by student organizations to include SkillsUSA. (CONTREN Modules: 00107-04 and 00108-07) (DOK 2) COM, EMP.

Suggested Enduring Understandings

1. Leadership and team-building skills are skills needed to be successful in a career.
2. Student involvement in SkillsUSA develops and enhances the skills for which employers are looking.

Suggested Essential Questions

1. What leadership and team-building skills are necessary for success in any career?
2. What activities does SkillsUSA provide that can prepare you for the world of work?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Demonstrate effective team-building and leadership skills. (DOK1)	a. 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 Skills USA Web site is http://www.skillsusa.org/, and the Mississippi Skills USA 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. CS1, CS2, CS3, CS5, T1, T2, R1, R2	a. Have students write a short essay (half-page minimum) about how SkillsUSA is an important organization and how it can benefit the Installation and Service 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 **Writing Rubric** to evaluate student writings. Monitor the class for participation.

b. Demonstrate through practice appropriate work ethics. (DOK2)	b. 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. 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 9 weeks to encourage team competition among project groups. Use team-building concepts to create student cooperation and teamwork. CS1, CS2, CS3, CS4, CS5, T1, T2, T3, R1, R2, R3	b. 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.

Competency 4: Describe general safety rules for working in a shop/lab and industry. (CONTREN Modules: 00101-04) (DOK 1) SAF

Suggested Enduring Understandings	Suggested Essential Questions
1. Safe use and proper choice of tools is important to safely completing a job. 2. Understanding common safety violations and the consequences of committing unsafe acts is important in the workplace.	1. Why do we have safety rules and regulations? 2. How do fires happen, and how do you extinguish a fire? 3. What happens when you choose the improper tool for the job or use a tool in an incorrect manner?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Discuss safety issues and prevention associated with the installation and service shop area. (DOK1)	a. Use PowerPoint presentations from the Contren Learning Series (NCCER). This should prepare the students for school shop safety and NCCER examinations. 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. Then discuss the school shop/lab safety rules that pertain to the school premise, and explain that the students 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	a. 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. Explain and demonstrate proper lifting procedures, and explain the importance of safety when lifting

		tall or long workpieces. 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 and properly interpret a mock MSDS chemical sheet. 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, eyewash and showers, spill kits, and emergency evacuation routes.
b. Explain fire safety and prevention in the workplace. (DOK1)	b. Explain the fire triangle—fuel, oxygen, and heat—and explain what flash point is for various shop materials. Then explain and discuss the various types of fires with students such as wood, grease, electrical, and metal. Explain the classes of fire extinguishers and with what types of fires to use them. Demonstrate the proper use of a fire extinguisher. The following is a great 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. CS2, T1, T2, R1, R2, R3	b. 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.~~

Standards

Industry Standards

CONTREN CORE

SAF Basic Safety
COM Basic Communication Skills
EMP Basic Employability Skills

CONTREN INDUSTRIAL MAINTENANCE LEVEL ONE

OTI Orientation to the Trade

CONTREN HVAC LEVEL ONE

INT Introduction to HVAC

21st Century Learning Standards

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

National Educational Technology Standards for Students

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

ACT College Readiness Standards

R1 Main Ideas and Author's Approach
R2 Supporting Details
R3 Sequential, Comparative, and Cause–Effect Relationships
R4 Meaning of Words
R5 Generalizations and Conclusions
W1 Expressing Judgments
W2 Focusing on the Topic
W3 Developing a Position

References

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~~Suggested Rubrics and Checklists~~

Interpret MSDS Rubric

NAME: **DATE:** **PERIOD:**

Your instructor will furnish you with the name of a chemical that is commonly used in agricultural and natural resources occupations. You are to conduct a search of the Internet to locate a material safety data sheet (MSDS) for this material and use it to answer the following questions.

1. What is the Web address of the Internet site where you found this information?

2. If you accidentally drank some of this material, what would be the first aid procedure you would do first?

3. What special precautions should be taken in storing this material?

4. What is the flash point of this material?

5. If you spilled a small amount of this product, how would you clean it up?

6. What immediate effects would likely happen if you spilled some of this material on your skin?

Role-Play or Skit Rubric

NAME: **DATE:** **PERIOD:**

Behavior/Skill	Excellent 4	Good 3	Needs Improvement 2	Unacceptable 1	Total Score
ACCURACY	ALL INFORMATION WAS ACCURATE.	ALMOST ALL INFORMATION WAS ACCURATE.	MOST INFORMATION WAS ACCURATE.	VERY LITTLE INFORMATION WAS ACCURATE.	
ROLE	EXCELLENT CHARACTER DEVELOPMENT; STUDENT CONTRIBUTED IN A SIGNIFICANT MANNER.	GOOD CHARACTER DEVELOPMENT; STUDENT CONTRIBUTED IN A COOPERATIVE MANNER.	FAIR CHARACTER DEVELOPMENT; STUDENT MIGHT HAVE CONTRIBUTED.	LITTLE OR NO CHARACTER DEVELOPMENT; STUDENT DID NOT CONTRIBUTE MUCH AT ALL.	
KNOWLEDGE GAINED	CAN CLEARLY EXPLAIN SEVERAL WAYS IN WHICH HIS OR HER CHARACTER "SAW" THINGS DIFFERENTLY THAN OTHER CHARACTERS AND CAN EXPLAIN WHY	CAN CLEARLY EXPLAIN SEVERAL WAYS IN WHICH HIS OR HER CHARACTER "SAW" THINGS DIFFERENTLY THAN OTHER CHARACTERS	CAN CLEARLY EXPLAIN ONE WAY IN WHICH HIS OR HER CHARACTER "SAW" THINGS DIFFERENTLY THAN OTHER CHARACTERS	CANNOT EXPLAIN ANY WAY IN WHICH HIS OR HER CHARACTER "SAW" THINGS DIFFERENTLY THAN OTHER CHARACTERS	
PROPS	USED SEVERAL PROPS AND SHOWED CONSIDERABLE CREATIVITY	USED ONE OR TWO APPROPRIATE PROPS THAT MADE THE PRESENTATION BETTER	USED ONE OR TWO PROPS THAT MADE THE PRESENTATION BETTER	USED NO PROPS TO MAKE THE PRESENTATION BETTER	
REQUIRED ELEMENTS	INCLUDED MORE INFORMATION THAN REQUIRED	INCLUDED ALL REQUIRED INFORMATION	INCLUDED MOST REQUIRED INFORMATION	INCLUDED LESS INFORMATION THAN REQUIRED	

Comments:

Presentation Assessment Rubric

Name: _____ **Date:** _____ **Period:** _____

Behavior/Skill	Excellent 4	Good 3	Needs Improvement 2	Unacceptable 1	Total Score
CONTENT	CLEAR, APPROPRIATE, AND CORRECT	MOSTLY CLEAR, APPROPRIATE, AND CORRECT	SOMEWHAT CONFUSING, INCORRECT, OR FLAWED	CONFUSING, INCORRECT, OR FLAWED	
CLARITY	LOGICAL, INTERESTING SEQUENCE	LOGICAL SEQUENCE	UNCLEAR SEQUENCE	NO SEQUENCE	
PRESENTATION	CLEAR VOICE AND PRECISE PRONUNCIATION	CLEAR VOICE AND MOSTLY CORRECT PRONUNCIATION	LOW VOICE AND INCORRECT PRONUNCIATION	MUMBLING AND INCORRECT PRONUNCIATION	
VISUAL AIDS	ATTRACTIVE, ACCURATE, AND GRAMMATICALLY CORRECT	ADEQUATE, MOSTLY ACCURATE, AND FEW GRAMMATICAL ERRORS	POORLY PLANNED, SOMEWHAT ACCURATE, AND SOME GRAMMATICAL ERRORS	WEAK, INACCURATE, AND MANY GRAMMATICAL ERRORS	
LENGTH	APPROPRIATE LENGTH	SLIGHTLY TOO LONG OR SHORT	MODERATELY TOO LONG OR SHORT	EXTREMELY TOO LONG OR SHORT	
EYE CONTACT	MAINTAINS EYE CONTACT, SELDOM LOOKING AT NOTES	MAINTAINS EYE CONTACT MOST OF TIME BUT FREQUENTLY RETURNS TO NOTES	OCCASIONALLY USES EYE CONTACT BUT READS MOST OF INFORMATION	NO EYE CONTACT BECAUSE READING INFORMATION	
				TOTAL	

