



TENNESSEE DEPARTMENT OF

**EDUCATION**

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## Mechanical, Electrical, & Plumbing Systems

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<b>Primary Career Cluster:</b>	Architecture & Construction
<b>Consultant:</b>	Rachel Allen, (615) 532-2835, <a href="mailto:Rachel.Allen@tn.gov">Rachel.Allen@tn.gov</a>
<b>Course Code(s):</b>	TBD
<b>Prerequisite(s):</b>	<i>Fundamentals of Construction</i>
<b>Credit:</b>	1
<b>Grade Level:</b>	10
<b>Graduation Requirements:</b>	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Architecture & Construction courses.
<b>Programs of Study and Sequence:</b>	This is the second course in the <i>Mechanical, Electrical, and Plumbing (MEP) Systems</i> program of study.
<b>Necessary Equipment:</b>	Refer to the Teacher Resources page.
<b>Aligned Student Organization(s):</b>	SkillsUSA: <a href="http://site1.tnskillsusa.com/">http://site1.tnskillsusa.com/</a> Brandon Hudson, (615) 532-2804, <a href="mailto:Brandon.Hudson@tn.gov">Brandon.Hudson@tn.gov</a>
<b>Coordinating Work-Based Learning:</b>	Teachers who hold an active work-based learning (WBL) Certificate issued by the Tennessee Department of Education may offer appropriate student placement. To learn more, please visit <a href="http://www.tn.gov/education/cte/work_based_learning.shtml">http://www.tn.gov/education/cte/work_based_learning.shtml</a> .
<b>Available Student Industry Certifications:</b>	Students completing the course through an NCCER accredited program may receive module credit for NCCER.
<b>Dual Credit or Dual Enrollment Opportunities:</b>	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
<b>Teacher Endorsement(s):</b>	501, 502, 523, 527, 532, 567, 580, 592, 598
<b>Required Teacher Certifications/Training:</b>	TBD
<b>Teacher Resources:</b>	<a href="http://www.tn.gov/education/cte/ArchitectureConstruction.shtml">http://www.tn.gov/education/cte/ArchitectureConstruction.shtml</a>

### Course Description

*Mechanical, Electrical, and Plumbing Systems* prepares students for electrical, plumbing, and HVAC careers by introducing students to the physical principles of these systems and the fundamental skills needed to work with them. Upon completion of this course, proficient students will be able to follow safety procedures and use tools to perform basic operations with electrical circuits, as well as

demonstrate understanding in fundamental concepts of electricity theory (i.e. Ohm's Law). Students will be able to apply proper tools and procedures to perform basic operations with plastic piping, including measuring, cutting, and joining pipe. Furthermore, students will be able to apply mathematics concepts to solve HVAC, electrical, and plumbing problems. Standards in this course also include principles of the construction industry and business and project management. Students will continue compiling artifacts for inclusion in their portfolios, which they will carry with them throughout the full sequence of courses in this program of study. Standards in this course are aligned with Tennessee State Standards for English Language Arts & Literacy in Technical Subjects, Tennessee State Standards in Mathematics, Tennessee Physical Science Standards, Tennessee Physics Standards, and the National Center for Construction Education and Research (NCCER) Curriculum.\*

## Program of Study Application

This is the second course in the *Mechanical, Electrical, & Plumbing (MEP) Systems* program of study. For more information on the benefits and requirements of implementing this program in full, please visit the Architecture & Construction website at <http://www.tn.gov/education/cte/ArchitectureConstruction.shtml>.

## Course Standards

### Safety

- 1) Identify safety hazards on a jobsite and demonstrate practices for safe working. Accurately read, interpret, and demonstrate adherence to safety rules, including but not limited to rules pertaining to electrical safety, Occupational Safety and Health Administration (OSHA) guidelines, and state and national code requirements. Be able to distinguish between the rules and explain why certain rules apply. Perform a hazard assessment for a given task, such as working on a ladder to install electrical components. Explain the steps necessary to safely perform the task, outlining steps to take in case of an emergency. (TN Reading 3, 4, 6; TN Writing 2)
- 2) Maintain safety records and demonstrate adherence to industry-standard practices regarding general machine safety, tool safety, equipment safety, electrical safety, and fire safety to protect all personnel and equipment. For example, when operating tools and equipment, regularly inspect and carefully employ the appropriate personal protective equipment (PPE), as recommended by Occupational Safety & Health Administration (OSHA) regulations. Incorporate safety procedures when operating tools and equipment, such as hand and power tools, ladders, scaffolding, and lifting equipment. Complete safety test with 100 percent accuracy. (TN Reading 3, 4)
- 3) Follow procedures to work safely around materials. Adhere to responsibilities for employees in material safety as outlined by the Hazard Communication Standard (HazCom), such as locating and interpreting material safety data sheets (MSDS). Demonstrate safe procedures to move materials by planning the movement, properly lifting, stacking, and storing materials, and selecting proper materials-handling equipment. (TN Reading 3, 4)



## Tools & Equipment

- 4) For each of the systems covered in this course, identify and select the proper tools and accessories, critique the readiness of the tools, use the tools to accomplish the desired tasks, and then return the tools and accessories to their proper storage. For example, demonstrate the ability to safely use a deburring tool to ream a pipe end and effectively clean and store the tool. (TN Reading 3)

## Career Exploration

- 5) Compare and contrast career opportunities within the HVAC, electrical, and plumbing industries. Building on career exploration conducted in *Fundamentals of Construction*, produce a chart or other graphic comparing the skills, responsibilities, and personal characteristics of successful professionals in each of the three industries. Drawing on the research, create a personnel profile or a mock job description for one of these professionals, citing the use of skills and characteristics during a typical day on the job. (TN Reading 2, 4, 5, 7, 9; TN Writing 2)
- 6) Explain what an apprenticeship is, referencing data from the U.S. Department of Labor and other sources. Write persuasively to describe the benefits of the apprenticeship approach of on-the-job training paired with related training for individuals seeking construction careers. Use a variety of sources to gather data, cite each source, and briefly describe why the chosen source is reliable. (TN Reading 1, 7, 8; TN Writing 1, 8)
- 7) Research apprenticeships and postsecondary institutions (colleges of applied technology, community colleges, and four-year universities) in Tennessee and other states that offer construction-related programs. Write an informative paper or develop an infographic identifying entry requirements for a specific apprenticeship or postsecondary program of study, and the secondary courses that will prepare students to be successful in the program. (TN Reading 1, 3; TN Writing 2, 4, 7)

## Construction Industry Principles

- 8) Examine how the roles and responsibilities among construction trades and professions work in relationship to completing a project. Describe how electricians, plumbers, and HVAC technicians coordinate work with other construction personnel to complete a project, including submitting bids for subcontracted work and requesting clarification through a RFI (request for information) process. (TN Reading 2, 3, 4; TN Writing 2)
- 9) Explain inspection procedures used to enforce building codes during the construction of a residential or commercial building, outlining the roles and responsibilities of the building inspector and the contractor and the intervals at which inspections are performed. (TN Reading 2, 3, 4)

## Construction Math

- 10) Apply mathematics concepts to solve HVAC, electrical, and plumbing problems, distinguishing which principles apply to a given problem. Concepts should include, but are not limited to:



Concepts from *Fundamentals of Construction*:

- a. Operating with whole numbers, fractions, and decimals. (TN Math N-Q)
- b. Performing conversions between fractions, decimals, and percentages. For example, convert a decimal to a fraction to prepare a unit for measurement on a fractional scale to the precision of  $\frac{1}{16}$  of an inch. (TN Math N-Q)
- c. Working with units such as feet, inches, meters, centimeters, and millimeters, and determining appropriate units for a given construction task. For example, determine how many pieces of 2 ft. 4 in. PVC pipe may be cut from a 10 ft. piece and how much pipe will be left over. (TN Math N-Q)
- d. Calculating the area of two-dimensional spaces. Calculating surface area and volume for three-dimensional objects employing related geometric terminology. (TN Math G-GMD, G-MG)
- e. Performing proportionate reasoning to estimate quantities. (TN Math N-Q)
- f. Using basic rules of right triangles, such as the Pythagorean Theorem, to find missing lengths. (TN Math G-SRT)

Additional Concepts:

- g. Performing conversions between the metric system and the English system and among units within the metric system. (TN Math N-Q)
- h. Calculating the square and square root of numbers. (TN Math A-SSE)
- i. Solving algebraic equations. (TN Math A-REI)
- j. Calculating values associated with angles and triangles. (TN Math G-SRT)

## Electrical Systems

- 11) Describe how different levels of electrical shock affect the human body. Research current OSHA standards and other regulations specific to electrical systems to identify methods and equipment to reduce the risk of injury due to electrical shock. Drawing on evidence from textbooks and OSHA standards, apply lockout/tagout procedures to ensure safe working conditions. For example, perform a lockout/tagout to prepare to work on an electrical device. (TN Reading 1, 2, 3, 4)
- 12) Examine electrical circuits and components. Explain the difference between conductors and insulators. Demonstrate understanding of the layout and operation of electrical circuits (series, parallel, and series-parallel circuits) and draw connections to the physical laws, such as Ohm's law, which govern the behavior of electrical circuits and devices. For example, describe the function of resistors in electrical circuits, explaining how specific laws apply. (TN Reading 1, 2, 4)
- 13) Examine schematic electrical diagrams and identify common electrical symbols used for the components of electrical circuits. Draw a basic schematic diagram of a given electrical circuit, accurately incorporating the appropriate symbol for each given component. In a written or oral presentation, explain the drawing to a peer, accurately describing the name and function of each component, how the components work together, and the impact of the physical laws on the circuit. (TN Reading 4, 7; TN Physical Science 2)
- 14) Apply Ohm's law to solving given problems in electrical systems. Defend the solution using supporting evidence that explains the cause and effect relationship between Ohm's law and each of the following:
  - a. Voltage



- b. Current
- c. Resistance
- d. Voltage drop

For example, use Ohm's law to calculate the current flow of a circuit for an electric dryer with a given voltage and resistance. (TN Reading 1, 2, 3, 4, 5; TN Writing 1, 4; TN Math N-Q, A-SSE, A-CED, A-REI; TN Physical Science 2)

- 15) Assemble basic series and parallel circuits according to electrical diagrams using a transformer or battery, wires, and selected load devices. Use the proper instrument to measure voltage, current, and resistance, and check circuit continuity in an energized circuit. Test and correct the performance of the circuits using electrical test instruments appropriately. (TN Reading 3, 4, 5; TN Math N-Q; TN Physical Science 2)
- 16) Analyze the composition and properties of conductors. Explain how the markings on a conductor relate to the physical properties of the conductor, including the insulation and jacket material, conductor size and type, number of conductors, temperature rating, voltage rating, and permitted uses of the conductor. Inspect electrical charts and tables to determine the ampacity of a given conductor and to draw conclusions about the relationships among the physical properties of a conductor, such as size and ampacity. Explain how color coding is used to distinguish among conductor purposes. Create a visual display a beginning electrician might use to interpret the meaning of color and markings on conductors. (TN Reading 1, 2, 3, 4; TN Writing 4)
- 17) Determine the procedures necessary to safely replace or install electrical devices in a device box, such as a light fixture, receptacle, or switch. Draw on resources such as the device manufacturer's instructions and other instructional texts to determine the tools, steps, and safety procedures involved. Apply knowledge about conductors and electrical lockout/tagout procedures to safely complete installations of a device in a device box. Steps should include using test equipment to verify the power is off and connecting conductors to the proper terminals. For example, install a single-pole switch in a device box. (TN Reading 2, 3, 4, 5, 7; TN Writing 2, 4)

## **Plumbing Systems**

- 18) Examine safety considerations specific to plumbers by identifying possible hazards on a job site. In a written or oral presentation, explain how to work safely in and around confined spaces and trenches, as a journeyman plumber would to a plumber's helper. (TN Writing 4)
- 19) Describe the movement of water and waste within the plumbing systems of a building, drawing distinctions between water supply systems and drain, waste, and vent systems. Explain how physical principles such as gravity and pressure apply within plumbing systems, and how they contribute to the proper functioning and efficiency of the system. Illustrate why an understanding of these physical principles is important to a plumbing professional in the design, installation, maintenance, and repair of plumbing systems. (TN Reading 2, 3, 4, 5, 7; TN Writing 2; TN Physical Science 1, 4)



- 20) Determine common requirements found in plumbing codes and explain why the codes are necessary; include the importance of proper plumbing on human health. Examine a case in which poor plumbing contributed to the outbreak of disease in a community. Write an explanatory text to illustrate the problem and describe how it could have been prevented with proper plumbing applications. (TN Reading 2, 4, 5; TN Writing 2)

### **Piping**

- 21) Analyze the parts of a pipe fitting including the face, center, and back. Determine fitting allowances by using measuring and calculating techniques and by consulting manufacturer's tables. Calculate the length of pipe needed for a given application by implementing common pipe measuring techniques. (TN Reading 3, 4; TN Math N-Q)
- 22) Compare and contrast the material properties and uses of the various types of plastic piping, including storing and handling, safety issues, and types of fitting and hanging equipment. Analyze the use of plastic piping in plumbing systems and HVAC systems. Describe the factors influencing the decision to use plastic piping in a residence. Demonstrate the ability to select the correct materials, tools, and PPE to complete plastic piping projects by creating a list of the items needed for a specific installation. For example, for a residential bathroom sink drain, create a basic list of the materials, tools, and equipment needed to install the drain. (TN Reading 2, 3, 4, 7; TN Writing 4, 9)
- 23) Employ tools and procedures to safely measure, cut, ream, and join plastic piping and fittings. For example, accurately measure PVC pipe, use a miter box and handsaw to cut pieces of pipe, ream and chamfer the ends, and join the pipe using solvent cement. (TN Reading 3, 4; TN Math N-Q)