Comments:

Safety Review Rubric I

		Scoring Criteria		
The student	Excellent 4	Good 3	Needs Improvement 2	Unacceptable 1
Selects appropriate PPE				
Wears protective clothing and eye protection				
Demonstrates fire extinguisher operation				
Subtotal for safety equipment				
Maintains clean facility				
Cleans area after tasks are complete				
Stores materials properly				
Subtotal for facility cleanliness				
Models appropriate behavior				
Observes safety rules				
Follows written directions				
Follows oral directions				
Observes surroundings				
Subtotal for appropriate behaviors				

Writing Rubric

	4	3	2	1
Writing Structure	Sentences and paragraphs are complete, well constructed, and of varied structure.	All sentences are complete and well constructed (no fragments and no run-ons). Paragraphing is generally done well.	Most sentences are complete and well constructed. Paragraphing needs some work.	There are many sentence fragments or run-on sentences, OR paragraphing needs lots of work.
Content	The writing contains a description of all components of the communication process.	The writing contains a description of three components of the communication process.	The writing contains a description of two components of the communication process.	The writing contains a description of one component of the communication process.
Content Accuracy	The writing contains at least three accurate examples of types of communication.	The writing contains at least two accurate examples of types of communication.	The writing contains at least one accurate example of types of communication.	The writing contains no examples of types of communication.
Content Understanding	Ideas are expressed in a clear and organized fashion.	Ideas are expressed in a pretty clear manner, but the organization could be better.	Ideas are somewhat organized but are not very clear.	The writing seems to be a collection of unrelated sentences.

Name: _____

Date: _____

Period: _____

Work Ethic and Values Rubric

Behavior/Skill	Exemplary 4 Points	Accomplished 3 Points	Developing 2 Points	Beginning 1 Point	Score
Punctuality (arrives on time)					
Preparation (completes pre-assignments and brings necessary materials)					
Respects other students/workers					
Listens to supervisor and follows directions					
Accepts responsibility for actions					
Demonstrates positive personality traits (kindness, trustworthiness, honesty)					
Demonstrates productivity (patience, thoroughness, hard working)					
Demonstrates a concern for others					
Remains on task and allows others to remain on task					
Takes initiative as appropriate					
				Total Score	

Unit 6: Trade Math, Ferrous Metal Piping Practice, Introduction to Cooling, and Introduction to Heating

Competency 1: Identify proper math to use for problem solving; use English and metric measurement; use powers, algebra, and geometric calculation to solve for HVAC problems; and convert Fahrenheit to Celsius. (CONTREN Module: 03102-07) (DOK 2). TMH

Suggested Enduring Understandings

1. Understanding English and metric measurements is important in industrial maintenance trades.
2. Understanding the units of measurement used in HVAC is important in industrial maintenance trades.

Suggested Essential Questions

1. Why should temperature conversions be made in HVAC?
2. Why are there different units of measure related to HVAC?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Demonstrate how to calculate mathematic problems found in the HVAC area. (DOK2) PRA1, PRA5, TTA1, TTA2, TTA4, TTA5, ALG3, ALG4	a. Identify similar units of measurement in both the inch–pound (English) and metric systems and state which units are larger; convert measured values in the inch–pound system to equivalent metric values and vice versa; express numbers as powers of ten; determine the powers and roots of numbers; solve basic algebraic equations; identify various geometric figures; use the Pythagorean theorem to make calculations involving right triangles; calculate perimeter, area, and volume; convert feet to inches and vice versa; and convert temperature values between Celsius and Fahrenheit. The instructor should convert Fahrenheit to Celsius. Read the pressure temperature chart, and calculate the saturation temperature. See an example of a pressure temperature chart at the following Web site: T6, M1, M3, M7, R1, R3, S1, W1 http://www.longviewweb.com/pressure.htm	a. Have the students mathematically convert Fahrenheit to Celsius and vice versa. The following Web sites will be useful for the students to use when converting degrees: • http://wiki.answers.com/Q/How_do_you_convert_Fahrenheit_to_Celsius • http://www.calculateme.com/cTemperature/FahrenheitToCelsius.htm • http://www.wbuf.noaa.gov/tempfc.htm • http://walking.about.com/library/cal/uctemp.htm The Web sites should only be used to verify the students' calculations.

Competency 2: Recognize types and sizes of ferrous metal piping and pipe fittings, and also recognize and use tools used to cut, ream, and thread ferrous pipe in the HVAC application. (CONTREN Module: 03105-07) (DOK 2). FMP

Suggested Enduring Understandings

1. Understanding the various types of ferrous pipe and fittings used in HVAC is important in industrial maintenance trades.

Suggested Essential Questions

1. Which type of pipe is applicable for HVAC applications?
2. Why is it important to know how to cut, thread,

2. Understanding the tools and method of measurement used in cutting, threading, and reaming ferrous pipe is important in industrial maintenance trades.

and join pipe?
3. Why is it important to check for leaks?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Explain the uses of ferrous metal pipes in the HVAC trade. (DOK2) PRA1, TTA2, TTA4, TTA5, ALG4	a. Identify the types of ferrous metal pipes; measure the sizes of ferrous metal pipes; identify the common malleable iron fittings; cut, ream, and thread ferrous metal pipe; join lengths of threaded pipe together and install fittings; and describe the main points to consider when installing pipe runs. Demonstrate and discuss how to measure, cut, thread, and join pipe and fittings. Using two 90° elbows, one tee, and a union, connect piping together to illustrate how pipe and fitting are assembled. T6, M1, M5, M7	a. The students should cut three pieces of iron pipe 20 in. in length. They should thread both ends of the pipe and install a coupling between two joints of pipe and a union between the second and third joint of pipe.

Competency 3: Explain the basic theory of cooling systems, heat transfer, trade terms, refrigerants, components of the cooling system, controls, and proper piping of the cooling system. (CONTREN Module: 03107-07) (DOK 2) ITC

Suggested Enduring Understandings

1. Knowing how heat transfer occurs in an HVAC system is necessary in industrial maintenance trades.
2. Knowing how the refrigeration cycle works is necessary in industrial maintenance trades.
3. Knowing how temperature and pressure are related is necessary in industrial maintenance trades.

Suggested Essential Questions

1. What are the three types of heat transfer?
2. What are the four main components of all the refrigeration systems?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Explain how an HVAC system removes heat from an air-conditioned area of an HVAC system. (DOK2) PRA1, TTA2, TTA4, TTA5, ALG4	a. Explain how heat transfer occurs in a cooling system, demonstrating an understanding of the terms and concepts used in the refrigeration cycle; calculate the temperature and pressure relationships at key points in the refrigeration cycle, under supervision; use temperature- and pressure-measuring instruments to make readings at key points in the refrigeration cycle; identify commonly used refrigerants, and demonstrate the proper procedures for handling these refrigerants; and state the correct methods to	a. Have the students create a poster of a simple refrigeration system. The poster should include each of the four major components of a refrigeration unit. Have the students hang the posters in the classroom and then explain how the system they constructed works. Use the **Poster Assessment Rubric** to grade the students'

	be used when piping a refrigeration system. Use a bucket of water and a sponge to illustrate how an air-conditioning system works. Explain that refrigerant (sponge) removes heat (water) from inside the students' homes (bucket) and dumps the heat outside (squeeze out sponge). T6, R1, R3, S1, W5 Explain and demonstrate how and where to make readings in key points of the refrigeration cycle to determine if the system is operating properly. T6, R1, R3, S1, W5	work.
b. Identify the major components, accessories, and control devices available for cooling systems, and explain how each works. (DOK2) PRA1, TTA2, TTA4, TTA5, ALG4	b. Using an HVAC in the shop, label each major component using self-stick paper while referencing the unit's piping schematic. Explain how each component works within the system. T6, R1, R3, S1, W5	b. Using a system other than the demonstrator unit, label the four major components of the unit A, B, C, and D. Have the students draw the piping schematic for the unit and indicate where each labeled device is in their schematic.

Competency 4: Explain methods of heat transfer and characteristics of combustion, identify types of fuels and types of furnaces and components of the electric and gas furnace, identify and safely use meters in gas measurement, and perform maintenance on electric and gas furnaces. (CONTREN Modules: 03108-07)(DOK 2) TTH

Suggested Enduring Understandings

1. Understanding the sequence of operation of the heating equipment is important in industrial maintenance trades.
2. Meters in gas measurement on electric and gas furnaces must be safely used.

Suggested Essential Questions

1. What is the difference between electric and gas heat?
2. What is a BTU?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Explain how an HVAC heating system operates. (DOK2) PRA1, TTA2, TTA4, TTA5, ALG4	a. Explain the three methods by which heat is transferred and give an example of each, describe how combustion occurs and identify the byproducts of combustion, identify various types of fuels used in heating, identify the major components and accessories of an induced draft and condensing gas furnace and explain the function of each component, state the factors that must be considered when installing a furnace, and identify the major components of a	a. Create student pairs. Have the pairs label each part of the heating system using self-stick labels. After labeling each part, the students should explain the function of the component. Have students demonstrate how to use a manometer to properly adjust manifold pressure on gas furnaces.

	gas furnace and describe how each works. With supervision, use a manometer to measure and adjust manifold pressure on a gas furnace, and identify the major components of an oil furnace and describe how each works. Using an induced gas furnace, identify the major components within the heating system. Use self-stick paper to label each component of the heating system. Explain and demonstrate how to use a manometer to properly adjust manifold pressure on gas furnaces. T6, R1, R3, S1, W5	
b. Describe how an electric furnace works. (DOK1) PRA1, TTA2, TTA4, TTA5, ALG4	b. Explain the sequence of operation on natural gas and electric furnaces. T6, R1, R3, S1, W5	b. Have students write a paragraph describing how a resistive element is used to create heat in a house and the sequence of operation of the heating control circuit (http://www.engineeringtoolbox.com/).
c. With supervision, perform basic furnace preventive maintenance procedures such as cleaning and filter replacement. (DOK2)	c. Explain and demonstrate how to perform preventative maintenance on gas and electric furnaces. T6, R1, R3, S1, W5	c. Have the students remove and service the blower of the heating unit.

Standards

Industry Standards

CONTREN HVAC LEVEL ONE

TMH Trade Mathematics
FMP Ferrous Metal Piping Practices
ITC Introduction to Cooling
ITH Introduction to Heating

Applied Academic Credit Standards

PRE-ALGEBRA

PRA1 Apply concepts and perform basic operations using real numbers in real-world contexts.
PRA5 Interpret, organize, and make predictions about a variety of data using concepts of probability.

TRANSITION TO ALGEBRA

TTA1 Understand relationships between numbers and their properties, and perform operations fluently.
TTA2 Understand, represent, and analyze patterns, relations, and functions.
TTA4 Demonstrate and apply various formulas in problem-solving situations.
TTA5 Interpret data.

ALGEBRA I

ALG1-3 Understand how algebra and geometric representations interconnect and build on one another.
ALG1-4 Demonstrate and apply various formulas in problem-solving situations.

National Educational Technology Standards for Students

T6 Technology Operations and Concepts

ACT College Readiness Standards

M1 Basic Operations and Applications
M5 Graphical Representations
M7 Measurement
R1 Main Ideas and Author's Approach
R3 Sequential, Comparative, and Cause–Effect Relationships
S1 Interpretation of Data
W5 Using Language

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~~Suggested Rubrics and Checklists~~

Poster Assessment Rubric

NAME: **DATE:** **PERIOD:**

Behavior/Skill	Excellent 4	Good 3	Needs Improvement 2	Unacceptable 1	Total Score
CONTENT	CLEAR, APPROPRIATE, AND CORRECT	MOSTLY CLEAR, APPROPRIATE, AND CORRECT	SOMEWHAT CONFUSING, INCORRECT, OR FLAWED	CONFUSING, INCORRECT, OR FLAWED	
CLARITY	LOGICAL, INTERESTING SEQUENCE	LOGICAL SEQUENCE	UNCLEAR SEQUENCE	NO SEQUENCE	
VISUAL AIDS	ATTRACTIVE, ACCURATE, AND GRAMMATICALLY CORRECT	ADEQUATE, MOSTLY ACCURATE, AND FEW GRAMMATICAL ERRORS	POORLY PLANNED, SOMEWHAT ACCURATE, AND SOME GRAMMATICAL ERRORS	WEAK, INACCURATE, AND MANY GRAMMATICAL ERRORS	
LENGTH	APPROPRIATE LENGTH	SLIGHTLY TOO LONG OR SHORT	MODERATELY TOO LONG OR SHORT	EXTREMELY TOO LONG OR SHORT	
				TOTAL	

Comments:

Unit 7: Air Distribution Systems, Leak Detection Evacuation Recovery and Charging, Alternating Current, and Basic Electronics

Competency 1: The student will understand the general practices of designing and installing HVAC duct and piping systems (CONTREN Modules: 03109-07) (DOK 2). ADS

Suggested Enduring Understandings

1. Being able to describe the parts and function of the air distribution system is important in industrial maintenance trades.
2. Understanding what air velocity, pressure, and volume are in an HVAC system is important in industrial maintenance trades.

Suggested Essential Questions

1. What is air distribution, and how does it relate to HVAC?
2. What causes temperature variation from one room to another on the same HVAC system?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Discuss and explain the patterns of air flow and pressures in an HVAC duct. (DOK2) PRA1, TTA2, TTA4, TTA5, ALG4	a. Describe and explain the airflow and pressures in a basic forced-air distribution system and the differences between propeller and centrifugal fans and blowers, and identify instruments used to make measurements in air systems. Explain the use of each instrument, and make basic temperature, air pressure, and velocity measurements in an air distribution system. Using a blower fan with a simple duct system in the shop, measure the static pressure, velocity pressure, and cubic foot per minute (CFM) of the system. T6, R1, R3, S1, W5	a. Students should calculate the estimated CFM, measure the actual CFM, and compare the findings.
b. Identify types of duct systems, and explain where each is used in installation and service applications. (DOK2) PRA1, TTA2, TTA4, TTA5, ALG4	b. Identify the various types of duct systems, and explain why and where each type is used. Demonstrate or explain the installation of metal, fiberboard, and flexible duct; installation fittings and transitions used in duct systems; the use and installation of diffusers, registers, and grilles used in duct systems; the use and installation of dampers used in duct systems; and the use and installation of insulation and vapor barriers used in duct systems. Present a slide presentation on types of duct systems and where they are used. You may reference Web pages such as http://ducts.lbl.gov/ and http://www.energystar.gov/ia/new_homes/features/DuctSystems_062906.pdf. Take the students out into the school, and show the students the type of duct system(s)	b. Have the students draw a hand sketch of the school building. They should include the duct system used within the school. Have the students build a small duct system utilizing different methods and materials found in the HVAC area.

	used to heat and cool the building. Discuss various types of duct material and types of installation for different types of duct material. T6, R1, R3, S1, W5	

Competency 2: The student will identify leaks in an HVAC system and perform the proper steps to repair the leak restoring the unit to operation. (CONTREN Modules: 03205-07) (DOK 2) LDE

Suggested Enduring Understandings

1. Being able to recognize different methods of leak detection is important in industrial maintenance trades.
2. Being able to properly repair, evacuate, and recharge a refrigerant system is important in industrial maintenance trades.