### **Heating, Ventilation, and Air Conditioning Systems (HVAC)**

- 24) Examine safety considerations specific to HVAC technicians by identifying possible hazards on a job site. Analyze the regulations that impact the work of HVAC technicians, such as the Clean Air Act and EPA guidelines. Create an informational artifact summarizing these regulations to an individual contemplating starting an HVAC business, explaining key considerations and citing resources that the future business owner can consult. (TN Reading 1, 2, 4; TN Writing 2, 4, 9)
- 25) Describe the basic components included in an HVAC system, outlining the purposes of each, citing textual resources such as blueprints, manuals, and manufacturers' specifications. Drawing on this evidence, write persuasively to describe the impact of a well-tuned HVAC system on building energy efficiency as well as on human health and well-being. Similarly, describe the negative consequences that can arise due to a poorly functioning or improperly installed HVAC system. (TN Reading 1, 2, 4, 6, 7; TN Writing 1, 8, 9)
- 26) Explain the fundamental concepts of heating and combustion, including describing the processes by which heat is transferred. Illustrate the differences in heat transfer by conduction, convection, and radiation by performing experiments. Record observations, citing evidence that heat is being transferred, identifying the heat source, noting the direction heat is moving, and determining the type of heat transfer taking place. (TN Reading 2, 3, 4, 5; TN Writing 7; TN Physical Science 2; TN Physics 2)



- 27) Relate the types of heat transfer to the various heating systems used within a building. Examine the schematic layout of a heating system within a building, such as a single family residence, and note the movement of heat, identifying areas of heat loss and heat gain. Citing the principles of heat transfer, propose strategies the homeowner could use to conserve energy in the home. (TN Reading 2, 3, 4, 5; TN Physical Science 2; TN Physics 2)

### **Business and Project Management**

- 28) Describe strategies used to promote collaboration, trust, and clear communication among internal and external parties on a job site. Practice effective verbal, nonverbal, written, and electronic communication skills for working with colleagues, employers, clients, and other personnel while demonstrating the ability to: listen attentively, speak courteously and respectfully, resolve obstacles in construction, and respond to criticism. For example, assume the roles of a construction business owner and a potential client, listen to the needs of a potential client, and respond to the potential client by email; explain the services provided by the company and the next steps needed to begin the project. Other role playing could include a construction business owner and a potential subcontractor. (TN Reading 2, 3; TN Writing 2, 4)
- 29) Describe the components and purpose of a basic contract document for a residential project. Recognize the relationship and responsibilities of various parties to a contract. Write a basic contract for a construction job, such as an electrical service agreement for wiring work done for a residential client. (TN Reading 2, 3, 4, 5)

### **Portfolio**

- 30) Update materials from coursework to add to the portfolio started in *Fundamentals of Construction*. Continually reflect on coursework experiences and revise and refine the career plan generated in the prior course. Include photographs or illustrations and written descriptions of sequential progress in construction projects. (TN Writing 2, 4, 5, 6)

## **Standards Alignment Notes**

\*References to other standards include:

- TN Reading: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 9-10 Students (page 62).
  - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standard 10 at the conclusion of the course.
- TN Writing: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 9-10 Students (pages 64-66).
  - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 3 and 10 at the conclusion of the course.



- TN Math: [Tennessee State Standards for Mathematics; Math Standards for High School: Number and Quantity, Algebra, Geometry](#) (pages 58-83).
  - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project based activities or collaborate on lesson planning. Students who are engaging in activities listed above should be able to demonstrate quantitative, algebraic, and geometric reasoning as applied to specific technical concepts. In addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.
- TN Physical Science: Tennessee Science: [Physical Science](#) standards 1, 2, and 4 may provide additional insight and activities for educators.
- TN Physics: Tennessee Science: [Physics](#) standard 5 may provide additional insight and activities for educators.
- NCCER Curriculum: [National Center for Construction Education and Research](#)
  - Note: NCCER accreditation is required to offer NCCER credentials to students. Instructors trained through the NCCER Instructor Certification Training Program (ICTP) may use the NCCER curricula to teach the listed standards. By doing so, their students will receive module credit for NCCER and be placed in NCCER's National Registry Database.
- P21: Partnership for 21st Century Skills [Framework for 21st Century Learning](#)
  - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.







## Electrical Systems

<b>Primary Career Cluster:</b>	Architecture & Construction
<b>Consultant:</b>	Rachel Allen, (615) 532-2835, <a href="mailto:Rachel.Allen@tn.gov">Rachel.Allen@tn.gov</a>
<b>Course Code(s):</b>	TBD
<b>Prerequisite(s):</b>	<i>Fundamentals of Construction and Mechanical, Electrical, &amp; Plumbing Systems</i>
<b>Credit:</b>	1
<b>Grade Level:</b>	11-12
<b>Graduation Requirements:</b>	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Architecture & Construction courses.
<b>Programs of Study and Sequence:</b>	This is one of the third course options in the <i>Mechanical, Electrical, &amp; Plumbing Systems</i> program of study.
<b>Necessary Equipment:</b>	Refer to the Teacher Resources page.
<b>Aligned Student Organization(s):</b>	SkillsUSA: <a href="http://site1.tnskillsusa.com/">http://site1.tnskillsusa.com/</a> Brandon Hudson, (615) 532-2804, <a href="mailto:Brandon.Hudson@tn.gov">Brandon.Hudson@tn.gov</a>
<b>Coordinating Work-Based Learning:</b>	Teachers who hold an active work-based learning (WBL) Certificate issued by the Tennessee Department of Education may offer appropriate student placement. To learn more, please visit <a href="http://www.tn.gov/education/cte/work_based_learning.shtml">http://www.tn.gov/education/cte/work_based_learning.shtml</a> .
<b>Available Student Industry Certifications:</b>	Students completing the course through an NCCER accredited program may receive module credit for NCCER.
<b>Dual Credit or Dual Enrollment Opportunities:</b>	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
<b>Teacher Endorsement(s):</b>	501, 502, 523, 532, 567, 580, 592
<b>Required Teacher Certifications/Training:</b>	TBD
<b>Teacher Resources:</b>	<a href="http://www.tn.gov/education/cte/ArchitectureConstruction.shtml">http://www.tn.gov/education/cte/ArchitectureConstruction.shtml</a>

### Course Description

*Electrical Systems* prepares students for careers as electricians across a variety of residential and commercial environments. Upon completion of this course, proficient students will be able to implement safety procedures and tools to perform operations with device boxes, conduit, raceway systems conductors, and cable. Students will read and interpret the National Electrical Code, drawings,

specifications, and diagrams to determine materials and procedures needed to complete a project. Students will calculate residential loads to recommend electrical hardware. Standards in this course also introduce basic troubleshooting procedures and alternate power systems, and expand on principles of the construction industry, delving deeper into business and project management. Students will continue compiling artifacts for inclusion in their portfolios, which they will carry with them throughout the full sequence of courses in this program of study. Standards in this course are aligned with Tennessee State Standards for English Language Arts & Literacy in Technical Subjects, Tennessee State Standards in Mathematics, and Tennessee State Standards in Chemistry I, Physics, Physical Science, and Environmental Science, as well as the National Center for Construction Education and Research (NCCER) Curriculum.\*

## Program of Study Application

This is one of the third course options in the *Mechanical, Electrical, & Plumbing Systems* program of study. This course can feed into a fourth-level *Construction Practicum* course in which students apply the skills learned throughout the program of study toward the completion of an in-depth, semester- or year-long Work-Based Learning (WBL) apprenticeship or internship. For more information on the benefits and requirements of implementing this program in full, please visit the Architecture & Construction website at <http://www.tn.gov/education/cte/ArchitectureConstruction.shtml>.