Suggested Essential Questions

1. Which is the best detection method in different applications?
2. How can I correctly recharge a system?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Define and perform a leak test on an HVAC system. (DOK2) PRA1, PRA2, TTA2, TTA4, TTA5, ALG2	a. Identify the common types of leak detectors, and explain how each is used. Perform leak detection tests using selected methods, identify the service equipment used for evacuating a system, and explain why each item of equipment is used. Show and explain the use of leak detectors. Use refrigerant drum to install trace gas in a leaking system. Use the leak detector to detect leaking gas allowing the student to hear the audible alarm of the detector. Use the following Web sites to illustrate the importance of EPA regulation on handling and transporting refrigerant: T6, M7, W1 • http://www.epatest.com/608/, http://www.epa.gov/Ozone/title6/608/index.html • http://www.epa.gov/oar/caa/caa608.txt • http://www.epa.gov/Ozone/title6/608/608fact.html	a. Using a leaking system, pair students and allow them to locate and repair the leak. Have the students label the leaking area with a paper tag with their names and date on the tag. The students should write a short essay with suggestions about what may have caused the leak and how the leak can be repaired.
b. Use nitrogen to purge a system and charge refrigerant into a system by the following methods (DOK2): PRA1, TTA2, TTA4, TTA5, ALG4 • Weight • Superheat • Subcooling • Charging pressure	b. Identify the service equipment used for recovering refrigerant from a system and for recycling the recovered refrigerant, and explain why each item of equipment is used. Identify the service equipment used for charging refrigerant into a system, and explain why each item of equipment is used. Demonstrate how to purge a system and charge a refrigeration system using the reclamation unit, and discuss the purpose of evacuating atmosphere from the system before charging with Freon. The following	b. Write a report on the processes for purging and charging a refrigeration system. Use the **Writing Rubric** to assess the report. Give the students the saturation temperature and refrigerant temperature, and have them calculate the

	Web site may be given to the students to use as a reference regarding Freon: http://inventors.about.com/library/inventors/blfreon.htm. E3, M1, M3, M7, R1, R2, R3, R4, R5, W1,W2, W3, W4, W5	superheat and subcooling.

Competency 3: Gain an understanding of the safe operation of electrical transformers, motors, and single- and three-phase HVAC devices. (CONTREN Modules: 03206-07) (DOK 2) ALT

Suggested Enduring Understandings

1. Understanding the difference between motors and transformers is important in industrial maintenance trades.
2. Knowing the difference between three-phase and single-phase voltages is important in industrial maintenance trades.
3. Knowing the function of relays, capacitors, and contactors is important in industrial maintenance trades.

Suggested Essential Questions

1. Why does the size of the motor/transformer matter?
2. What is the difference between high and low voltage?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Explain and demonstrate the safe operation of various types of transformers. (DOK2) PRA1, PRA2, TTA4, TTA5, ALG2	a. Explain how alternating current is developed, and draw a sine wave; then identify single-phase and three-phase wiring arrangements. Using two separate step-up transformers, wire a circuit stepping 120 VAC down to 24 VAC. Explain the induction of the transformer. Then connect the 24 VAC of the second transformer to the 24 VAC output of the first transformer. Read the output voltage of the second transformer. This circuit is intended to step 120 VAC down to 24 VAC and back up to 120 VAC. Take measurements throughout the circuit explaining the characteristics of the circuit. T6, M7, W1	a. Have the students use a transformer, a normally open push-button switch, and a relay. Students will wire the circuit to turn on a three-phase fan motor. Also have students draw the wiring schematic of the circuit.
b. Describe the types of capacitors and motors found in the HVAC unit. (DOK1) PRA1, PRA2, TTA4, TTA5, ALG2	b. Explain and describe the types of capacitors and their applications, explain the operation of single-phase and three-phase induction motors, and identify the various types of single-phase motors and their applications. Show the students a run-and-start capacitor, and demonstrate how to check the capacitor using a capacitor testing meter. Make sure to have a tested "good" and "bad" capacitor on hand for the students to practice checking. Discuss what happens to capacitors to make them break down in terms of electrolytic dielectric decomposition and over voltage	b. Give the students a known good capacitor and a known bad capacitor. Have students test the capacitor using a capacitance meter. The students should verbally indicate which capacitor is faulty and how they determined that it was faulty.

	damage. T6, M7, W1.	
c. State and demonstrate the safety precautions that must be followed when working with electrical equipment and testing AC components, including capacitors, transformers, and motors. (DOK1) PRA1, PRA2, TTA4, TTA5, ALG2	c. Demonstrate the proper method for discharging a capacitor by shorting the capacitor posts using a 5-W, 20,000-Ω bleed resistor. Never allow the students to discharge the capacitor by placing a screwdriver across the terminals. T6, M7, W1.	c. Read a name plate on a motor, and determine information needed to purchase a new motor. Read a name plate on a transformer, and determine the information needed to purchase a new transformer. Have the students write a short essay explaining why equipment and components are grounded. They should also explain the difference between a "grounded" conductor and a "grounding" conductor.

Competency 4: Explain and apply basic electrical theory to HVAC applications and how to troubleshoot common electronic devices found in HVAC systems. (CONTREN Modules: 03207-07)(DOK 2) BAE

Suggested Enduring Understandings

1. Knowing what electronic devices are and how they differ from non-electronic electrical devices is important in industrial maintenance trades.

Suggested Essential Questions

1. Why is electricity important?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Explain basic electronic theory of semiconductors, and test the operation of various semiconductor devices such as resistors, diodes, LEDs, thermistors, cad cells, and photo diodes. Explain how these devices are used in power and control circuits. (DOK2) PRA1, PRA2, TTA4, TTA5, ALG2	a. Explain and demonstrate how to use a thermistor and a multimeter, and measure the temperature of the ambient temperature of the room and the discharge temperature of the refrigerant leaving the compressor. T6, M7, W1	a. Have students use a thermistor and a multimeter to measure the temperature of the ambient temperature of the room and the temperature of a cup of ice water.

Standards

Industry Standards

CONTREN HVAC LEVEL ONE

ADS Air Distribution Systems

CONTREN HVAC LEVEL TWO

LDE Leak Detection, Evacuation, Recovery, and Charging
ALT Alternating Current
BAE Basic Electronics

Applied Academic Credit Standards

PRE-ALGEBRA

PRA1 Apply concepts and perform basic operations using real numbers in real-world contexts.
PRA2 Apply properties to simplify algebraic expressions, solve linear equations and inequalities, and apply principles of graphing.

TRANSITION TO ALGEBRA

TTA2 Understand, represent, and analyze patterns, relations, and functions.
TTA4 Demonstrate and apply various formulas in problem-solving situations.
TTA5 Interpret data.

ALGEBRA I

ALG1-2 Understand, represent, and analyze patterns, relations, and functions.
ALG1-4 Demonstrate and apply various formulas in problem-solving situations.