## Course Standards

### Safety

- 1) Identify safety hazards on a jobsite and demonstrate practices for safe working. Accurately read, interpret, and demonstrate safety rules, including but not limited to rules pertaining to electrical safety, Occupational Safety and Health Administration (OSHA) guidelines, and state and national code requirements. Be able to distinguish between the rules and explain why certain rules apply. Recognize and employ universal construction signs and symbols such as colors, flags, stakes, and hand signals that apply to construction workplace situations. Research and evaluate construction company safety plans from local industry. Explain the need for jobsite security to prevent liability. Drawing from examples, create and implement a jobsite safety program in the class to ensure safe practices and procedures including jobsite security procedures. (TN Reading 3, 4, 6; TN Writing 2, 4)
- 2) Maintain safety records and demonstrate adherence to industry-standard practices regarding general machine safety, tool safety, equipment safety, electrical safety, and fire safety to protect all personnel and equipment. For example, when operating tools and equipment, regularly inspect and carefully employ the appropriate personal protective equipment (PPE), as recommended by Occupational, Safety & Health Administration (OSHA) regulations. Incorporate safety procedures when operating tools and equipment, such as hand and power tools, ladders, scaffolding, and lifting equipment. Complete safety test with 100 percent accuracy. (TN Reading 3, 4)
- 3) Follow procedures to work safely around materials. Adhere to responsibilities for employees in material safety as outlined by the Hazard Communication Standard (HazCom), such as locating and interpreting material safety data sheets (MSDS). For example, obtain an MSDS for a given



material from a supplier in the community. Demonstrate safe procedures to move materials by planning the movement, properly lifting, stacking, and storing materials, and selecting proper materials-handling equipment. (TN Reading 3, 4)

- 4) Describe hazards involved when working with electricity and determine procedures to safeguard against them in the workplace, including ensuring power load balance, adhering to the appropriate use of ground-fault circuit interrupters (GFCIs) when working with power tools, and performing lockout/tagout procedures. (TN Reading 3, 4)

### **Tools & Equipment**

- 5) Identify and select the proper tools and accessories, critique the readiness of the tools, use the tools to accomplish the desired tasks, and then return the tools and accessories to their proper storage. Research a new technology recently developed for the electrical industry. Write persuasively to convince an employer how the use of the technology could benefit the company, citing evidence from resources. For example, describe how a new power tool could improve efficiency for a technician. (TN Reading 2, 3, 4; TN Writing 1, 9)
- 6) Distinguish among the various types and uses of electrical test equipment. Determine the appropriate test equipment for a given situation and environment and the procedures necessary for safe use. Utilizing test equipment such as a voltmeter, inspect and test an electrical wiring system for compliance according to drawings, specifications, and code requirements. (TN Reading 3, 4, 6; TN Math N-Q; TN Physical Science 2; TN Physics 5)

### **Construction Industry Principles**

- 7) Locate and assess the Tennessee Contractor's Licensing Board's website and analyze the policies and requirements for construction work in Tennessee. Explain how such policies impact local construction businesses. (TN Reading 2, 3, 4; TN Writing 7, 8)
- 8) Describe alternatives to traditional project delivery methods, such as the design-build and construction management-related methods, distinguishing among the roles and relationships of various construction personnel in each scenario. Examine the project delivery method of an actual company. Develop a company profile with supporting graphics the company could share with a client, describing the services provided and explaining the project delivery method used by the company. (TN Reading 2, 3, 4, 5, 7, 8; TN Writing 2, 4)

### **National Electrical Code (NEC®)**

- 9) Describe the purpose and layout of the National Electrical Code (NEC®). Create a chart to illustrate what is and is not covered by the NEC®, citing evidence from *NEC® Article 90*. Navigate, read, and interpret the NEC® to determine requirements for a given electrical installation. For example, interpret the NEC® to compare and contrast the box requirements for a device box to support a wall receptacle with those for a box to support a lighting fixture. (TN Reading 1, 2, 4, 6, 7, 9; TN Writing 2, 9)



## Device Boxes

- 10) Distinguish among the various types of device boxes, such as metallic and nonmetallic device boxes. For a variety of given residential and/or commercial applications, select appropriate device boxes according to drawings, specifications, and code requirements. Steps should include identifying the proper box type and size; and determining the minimum size pull or junction box for conduit entering and exiting (both for a straight pull and at an angle). (TN Reading 3, 4, 6, 9)
- 11) Utilize the proper tools, equipment, and procedures to safely perform installation of a variety of device boxes according to drawings, specifications, and code requirements. (TN Reading 2, 3, 4)

## Hand Bending

- 12) Describe the procedures, techniques, and tools for hand bending and installing conduit. Implement geometric principles to plan and use a hand bender to make 90 degree bends, back-to-back bends, offsets, kicks, and saddle bends. For example, use trigonometric ratios of right triangles to determine the offset angle of an offset bend and use the calculation to accurately create the bend. (TN Reading 3, 4; TN Math N-Q, G-RST)
- 13) Apply the appropriate tools, equipment, and procedures to safely cut, ream, and thread conduit. For example, ream the inside edge of a piece of conduit using a hand reamer. (TN Reading 3, 4)

## Raceway Systems

- 14) Explain the function of raceway systems, including acting as a grounding conductor. Distinguish among the various types of raceways, fittings, and conduit bodies available for raceway systems. Analyze a given environment and select the appropriate materials and installation methods for a raceway system, citing evidence from textbooks and codes. For example, recommend the appropriate raceway materials and installation method for a wood frame building of given parameters, drawing on evidence from codes such as the National Electrical Code (NEC®). (TN Reading 2, 3, 4, 6, 9; TN Writing 2, 9)
- 15) Outline the methods and procedures used to install various raceway systems, including terminating conduit. Accurately connect conduit to a box according to code requirements, explaining the need for a proper connection based on grounding requirements and protection of the wires. Apply the appropriate tools and procedures to install flexible raceway systems. (TN Reading 2, 3, 4, 6)