National Educational Technology Standards for Students

T6 Technology Operations and Concepts

ACT College Readiness Standards

E1 Topic Development in Terms of Purpose and Focus
M1 Basic Operations and Applications
M3 Numbers: Concepts and Properties
M7 Measurement
R1 Main Ideas and Author's Approach
R2 Supporting Details
R3 Sequential, Comparative, and Cause–Effect Relationships
R4 Meaning of Words
R5 Generalizations and Conclusions
S1 Interpretation of Data
W1 Expressing Judgments
W2 Focusing on the Topic
W3 Developing a Position
W4 Organizing Ideas
W5 Using Language

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~~Suggested Rubrics and Checklists~~

Name: _____

Date: _____

Period: _____

Student Orientation Documents Checklist

- ☐ Acceptable Use Policy
- ☐ Student Responsibility Contract
- ☐ Web Page Policy
- ☐ Classroom Management Policy
- ☐ Technology Student Association (or other Career and Technical Student Organization) Membership Information

Name: _____

Date: _____

Period: _____

Group Participation Rubric

Project Title:

	1 point	2 points	3 points	4 points	Total
Group Discussions	Rarely contributed to discussions of the group	Contributed good effort to discussions of the group	Contributed great effort to discussions of the group	Contributed exceptional effort to discussions of the group	
On-Task Behavior	Exhibited on-task behavior inconsistently	Exhibited on-task behavior some of the time	Exhibited on-task behavior most of the time	Exhibited on-task behavior consistently	
Helping Others	Did not assist other group members	Seldom assisted other group members	Occasionally assisted other group members	Assisted other group members	
Listening	Ignored ideas of group members	Seldom listened to ideas of group members	Occasionally listened to ideas of group members	Always listened to ideas of group members	
				Total Score	

Name: _____

Date: _____

Period: _____

Writing Rubric

Project Title:

Criteria					Points
	1 Point	2 Points	3 Points	4 Points	
Organization	Sequence of information is difficult to follow.	Reader has difficulty following work because student jumps around.	Student presents information in logical sequence that reader can follow.	Information is in logical, interesting, sequence that reader can follow.	_____
Format and Sentences	Student does not follow the required format; plagiarism is depicted.	Student does not follow format; essay includes sentences that are unclear and incorrect.	Student follows format; article is attached; article is written.	Student follows format; article is attached and typed.	_____
Grammar and Spelling	Demonstrates little concept of proper grammar usage and spelling	Presentation has three misspellings and/or grammatical errors.	Presentation has no more than two misspellings and/or grammatical errors.	Presentation has no misspellings or grammatical errors.	_____
Creativity	Work displays no creativity.	Work displays little creativity.	Work displays some creativity.	Work is very neat and creative.	_____
Due Date	Worked turned in a week late	Worked turned in 3 days late	Work turned in 1 day late	Work turned in on time	_____
				Total Points	

Name: _____

Date: _____

Period: _____

Safety Scenarios – What Would You Do?

Scenario No. 1: Juan comes into class after lunch and sits at his desk. He is exhausted from playing basketball at lunch, so he puts his head down on his desk. He feels something on his face and realizes that it is some broken glass. Someone in the previous class must have broken a test tube. What should the students from the previous class have done differently?

Scenario No. 2: Veronica is working with a Bunsen burner (open flame). Her hair swings down and lands in the flame. What should she have done before she lit the Bunsen burner?

Scenario No. 3: Ms. Patterson has given you very specific directions on how to complete a lab experiment. Your lab partner is curious and wants to see what will happen if you add 30 drops of indicator to a solution instead of 2 drops. What should you tell your partner?

Scenario No. 4: During a lab, Edgar realizes that his pencil needs to be sharpened, so he gets up to sharpen it. His partner gets bored without him, so he gets up to go see how other experiments are going. Someone at another table gets up to get a paper towel because her hands are getting messy. Adriana has Ms. Patterson's permission to get up and get a beaker. As she walks back to her seat, Edgar's pencil breaks again, so he pushes out his chair to go back to the sharpener. This trips Adriana, and she breaks the beaker. How could this have been avoided?

Scenario No. 5: Today is the first day that the class is working on its modules. In the Thermal Unit, there is a certain type of wax that must be used along with gloves and a lighter for safety. While checking the equipment inventory, Stephanie noticed that the lighter was missing. She informed Ms. Patterson of the situation. Ms. Patterson instructed Stephanie to skip that particular experiment. Yet, because Stephanie was so excited about the experiment, she used the hot plate instead to light a piece of paper. She quickly threw the paper in the trash to avoid getting caught by the teacher. What rule did Stephanie break? What other hazards may occur from this incident?

Scenario No. 6: You are following all the rules and are being very careful, but you accidentally adjusted the pressure to high on the Pneumatic Module. You placed your safety glasses on your forehead instead of putting them on. What are some possible incidents that could occur? How would you handle them? What if you were following all the rules and a tube accidentally loosens? What would you do?

Scenario No. 7: You are the division head for a large chemical plant that is part of a Fortune 500 company. Because of the nature of your business, there are a number of medical facilities on-site to handle medical emergencies and accidents. You learn through the grapevine that a nurse stationed at one of the infirmaries has been diagnosed with the AIDS virus and that some employees are worried. How would you handle this situation?

Student Competency Profile

Student's Name: _____

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

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

Unit 1: Orientation and Safety

_____ 1. Describe local program and vocational/career technical center policies and procedures.

_____ 2. Describe employment opportunities and responsibilities of the industrial and HVAC mechanic.

_____ 3. Explore leadership skills and personal development opportunities provided for students by student organizations to include SkillsUSA.

_____ 4. Describe general safety rules for working in a shop/lab and industry.

Unit 2: Math, Introduction to Blueprints, and Hand and Power Tools

_____ 1. Apply the four basic math skills with whole numbers, fractions, and percents.

_____ 2. Perform basic mathematical calculations related to industrial maintenance shop operations.

_____ 3. Identify and perform functions using various measuring tools and instruments.

_____ 4. Read, analyze, and design a blueprint.

_____ 5. Demonstrate the use and maintenance of various hand and power tools found in the industrial maintenance and HVAC trade.

Unit 3: Orientation to the Trade, Tools of the Trade, Fasteners and Anchors, and Oxy-Fuel Cutting (IM)

_____ 1. The student will research and distinguish job opportunities in the industrial maintenance field and then reflect upon the importance of the industrial maintenance mechanic's role in modern manufacturing and service industry.

_____ 2. Identify and use tools found in the industrial maintenance trade, describe how each is used, and discuss proper care and maintenance of the tools.

_____ 3. Identify various fasteners and anchors found in the industrial and HVAC trade, how to install and remove fasteners and anchors, and how to select the correct fastener or anchor for an application.

_____ 4. Identify and describe the basic equipment, setup, and safety rules for proper use of equipment, and prepare base metal for oxy-fuel welding.

Unit 4: Introduction to HVAC, Tools of the Trade (HVAC), Copper and Plastic Piping, Soldering and Brazing, and Basic Electricity (IM)

_____ 1. Identify and explain heating, ventilation, and air-conditioning systems, HVAC environmental law, and job opportunities that are available in the HVAC profession.

_____ 2. Demonstrate the safe use and routine maintenance of hand and power tools used in the HVAC trade.

3. Identify and discuss the tools used in the piping trade, discuss the materials and methods of connecting piping systems, and perform copper and plastic piping tasks found in the industrial maintenance and HVAC environment.

4. Prepare and solder copper piping systems in various industrial and HVAC applications and properly clean, install fittings, and braze piping (silver solder).

5. Identify electrical safety hazards, demonstrate safety around circuits and equipment, describe basic electricity laws, interpret electrical drawings and schematics, and demonstrate wiring basic electrical circuits.

Unit 5: Orientation and Safety (Review and Reinforcement)

1. Describe local program and vocational/career technical center policies and procedures.

2. Describe employment opportunities and responsibilities of the industrial and HVAC mechanic.

3. Explore leadership skills and personal development opportunities provided for students by student organizations to include SkillsUSA.