## Conductors & Cables

- 16) Building on knowledge of conductors from *Mechanical, Electrical, & Plumbing Systems*, read and interpret the NEC® and other instructional texts to determine the allowable ampacity of conductors for a variety of given applications. Include the insulation and jacket material, conductor size and type, number of conductors, temperature rating, and voltage rating of each. Describe possible consequences of improper conductor selection or installation, citing evidence from resources such as textbooks or trade journals. (TN Reading 1, 2, 3, 4, 5)



- 17) Describe the proper methods and procedures for installing conductors in a raceway system, noting potential hazards that exist when conductors are installed incorrectly. Employ tools and procedures to safely install conductors in a raceway system and verify the installation is performed according to code requirements. (TN Reading 2, 3, 4, 6; TN Writing 2, 9)

### **Construction Drawings & Specifications**

- 18) Read and interpret electrical drawings and specifications, including detail drawings and equipment schedules, to create a list of materials needed for a given electrical project. For example, analyze a lighting plan, light fixture schedule, and specifications for a residence to determine the materials needed to install the lighting system. (TN Reading 2, 3, 4, 6, 7; TN Writing 2, 9; TN Math N-Q)
- 19) Explain the relationship between construction drawings and specifications. For example, describe how both the construction drawings and specifications provide information about the raceway system indicated for a given building. Examine construction drawings and specifications to determine the requirements for a raceway system in a given building. (TN Reading 1, 2, 4, 5, 6, 7)
- 20) Describe processes by which construction professionals obtain clarification from architects regarding construction documents, such as by the use of requests for information (RFI's). Write a request for information (RFI) as would a construction professional to an architect to request clarification for a detail of the construction documents, such as the selection of a product. (TN Writing 4)

### **Residential Electrical Services**

- 21) Evaluate and recommend proper electrical hardware for a residential building. For example, for a residential dwelling with a given floor plan and schedule of major appliances, determine the size of the electrical service by referring to the National Electrical Code® to select the service-entrance equipment, such as conductors, panelboard, and protective devices. Steps should include: calculating the load for lighting, small appliances, and large appliances; and determining the number of branch circuits required. Describe the installation rules pertaining to dedicated circuits as applied to various equipment such as ranges, dryers, and HVAC systems. (TN Reading 2, 3, 4, 7; TN Math N-Q; TN Physical Science 2)

### **Basic Maintenance & Repair Process**

- 22) Identify and demonstrate basic troubleshooting strategies appropriate for evaluating electrical systems and devices. For example, in electrical systems, develop and implement a troubleshooting strategy to test and remedy an electrical fault. (TN Reading 3)
- 23) Identify routine maintenance procedures that should be performed on electrical systems for a given building. Create a timeline of recommended maintenance procedures for a client, justifying why each procedure is necessary by highlighting its preventive or cost-efficient characteristics. For example, create a schedule of tests to ensure emergency alarms are operating properly. (TN Reading 2, 3, 4, 7; TN Writing 4)



## Alternate Power Systems

- 24) Analyze typical electric power systems in a region by explaining how electricity is generated and distributed from a power plant to a given location. Research alternate electric power systems, including but not limited to photovoltaic systems and wind power technologies. Describe the functions of the systems and analyze their use in regions across the country according to informational texts and technical specs. Compare and contrast at least three types of power generation systems in a written text, chart, or visual display. (TN Reading 2, 3, 4, 7; TN Writing 2, 9; TN Math N-Q; TN Environmental Science 5)

## Business & Project Management

- 25) Establish and implement specific goals to manage project assignments in a timely manner, including organizing teams to effectively manage assignments, monitoring and reporting on project progress, and evaluating a completed project according to client requirements. For example, inspect and critique a team member's work, providing constructive feedback for improvement. Similarly, respond to constructive feedback from a team member to improve project outcomes and meet project goals. (TN Reading 2, 6; TN Writing 2)
- 26) Interpret construction drawings to determine the correct materials, tools, and equipment needed to complete a construction project. Plan and implement the steps needed to complete the project, adhering to inspection procedures and employing safe practices throughout. Draw from print and electronic examples to create a material list, cost estimation, project schedule, and inspection checklist for a project, applying the components of the documents to the given project. (TN Reading 2, 3; TN Writing 4)
- 27) Produce clear and coherent writing for communication in the electrical industry. Create a service order for a given electrical project. Explain the service order to a peer, as would a service technician to a client. (TN Writing 4)
- 28) Log daily activities completed during an electrical project. Document important facts concisely in a personal daily report as would an electrician to a supervisor including daily progress, equipment and materials used, personnel involved, and other occurrences. (TN Reading 3; TN Writing 2, 5, 10)

## Portfolio

- 29) Update materials from coursework to add to the portfolio started in *Fundamentals of Construction and Mechanical, Electrical, & Plumbing Systems*. Continually reflect on coursework experiences and revise and refine the career plan generated in prior courses. Include photographs or illustrations and written descriptions of sequential progress in construction projects. (TN Writing 2, 4, 5, 6)



## Standards Alignment Notes

\*References to other standards include:

- TN Reading: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 11-12 Students (page 62).
  - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standard 10 at the conclusion of the course.
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  - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standard 3 at the conclusion of the course.
- TN Math: [Tennessee State Standards for Mathematics; Math Standards for High School: Number and Quantity, Geometry](#) (pages 58-83).
  - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project based activities or collaborate on lesson planning. Students who are engaging in activities listed above should be able to demonstrate quantitative and geometric reasoning as applied to specific technical concepts. In addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.
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- TN Physics: Tennessee Science: [Physics](#) standard 2 may provide additional insight and activities for educators.
- TN Physical Science: Tennessee Science: [Physical Science](#) standards 1 and 2 may provide additional insight and activities for educators.
- TN Environmental Science: Tennessee Science: [Environmental Science](#) standard 5 may provide additional insight and activities for educators.
- NCCER Curriculum: [National Center for Construction Education and Research](#)
  - Note: NCCER accreditation is required to offer NCCER credentials to students. Instructors trained through the NCCER Instructor Certification Training Program (ICTP) may use the NCCER curricula to teach the listed standards. By doing so, their students will receive a certificate of completion for NCCER Electrical Level One and be placed in NCCER's National Registry Database.
- P21: Partnership for 21st Century Skills [Framework for 21st Century Learning](#)
  - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.





TENNESSEE DEPARTMENT OF  
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## HVAC

<b>Primary Career Cluster:</b>	Architecture & Construction
<b>Consultant:</b>	Rachel Allen, (615) 532-2835, <a href="mailto:Rachel.Allen@tn.gov">Rachel.Allen@tn.gov</a>
<b>Course Code(s):</b>	TBD
<b>Prerequisite(s):</b>	<i>Fundamentals of Construction and Mechanical, Electrical, &amp; Plumbing Systems</i>
<b>Credit:</b>	1
<b>Grade Level:</b>	11-12
<b>Graduation Requirements:</b>	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Architecture & Construction courses.
<b>Programs of Study and Sequence:</b>	This is one of the third course options in the <i>Mechanical, Electrical, &amp; Plumbing Systems</i> program of study.
<b>Necessary Equipment:</b>	Refer to the Teacher Resources page.
<b>Aligned Student Organization(s):</b>	SkillsUSA: <a href="http://site1.tnskillsusa.com/">http://site1.tnskillsusa.com/</a> Brandon Hudson, (615) 532-2804, <a href="mailto:Brandon.Hudson@tn.gov">Brandon.Hudson@tn.gov</a>
<b>Coordinating Work-Based Learning:</b>	Teachers who hold an active work-based learning (WBL) Certificate issued by the Tennessee Department of Education may offer appropriate student placement. To learn more, please visit <a href="http://www.tn.gov/education/cte/work_based_learning.shtml">http://www.tn.gov/education/cte/work_based_learning.shtml</a> .
<b>Available Student Industry Certifications:</b>	Students who complete this course may be qualified to sit for the EPA Section 608 Technician Certification. Additionally, students completing the course through an NCCER accredited program may receive module credit for NCCER.
<b>Dual Credit or Dual Enrollment Opportunities:</b>	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
<b>Teacher Endorsement(s):</b>	501, 502, 523, 532, 567, 592, 598
<b>Required Teacher Certifications/Training:</b>	TBD
<b>Teacher Resources:</b>	<a href="http://www.tn.gov/education/cte/ArchitectureConstruction.shtml">http://www.tn.gov/education/cte/ArchitectureConstruction.shtml</a>

### Course Description

HVAC prepares students for careers in residential and commercial heating, ventilation, air conditioning, and refrigeration. Upon completion of this course, proficient students will be able to demonstrate



knowledge and skill in performing basic operations with HVAC systems, with emphasis on safety, tools, and equipment specific to HVAC. In addition, students will be able to explain the functions and components of heating, cooling, and air distribution systems. They will demonstrate basic techniques to prepare piping and tubing for HVAC systems including performing soldering and brazing. Students will understand proper refrigerant management in preparation for EPA Section 608 Technician Certification. They will read and interpret drawings, specifications, and diagrams to determine materials needed to complete an HVAC project. Standards in this course also introduce basic troubleshooting and maintenance procedures and alternate power systems, and expand on principles of the construction industry, delving deeper into business and project management. Students will continue compiling artifacts for inclusion in their portfolios, which they will carry with them throughout the full sequence of courses in this program of study. Standards in this course are aligned with Tennessee State Standards for English Language Arts & Literacy in Technical Subjects, Tennessee State Standards in Mathematics, and Tennessee State Standards in Chemistry I, Physics, Physical Science, and Environmental Science, as well as the National Center for Construction Education and Research (NCCER) Curriculum.\*

## Program of Study Application

This is one of the third course options available in the *Mechanical, Electrical, & Plumbing Systems* program of study. This course can feed into a fourth-level *Construction Practicum* course in which students apply the skills learned throughout the program of study toward the completion of an in-depth, semester- or year-long Work-Based Learning (WBL) apprenticeship or internship. For more information on the benefits and requirements of implementing these programs in full, please visit the Architecture & Construction website at <http://www.tn.gov/education/cte/ArchitectureConstruction.shtml>.

## Course Standards

### Safety

- 1) Identify safety hazards on a jobsite and demonstrate practices for safe working. Accurately read, interpret, and demonstrate adherence to safety rules, including but not limited to rules pertaining to electrical safety, Occupational Safety and Health Administration (OSHA) guidelines, and state and national code requirements. Be able to distinguish between the rules and explain why certain rules apply. Recognize and employ universal construction signs and symbols such as colors, flags, stakes, and hand signals that apply to construction workplace situations. Research and evaluate construction company safety plans from local industry. Explain the need for jobsite security to prevent liability. Drawing from examples, create and implement a jobsite safety program in the class to ensure safe practices and procedures including jobsite security procedures. (TN Reading 3, 4, 6; TN Writing 2, 4)
- 2) Maintain safety records and demonstrate adherence to industry-standard practices regarding general machine safety, tool safety, equipment safety, electrical safety, and fire safety to protect all personnel and equipment. For example, when operating tools and equipment, regularly inspect and carefully employ the appropriate personal protective equipment (PPE), as recommended by Occupational, Safety & Health Administration (OSHA) regulations. Incorporate safety procedures when operating tools and equipment, such as hand and power tools, ladders, scaffolding, and lifting equipment. Complete safety test with 100 percent accuracy. (TN Reading 3, 4)



- 3) Follow procedures to work safely around materials. Adhere to responsibilities for employees in material safety as outlined by the Hazard Communication Standard (HazCom), such as locating and interpreting material safety data sheets (MSDS). For example, obtain an MSDS for a given material from a supplier in the community. Demonstrate safe procedures to move materials by planning the movement, properly lifting, stacking, and storing materials, and selecting proper materials-handling equipment. Describe hazards involved with HVAC work, including working around refrigerants, oils, and gases. (TN Reading 3, 4)

### Tools & Equipment

- 4) Identify and select the proper tools and accessories, critique the readiness of the tools, use the tools to accomplish the desired tasks, and then return the tools and accessories to their proper storage. Research a new technology recently developed for the HVAC industry. Write persuasively to convince an employer how the use of the technology could benefit the company, citing evidence from resources. For example, describe how a new tool could improve work efficiency for an HVAC technician. (TN Reading 2, 3, 4; TN Writing 1)

### Construction Industry Principles

- 5) Locate and assess the Tennessee Contractor's Licensing Board's website and analyze the policies and requirements for HVAC work in Tennessee. Explain how such policies impact local construction businesses. (TN Reading 2, 3, 4; TN Writing 7, 8)
- 6) Describe alternatives to traditional project delivery methods, such as the design-build and construction management-related methods, distinguishing among the roles and relationships of various construction personnel in each scenario. Examine the project delivery method of an actual company. Develop a company profile with supporting graphics the company could share with a client, describing the services provided and explaining the project delivery method used by the company. (TN Reading 2, 3, 4, 5, 7; TN Writing 2, 4)

### HVAC and Electricity

- 7) Building on knowledge of electricity from *Mechanical, Electrical, and Plumbing Systems*, describe the functions of electrical components used in HVAC systems. Examine an electrical diagram of an HVAC system and interpret symbols to describe the system, distinguishing between load devices and control devices. For example, annotate a basic HVAC electrical diagram to explain the purpose and function of each component in the overall system to an entry-level HVAC technician. (TN Reading 2, 3, 4, 6, 7; TN Writing 2, 4)

### Heating Systems

- 8) Building on knowledge of heat transfer from *Mechanical, Electrical, & Plumbing Systems*, describe the processes by which heat loss calculations are made for a residence. Describe a variety of ways in which heat is lost and why it is important for HVAC professionals to know how to perform heat loss calculations. For a given residence, follow procedures to perform a basic heat loss calculation for a residence with a given u-value and location. (TN Reading 2, 3, 4, 5; TN Math A-SSE, N-Q; TN Physical Science 2; TN Physics 2)