4. Describe general safety rules for working in a shop/lab and industry.

Unit 6: Trade Math, Ferrous Metal Piping Practice, Introduction to Cooling, and Introduction to Heating

1. Identify proper math to use for problem solving; use English and metric measurement; use powers, algebra, and geometric calculation to solve for HVAC problems; and convert Fahrenheit to Celsius.

2. Recognize types and sizes of ferrous metal piping and pipe fittings, and also recognize and use tools used to cut, ream, and thread ferrous pipe in the HVAC application.

3. Explain the basic theory of cooling systems, heat transfer, trade terms, refrigerants, components of the cooling system, controls, and proper piping of the cooling system.

4. Explain methods of heat transfer and characteristics of combustion, identify types of fuels and types of furnaces and components of the electric and gas furnace, identify and safely use meters in gas measurement, and perform maintenance on electric and gas furnaces.

Unit 7: Air Distribution Systems, Leak Detection Evacuation Recovery and Charging, Alternating Current, and Basic Electronics

1. The student will understand the general practices of designing and installing HVAC duct and piping systems.

2. The student will identify leaks in an HVAC system and perform the proper steps to repair the leak restoring the unit to operation.

3. Gain an understanding of the safe operation of electrical transformers, motors, and single- and three-phase HVAC devices.

4. Explain and apply basic electrical theory to HVAC applications and how to troubleshoot common electronic devices found in HVAC systems

Appendix A: 21st Century Skills Standards

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

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.

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

- Recognize, describe, and state the rule of generalized numerical and geometric patterns using tables, graphs, words, and symbols. (DOK 2)
- Solve equations that represent algebraic and real-world problems using multiple methods including the real number properties. (DOK 1)
- Formulate algebraic expressions, equations, and inequalities to reflect a given situation and vice versa. (DOK 2)
- Complete a function table based on a given rule and vice versa. (DOK 1)
- 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
- 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.

- Classify and compare three-dimensional shapes using their properties. (DOK 1)
- Construct two-dimensional representations of three-dimensional objects. (DOK 2)
- Justify the congruency or symmetry of two figures. (DOK 2)
- Perform transformations (rigid and non-rigid motions) on two-dimensional figures using the coordinate plane. (DOK 2)
- Create an argument using the Pythagorean theorem principles to show that a triangle is a right triangle. (DOK 2)

- ~~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.~~

- ~~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)~~
- ~~Use formulas and strategies, such as decomposition, to compute the perimeter and area of triangles, parallelograms, trapezoids, and the circumference and area of circles, and find the area of more complex shapes. (DOK 2)~~
- ~~Develop and justify geometric formulas for volume and surface area of cylinders, pyramids, and prisms. (DOK 3)~~
- ~~Solve problems involving scale factors using ratios and proportions. (DOK 2)~~

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

- ~~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)~~
- ~~Determine how outliers affect mean, median, mode, or range. (DOK 2)~~
- ~~Construct and interpret line graphs, frequency tables, circle graphs, box-and-whisker plots, and scatterplots to generalize trends from given data. (DOK 2)~~
- ~~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.~~

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

- ~~Simplify and evaluate numerical and algebraic expressions. (DOK 1)~~
- ~~Apply properties of real numbers with an emphasis on the distributive properties of multiplication over addition and subtraction. (DOK 1)~~
- ~~Solve and check equations and inequalities using one variable. (DOK 2)~~
- ~~Model inequalities (and their solutions) on a number line. (DOK 1)~~

- ~~Graph linear equations and nonlinear equations ($y = x^2$) using multiple methods including t-tables and slope-intercept. (DOK 2)~~
- ~~Given a linear graph, identify its slope as positive, negative, undefined, or zero, and interpret slope as rate of change. (DOK 2)~~
- ~~Determine slope, x-intercept, and y-intercept from a graph and/or equation in slope-intercept or standard form. (DOK 1)~~
- ~~Add, subtract, and multiply monomials and binomials. (DOK 1)~~
- ~~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.~~

- ~~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)~~
- ~~Find missing angle measurements for parallel lines cut by a transversal(s) and for a vertex of a polygon. (DOK 1)~~
- ~~Explain the Pythagorean theorem, and apply it to solve routine and non-routine problems. (DOK 3)~~
- ~~Solve real-world and non-routine problems involving congruent and similar figures. (DOK 3)~~
- ~~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.~~

- ~~Solve real-world application problems that include length, area, perimeter, and circumference using standard measurements. (DOK 2)~~
- ~~Develop, analyze, and explain methods for solving problems involving proportions, such as scaling and finding equivalent ratios. (DOK 3)~~
- ~~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.~~

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

- ~~Compare and contrast the subsets of real numbers. (DOK 1)~~

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

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

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

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

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

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

- ~~Solve real-world problems involving measurements (i.e., circumference, perimeter, area, volume, distance, temperature, etc.). (DOK 2)~~
- ~~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.~~

- ~~Construct graphs, make predictions, and draw conclusions from tables, line graphs, and scatterplots. (DOK 3)~~
- ~~Use a given mean, mode, median, and range to summarize and compare data sets including investigation of the different effects that change in data have on these~~

measures of central tendency, and select the appropriate measures of central tendency for a given purpose. (DOK 2)

- 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.

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

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

- Solve, check, and graph multi-step linear equations and inequalities in one variable, including rational coefficients in mathematical and real-world situations. (DOK 2)
- Solve and graph absolute value equations and inequalities in one variable. (DOK 2)
- Analyze the relationship between x and y values, determine whether a relation is a function, and identify domain and range. (DOK 2)
- 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)
- Graph and analyze linear functions. (DOK 2)
- Use algebraic and graphical methods to solve systems of linear equations and inequalities in mathematical and real-world situations. (DOK 2)
- Add, subtract, multiply, and divide polynomial expressions. (DOK 1)
- Factor polynomials by using greatest common factor (GCF), and factor quadratics that have only rational roots. (DOK 1)
- Determine the solutions to quadratic equations by using graphing, tables, completing the square, the quadratic formula, and factoring. (DOK 1)
- Justify why some polynomials are prime over the rational number system. (DOK 2)
- Graph and analyze absolute value and quadratic functions. (DOK 2)
- Write, graph, and analyze inequalities in two variables. (DOK 2)

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

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

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

- Solve real-world problems involving formulas for perimeter, area, distance, and rate. (DOK 2)
- 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)
- 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.~~

- ~~Draw conclusions and make predictions from scatterplots. (DOK 3)~~
- ~~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 that 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, 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, 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, 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, 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 multistep 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 and odd numbers and factors and multiples.~~
- ~~Apply number properties involving positive and 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 accurately model a situation.~~
- ~~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 multistep 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, 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, 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, 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, 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, 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 nonnumerical) from a simple data presentation (e.g., a table or graph with two or three variables, a food web diagram).
- Identify basic features of a table, graph, or diagram (e.g., headings, units of measurement, 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, 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 may 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, and/or~~
  - ~~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, and/or~~
  - ~~Evaluating implications or complications of the issue, and/or~~
  - ~~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 a 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 kinds of sentence structures to vary pace and to support meaning~~

Appendix D: National Industry Standards

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.