- 9) Analyze various types of gas furnaces and explain how they operate. Describe the equipment and controls involved, the concept of combustion, the various gas fuels, and their combustion characteristics. Explain the proper procedures for installing and maintaining gas furnaces. Perform basic maintenance tasks on a gas furnace, including replacing air filters and measuring temperature. (TN Reading 2, 3, 4; TN Chemistry I 2)
- 10) Compare and contrast gas furnaces, hydronic heating systems, and electric heating systems by analyzing the operating procedures and pros and cons of each system. Write a recommendation for a heating system for a client with a given location and building type. Cite evidence from retail catalogues, manufacturers' specifications, and energy ratings to justify the recommendation, defending why the selected system is a better choice than an alternative solution. (TN Reading 1, 2, 3, 4, 5, 9; TN Writing 1, 9)

### Cooling Systems

- 11) Describe the relationship between temperature and pressure and relate it to use of refrigerant in cooling systems. Summarize the processes involved in the basic mechanical refrigeration cycle, including the changes of state that occur and the basic patterns of the refrigerant flow. Analyze the major components of cooling systems and how they function, including compressors, condensers, evaporators, and controls. Draw evidence from textbooks, professional journals, and instructional websites to produce an explanation of the refrigerant cycle and the functioning processes of cooling systems in a written narrative with supporting graphics. (TN Reading 1, 2; TN Writing 2, 4, 6, 8, 9; TN Physical Science 1; TN Physics 2)
- 12) Utilize common measurement instruments including thermometers and gauge manifolds to measure temperature and pressure in an operating cooling system. Demonstrate the ability to calibrate a set of refrigerant gauges and thermometers, connect a refrigerant gauge manifold, and properly calculate subcooling and superheat on an operating system using a temperature probe. (TN Reading 3, 4; TN Math N-Q; TN Physical Science 1; TN Physics 2)

### Refrigerant Management

- 13) Building on knowledge from *Mechanical, Electrical, & Plumbing Systems*, describe the impact of refrigerants on the environment and the laws and regulations that are in place to protect the environment, such as the Montreal Protocol, the Clean Air Act, and EPA technician certification requirements. Distinguish among the various types of refrigerant, identifying the properties and cylinder color codes of each type. Read and interpret safety precautions and regulations impacting the recovery, containment, handling, and disposal of refrigerants, including EPA regulations, manufacturer's technical bulletins and MSDSs, and transportation requirements established by the U.S. Department of Transportation (DOT), analyzing how requirements are structured in the text. For example, evaluate the condition of a refrigerant container and determine if it meets DOT requirements, including proper labeling. Interpret unresolved or inadequately documented information. (TN Reading 1, 2, 3, 4, 5, 6, 7, 8, 9)
- 14) Describe the strategies and equipment used to leak test refrigerant circuits. Apply the appropriate tools, equipment, and procedures to safely pressurize a refrigerant system in preparation for leak testing and leak test the pressurized system. (TN Reading 2, 3)



- 15) Explain the various procedures used to recover refrigerant from equipment. Read and interpret technical documents to determine the required recovery level of a given HVAC system. Apply the appropriate tools, equipment, and procedures to safely perform refrigerant-recovery techniques while adhering to applicable regulations, including applying proper labeling and maintaining accurate records. Interpret and implement regulations surrounding the recycling, reclaiming, and disposing of refrigerant. (TN Reading 2, 3, 4)
- 16) Evaluate the purpose and procedures of system evacuation of an air conditioning system. Describe steps for selecting the appropriate tools to perform an evacuation for a given system. Compare and contrast common methods of evacuation such as deep vacuum and triple evacuation. Apply the appropriate tools, equipment, and procedures to safely perform a system evacuation. (TN Reading 3, 7, 9)
- 17) Explain and demonstrate how to properly charge various types of refrigerant circuits using different methods including by weight, by superheat, and by subcooling, safely employing the appropriate, tools, equipment and procedures. (TN Reading 3, 7)

### **Air Distribution Systems**

- 18) Describe the physical principles involved in air distribution systems, including pressure, velocity, and volume. Analyze the design of a simple air distribution system (i.e., as found in a typical residence) and explain how the system functions, noting where physical principles can be observed. Create a visual display with supporting text to explain the functions of the system. (TN Reading 2, 3, 4, 5, 7; TN Writing 2, 9; TN Physical Science 1)
- 19) Research the purpose and importance of ventilation in modern HVAC systems. Use technology to create a brochure an HVAC technician could share with a client to illustrate the impact of proper ventilation on indoor air quality including services provided by the technician and steps the client can take to insure high indoor air quality. (TN Reading 1, 2, 4; TN Writing 2, 4, 6, 9)
- 20) Recognize the various types and properties of mechanical equipment that make up an air distribution system, including various blowers, fans, duct materials, grilles, registers, and dampers. Relate the physical laws that apply to these systems, such as the Fan Laws, and demonstrate a basic understanding of how they work, as though leading a training or tutorial for fellow employees. (TN Reading 2, 3, 4, 5; TN Physical Science 1)
- 21) Illustrate how the design and proper installation of an air distribution system impacts the energy efficiency of the system. Drawing on observations, supporting technical manuals, and resources such as those from the U.S. Green Building Council and EPA Energy Star, create an oral or written recommendation for a client outlining strategies to increase energy efficiency for the HVAC system a given building, such as properly sealing the ducts, dampers, and vent locations. (TN Reading 2, 3, 4, 5; TN Writing 4; TN Physical Science 1)
- 22) Utilize test equipment including tachometers, manometers, and velometers to analyze the performance of an air distribution system. For example, collect measurements with a velometer, apply the information to calculate the airflow volume in a duct, and report the findings using



appropriate units. Read and interpret duct system charts to determine required duct sizes for a given air volume. (TN Reading 2, 3, 4; TN Math N-Q; TN Physical Science 1)

### **Basic Copper & Plastic Piping**

- 23) Distinguish among different types of plastic pipe, fittings, and valves for use in HVAC, and select the correct support and spacing for HVAC plastic piping. Compare and contrast the tools, hazards, and procedures for cutting and joining various types of plastic pipe, including but not limited to PVC, CPVC, and PEX. Employ tools and procedures to safely measure, cut, and join plastic piping and fittings for HVAC. (TN Reading 2, 3, 4; TN Math N-Q)
- 24) Describe the properties of various types of copper tubing used for HVAC. Describe common fittings, hangers, and supports used in copper tubing. Demonstrate how to measure, cut, and bend copper tubing for HVAC systems while preparing the tubing to be joined. Demonstrate techniques for mechanically joining copper tubing, including flared connections compression connections. Prepare tubing for soldering and brazing by swaging a tube. Inspect completed joints by safely performing leak testing procedures. (TN Reading 2, 3, 4; TN Math N-Q)