~~RIG – 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 INDUSTRIAL MAINTENANCE TECHNICIAN~~

~~LEVEL ONE~~

~~OTI – Orientation to the Trade~~

- ~~Describe the types of work performed by industrial maintenance craft workers.~~
- ~~Identify career opportunities available to industrial maintenance craft workers.~~
- ~~Explain the purpose and objectives of an apprentice training program.~~
- ~~Explain the responsibilities and characteristics of a good industrial maintenance craft worker.~~
- ~~Explain the importance of safety in relation to industrial maintenance craft workers.~~
- ~~Explain the role of NCCER in the training process.~~

~~TTI – Tools of the Trade~~

- ~~Explain the purpose of each of the tools commonly used by industrial maintenance craft workers.~~
- ~~Describe how to maintain each of the tools used by industrial maintenance craft workers.~~
- ~~Demonstrate the proper use and basic maintenance of selected industrial maintenance tools.~~

~~FAN – 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.~~

~~OXC – Oxy-Fuel Cutting~~

- ~~Identify and explain the use of oxy-fuel cutting equipment.~~
- ~~State the safety precautions for using oxy-fuel 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~~
- ~~Apply a rosebud flame to remove frozen components (also for preheat and expanding larger fittings).~~
- ~~Operate a motorized, portable oxy-fuel gas cutting machine.~~

~~GPI – Gaskets and Packing~~

- ~~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.~~
- ~~Describe the uses and methods of packing.~~

~~TMI – Craft-Related Mathematics~~

- ~~Identify and explain the use of special measuring devices.~~
- ~~Use tables of weights and measurements.~~
- ~~Use formulas to solve basic problems.~~
- ~~Solve area problems.~~
- ~~Solve volume problems.~~
- ~~Solve circumference problems.~~
- ~~Solve right triangles using the Pythagorean theorem.~~

~~CDI – Construction Drawings~~

- ~~Explain the basic layout of a blueprint.~~
- ~~Describe the information included in the title block of a blueprint.~~
- ~~Identify the types of lines used on blueprints.~~
- ~~Identify common symbols used on blueprints.~~
- ~~Understand the use of architect's and engineer's scales.~~
- ~~Demonstrate the use of an architect's scale.~~

~~PAD – Pumps and Drivers~~

- ~~Identify and explain centrifugal pumps.~~
- ~~Identify and explain rotary pumps.~~
- ~~Identify and explain reciprocating pumps.~~
- ~~Identify and explain metering pumps.~~
- ~~Identify and explain vacuum pumps.~~
- ~~Explain net positive suction head and cavitation.~~
- ~~Identify types of drivers.~~

~~ITV – Introduction to Valves~~

- ~~Identify types of valves that start and stop flow.~~
- ~~Identify types of valves that regulate flow.~~
- ~~Identify valves that relieve pressure.~~
- ~~Identify valves that regulate the direction of flow.~~

- Explain how to properly store and handle valves.
- Explain valve locations and positions.

ITE – Introduction to Test Equipment

- Explain the operation of and describe the following pieces of test equipment:
  - Tachometer
  - Pyrometers
  - Multimeters
  - Automated diagnostics tools
  - Wiggy voltage tester
  - Stroboscope
- Explain how to read and convert from one scale to another using the above test equipment.
- Define frequency, and explain the use of a frequency meter.

MHR – Material Handling and Hand 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:
  - Jacks
  - Block and tackle
  - Chain hoists
  - Come-alongs
- Tie knots used in rigging.
- Use and understand the correct hand signals to guide a crane operator.
- Identify basic rigging and crane safety procedures.

MSE – Mobile and Support Equipment

- State the safety precautions associated with the use of motor-driven equipment in industrial plants.
- Explain the operation and applications of the following motor-driven equipment commonly used in industrial plants:
  - Portable generators
  - Air compressors
  - Aerial lifts
  - Forklifts
  - Mobile cranes
- Operate and perform preventive maintenance on the following equipment:
  - Portable generators
  - Air compressors
  - Aerial lifts

LUB – Lubrication

- Explain OSHA hazard communication as pertaining to lubrication.
- Read and interpret a material data safety sheet (MSDS).
- Explain the EPA hazardous waste control program.
- Explain lubricant storage.
- Explain lubricant classification.
- Explain lubricant film protection.
- Explain properties of lubricants.
- Explain properties of greases.
- Explain how to select lubricants.
- Identify and explain types of additives.

- Identify and explain types of lubricating oils.
- Identify and use lubrication equipment to apply lubricants.
- Read and interpret a lubrication chart.

LEVEL TWO

NEC – Introduction to the National Electrical Code

- Explain the purpose and history of the National Electrical Code (NEC).
- Describe the layout of the NEC.
- Explain how to navigate the NEC.
- Describe the purpose of the National Electrical Manufacturers Association (NEMA) and the National Fire Protection Association (NFPA).
- Explain the role of nationally recognized testing laboratories.

ETO – Electrical Theory

- Define voltage, and identify the ways in which it can be produced.
- Explain the difference between conductors and insulators.
- Define the units of measurement that are used to measure the properties of electricity.
- Identify the meters used to measure voltage, current, and resistance.
- Explain the basic characteristics of series and parallel circuits.
- Use Kirchhoff's current law to calculate the total and unknown currents in parallel and series–parallel circuits.
- Use Kirchhoff's voltage law to calculate voltage drops in series, parallel, and series–parallel circuits.
- Use the formula for Ohm's law to calculate voltage, current, and resistance.

ALT – Alternating Current

- Calculate the peak and effective voltage or current values for an AC waveform.
- Calculate the phase relationship between two AC waveforms.
- Describe the voltage and current phase relationship in a resistive AC circuit.
- Describe the voltage and current transients that occur in an inductive circuit.
- Define inductive reactance, and state how it is affected by frequency.
- Describe the voltage and current transients that occur in a capacitive circuit.
- Define capacitive reactance, and state how it is affected by frequency.
- Explain the relationship between voltage and current in the following types of AC circuits:
  - RL circuit
  - RC circuit
  - LC circuit
  - RLC circuit
- Explain the following terms as they relate to AC circuits:
  - True power
  - Apparent power
  - Reactive power
  - Power factor
- Explain basic transformer action.

HBE – Hand Bending

- Identify the methods for hand bending and installing conduit.
- Calculate conduit bends.
- Make 90° bends, back-to-back bends, offsets, kicks, and saddle bends using a hand bender.
- Cut, ream, and thread conduit.

~~CON – Conductor Terminations and Splices~~

- ~~Describe how to make a sound conductor termination.~~
- ~~Prepare cable ends for terminations and splices, and connect the ends using lugs or connectors.~~
- ~~Train cable at termination points.~~
- ~~Describe the National Electrical Code requirements for making cable terminations and splices.~~
- ~~Demonstrate crimping techniques.~~
- ~~Select the proper lug or connector for the job.~~

~~LEVEL THREE~~

~~HPC – Hydraulic and Pneumatic Controls~~

- ~~Explain hydraulic system safety.~~
- ~~Explain the principles of hydraulics.~~
- ~~Identify and explain hydraulic fluids.~~
- ~~Identify and explain hydraulic system parts.~~
- ~~Identify and explain hydraulic pumps.~~
- ~~Identify and explain hydraulic motors.~~
- ~~Explain pneumatic safety.~~
- ~~Explain the physical characteristics of gases.~~
- ~~Explain compressing gases.~~
- ~~Explain the pneumatic transmission of energy.~~
- ~~Explain the principles of compressor operation.~~
- ~~Identify and explain types of compressors.~~
- ~~Explain compressed-air treatment.~~
- ~~Identify and explain pneumatic system components and symbols.~~

~~CONTREN HVAC~~

~~LEVEL ONE~~

~~INT – Introduction to HVAC~~

- ~~Explain the basic principles of heating, ventilating, and air-conditioning.~~
- ~~Identify career opportunities available to people in the HVAC trade.~~
- ~~Explain the purpose and objectives of an apprentice training program.~~
- ~~Describe how certified apprentice training can start in high school.~~
- ~~Describe what the Clean Air Act means to the HVAC trade.~~
- ~~Describe the types of regulatory codes encountered in the HVAC trade.~~
- ~~Identify the types of schedules/drawings used in the HVAC trade.~~

~~TMH – Trade Mathematics~~

- ~~Identify similar units of measurement in both the inch–pound (English) and metric systems, and state which units are larger.~~
- ~~Convert measured values in the inch–pound system to equivalent metric values and vice versa.~~
- ~~Express numbers as powers of ten.~~
- ~~Determine the powers and roots of numbers.~~
- ~~Solve basic algebraic equations.~~
- ~~Identify various geometric figures.~~
- ~~Use the Pythagorean theorem to make calculations involving right triangles.~~
- ~~Convert decimal feet to feet and inches and vice versa.~~
- ~~Calculate perimeter, area, and volume.~~
- ~~Convert temperature values between Celsius and Fahrenheit.~~

~~CPP – Copper and Plastic Piping Practices~~

- ~~State the precautions that must be taken when installing refrigerant piping.~~
- ~~Select the right tubing for a job.~~
- ~~Cut and bend copper tubing.~~
- ~~Safely join tubing by using flare and compression fittings.~~
- ~~Determine the kinds of hangers and supports needed for refrigerant piping.~~
- ~~State the basic safety requirements for pressure-testing a system once it has been installed.~~
- ~~Identify types of plastic pipe, and state their uses.~~
- ~~Cut and join lengths of plastic pipe.~~

~~SBR – Soldering and Brazing~~

- ~~Assemble and operate the tools used for soldering.~~
- ~~Prepare tubing and fittings for soldering.~~
- ~~Identify the purposes and uses of solder and solder fluxes.~~
- ~~Solder copper tubing and fittings.~~
- ~~Assemble and operate the tools used for brazing.~~
- ~~Prepare tubing and fittings for brazing.~~
- ~~Identify the purposes and uses of filler metals and fluxes used for brazing.~~
- ~~Braze copper tubing and fittings.~~
- ~~Identify the inert gases that can be used safely to purge tubing when brazing.~~

~~FMP – Ferrous Metal Piping Practices~~

- ~~Identify the types of ferrous metal pipes.~~
- ~~Measure the sizes of ferrous metal pipes.~~
- ~~Identify the common malleable iron fittings.~~
- ~~Cut, ream, and thread ferrous metal pipe.~~
- ~~Join lengths of threaded pipe together, and install fittings.~~
- ~~Describe the main points to consider when installing pipe runs.~~
- ~~Describe the methods used to join grooved piping.~~

~~BEL – Basic Electricity~~

- ~~State how electrical power is distributed.~~
- ~~Describe how voltage, current, resistance, and power are related.~~
- ~~Use Ohm's law to calculate the current, voltage, and resistance in a circuit~~
- ~~Use the power formula to calculate how much power is consumed by a circuit.~~
- ~~Describe the difference between series and parallel circuits, and calculate loads in each.~~
- ~~Describe the purpose and operation of the various electrical components used in HVAC equipment.~~
- ~~State and demonstrate the safety precautions that must be followed when working on electrical equipment.~~
- ~~Make voltage, current, and resistance measurements using electrical test equipment.~~
- ~~Read and interpret common electrical symbols.~~

~~ITC – Introduction to Cooling~~

- ~~Explain how heat transfer occurs in a cooling system, demonstrating an understanding of the terms and concepts used in the refrigeration cycle.~~
- ~~Calculate the temperature and pressure relationships at key points in the refrigeration cycle.~~
- ~~Under supervision, use temperature- and pressure-measuring instruments to make readings at key points in the refrigeration cycle.~~
- ~~Identify commonly used refrigerants, and demonstrate the proper procedures for handling these refrigerants.~~

- ~~Identify the major components of a cooling system, and explain how each type works.~~
- ~~Identify the major accessories available for cooling systems, and explain how each works.~~
- ~~Identify the control devices used in cooling systems, and explain how each works.~~
- ~~State the correct methods to be used when piping a refrigeration system.~~

~~ITH – Introduction to Heating~~

- ~~Explain the three methods by which heat is transferred, and give an example of each.~~
- ~~Describe how combustion occurs, and identify the byproducts of combustion.~~
- ~~Identify various types of fuels used in heating.~~
- ~~Identify the major components and accessories of an induced draft and condensing gas furnace, and explain the function of each component.~~
- ~~State the factors that must be considered when installing a furnace.~~
- ~~Identify the major components of a gas furnace, and describe how each works.~~
- ~~With supervision, use a manometer to measure and adjust manifold pressure on a gas furnace.~~
- ~~Identify the major components of an oil furnace, and describe how each works.~~
- ~~Describe how an electric furnace works.~~
- ~~With supervision, perform basic furnace preventive maintenance procedures such as cleaning and filter replacement.~~

~~ADS – Air Distribution Systems~~

- ~~Describe the airflow and pressures in a basic forced-air distribution system.~~
- ~~Explain the differences between propeller and centrifugal fans and blowers.~~
- ~~Identify the various types of duct systems, and explain why and where each type is used.~~
- ~~Demonstrate or explain the installation of metal, fiberboard, and flexible duct.~~
- ~~Demonstrate or explain the installation of fittings and transitions used in duct systems.~~
- ~~Demonstrate or explain the use and installation of diffusers, registers, and grilles used in duct systems.~~
- ~~Demonstrate or explain the use and installation of dampers used in duct systems.~~
- ~~Demonstrate or explain the use and installation of insulation and vapor barriers used in duct systems.~~
- ~~Identify instruments used to make measurements in air systems, and explain the use of each instrument.~~
- ~~Make basic temperature, air pressure, and velocity measurements in an air distribution system.~~

~~ACS – Commercial Airside Systems~~

- ~~Identify the differences in types of commercial all-air systems.~~
- ~~Identify the type of building in which a particular type of system is used.~~
- ~~Explain the typical range of capacities for a commercial air system.~~

~~LEVEL TWO~~

~~LDE – Leak Detection, Evacuation, Recovery, and Charging~~

- ~~Identify the common types of leak detectors, and explain how each is used.~~
- ~~Perform leak detection tests using selected methods.~~
- ~~Identify the service equipment used for evacuating a system, and explain why each item of equipment is used.~~
- ~~Perform system evacuation and dehydration.~~
- ~~Identify the service equipment used for recovering refrigerant from a system and for recycling the recovered refrigerant, and explain why each item of equipment is used.~~
- ~~Perform a refrigerant recovery.~~
- ~~Evacuate a system to a deep vacuum.~~
- ~~Identify the service equipment used for charging refrigerant into a system, and explain why each item of equipment is used.~~
- ~~Use nitrogen to purge a system.~~

- ~~Charge refrigerant into a system by the following methods:~~
  - ~~Weight~~
  - ~~Superheat~~
  - ~~Subcooling~~
  - ~~Charging pressure chart~~

~~ALT – Alternating Current~~

- ~~Describe the operation of various types of transformers.~~
- ~~Explain how alternating current is developed, and draw a sine wave.~~
- ~~Identify single-phase and three-phase wiring arrangements.~~
- ~~Explain how phase shift occurs in inductors and capacitors.~~
- ~~Describe the types of capacitors and their applications.~~
- ~~Explain the operation of single-phase and three-phase induction motors.~~
- ~~Identify the various types of single-phase motors and their applications.~~
- ~~State and demonstrate the safety precautions that must be followed when working with electrical equipment.~~
- ~~Test AC components, including capacitors, transformers, and motors.~~

~~BAE – Basic Electronics~~

- ~~Explain the basic theory of electronics and semiconductors.~~
- ~~Explain how various semiconductor devices such as diodes, LEDs, and photo diodes work and how they are used in power and control circuits.~~
- ~~Identify different types of resistors, and explain how their resistance values can be determined.~~
- ~~Describe the operation and function of thermistors and cad cells.~~
- ~~Test semiconductor components.~~
- ~~Identify the connectors on a personal computer.~~

~~Appendix E:~~

~~National Educational Technology Standards for Students~~

~~**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:~~

~~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:~~

~~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:~~

~~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:~~

~~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:~~

~~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:

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.