### **Soldering & Brazing**

- 25) Explain the purpose and process of soldering and brazing for an HVAC professional, outlining how the techniques work. Compare and contrast soldering and brazing, noting the uses, procedures, and equipment for each. Distinguish among the purposes, types, and uses of a variety of filler alloys and fluxes used in soldering and brazing, drawing on evidence from textbooks, manuals, and technical specifications to support claims. (TN Reading 2, 4, 9)
- 26) Describe the tools, equipment, and PPE used for soldering and brazing. Explain the safe operation of soldering and brazing equipment including assembling, testing, lighting, and shutting down acetylene and oxyacetylene equipment. Safely set up and shut down an acetylene single tank and oxyacetylene equipment. Describe and demonstrate procedures to safely prepare, solder, and braze copper tubing using various fittings. (TN Reading 2, 3, 4, 9)
- 27) Implement safe procedures to complete copper, brass, and steel tubing assemblies for a given layout. Steps include measuring, cutting, and fitting assemblies; choosing the proper filler alloys and fluxes for the assigned job; demonstrating proper use of acetylene and oxyacetylene equipment; and pressure testing assemblies to determine the proper completion of assemblies. (TN Reading 3)

### **Carbon Steel Piping**

- 28) Describe the characteristics and uses of steel pipe, making note of the similarities and differences in steel piping, plastic piping, and copper tubing. Draw on evidence from textbooks and physical observations to support claims. (TN Reading 2, 9)
- 29) Analyze the classification and measurement of pipe threads. Describe the uses of different types of fittings used on steel pipe. Employ tools and procedures to safely measure, cut, thread, and ream steel pipe. (TN Reading 2, 3)



- 30) Explain and demonstrate the methods of installing, connecting, and mechanically joining steel pipe, including joining threaded pipe using fittings, pipe grooving methods, and assembling flanged steel pipe. (TN Reading 3)

### **Basic Maintenance & Repair Process**

- 31) Identify and demonstrate basic troubleshooting strategies appropriate for evaluating HVAC systems, appliances, and devices. For example, develop and implement a troubleshooting strategy to test and remedy an undercharged system. (TN Reading 3)
- 32) Identify routine maintenance procedures that should be performed on HVAC systems for a given building. Create a timeline of recommended maintenance procedures for a client, justifying why each procedure is necessary by highlighting its preventive or cost-efficient characteristics. For example, create a schedule of items to inspect, clean, and replace in order to keep an HVAC system running efficiently. (TN Reading 2, 3, 4, 7; TN Writing 4)

### **Construction Drawings & Specifications**

- 33) Explain the relationship between construction drawings and specifications. Describe how both the construction drawings and specifications provide information about the HVAC system for a building. For example, examine construction drawings and specifications to determine the requirements for hangers and supports in a given HVAC piping system. (TN Reading 1, 2, 4, 5, 6, 7)
- 34) Describe processes by which construction professionals obtain clarification from architects regarding construction documents, such as by the use of requests for information (RFI's). Write a request for information (RFI), as would a construction professional to an architect to request clarification for a detail of the construction documents, such as the selection of a product. (TN Writing 4)

### **Business & Project Management**

- 35) Examine the components of a subcontract and explain the function of each component. For example, explain the responsibility of the subcontractor if damages are incurred due to delays caused by the subcontractor. (TN Reading 2, 4, 6)
- 36) Establish and implement specific goals to manage project assignments in a timely manner, including organizing teams to effectively manage assignments, monitoring and reporting on project progress, and evaluating a completed project according to client requirements. For example, inspect and critique a team member's work, providing constructive feedback for improvement. Similarly, respond to constructive feedback from a team member to improve project outcomes and meet project goals. (TN Reading 2, 6; TN Writing 2)
- 37) Interpret construction drawings and diagrams to determine the correct materials, tools, and equipment needed to complete an HVAC project. Plan and implement the steps needed to complete the project, adhering to inspection procedures and employing safe practices throughout. Draw from print and electronic examples to create a material list, cost estimation,



schedule, and inspection checklist for a project, applying the components of the documents to the given project. (TN Reading 2, 3; TN Writing 4)

- 38) Produce clear and coherent writing for communication in the HVAC industry. Create a service order for a given HVAC project. Explain the service order to a peer, as would a service technician to a client. (TN Reading 4)
- 39) Log daily activities completed during an HVAC project. Document important facts concisely in a personal daily report as would a technician to a supervisor including daily progress, equipment and materials used, personnel involved, and other occurrences. (TN Reading 3; TN Writing 2, 5, 10)

### Portfolio

- 40) Update materials from coursework to add to the portfolio started in *Fundamentals of Construction and Mechanical, Electrical, & Plumbing Systems*. Continually reflect on coursework experiences and revise and refine the career plan generated in prior courses. Include photographs or illustrations and written descriptions of sequential progress in construction projects. (TN Writing 2, 4, 5, 6)

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  - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project based activities or collaborate on lesson planning. Students who are engaging in activities listed above should be able to demonstrate quantitative and geometric reasoning as applied to specific technical concepts. In addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.
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- TN Physics: Tennessee Science: [Physics](#) standard 2 may provide additional insight and activities for educators.
- TN Physical Science: Tennessee Science: [Physical Science](#) standards 1 and 2 may provide additional insight and activities for educators.
- TN Environmental Science: Tennessee Science: [Environmental Science](#) standard 5 may provide additional insight and activities for educators.
- NCCER Curriculum: [National Center for Construction Education and Research](#)
  - Note: NCCER accreditation is required to offer NCCER credentials to students. Instructors trained through the NCCER Instructor Certification Training Program (ICTP) may use the NCCER curricula to teach the listed standards. By doing so, their students will receive a certificate of completion for NCCER HVAC Level One and be placed in NCCER's National Registry Database.
- P21: Partnership for 21st Century Skills [Framework for 21st Century Learning](#)
  - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.







## Plumbing Systems

<b>Primary Career Cluster:</b>	Architecture & Construction
<b>Consultant:</b>	Rachel Allen, (615) 532-2835, <a href="mailto:Rachel.Allen@tn.gov">Rachel.Allen@tn.gov</a>
<b>Course Code(s):</b>	TBD
<b>Prerequisite(s):</b>	<i>Fundamentals of Construction and Mechanical, Electrical, &amp; Plumbing Systems</i>
<b>Credit:</b>	1
<b>Grade Level:</b>	11-12
<b>Graduation Requirements:</b>	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Architecture & Construction courses.
<b>Programs of Study and Sequence:</b>	This is one of the third course options in the <i>Mechanical, Electrical, &amp; Plumbing Systems</i> program of study.
<b>Necessary Equipment:</b>	Refer to the Teacher Resources page.
<b>Aligned Student Organization(s):</b>	SkillsUSA: <a href="http://site1.tnskillsusa.com/">http://site1.tnskillsusa.com/</a> Brandon Hudson, (615) 532-2804, <a href="mailto:Brandon.Hudson@tn.gov">Brandon.Hudson@tn.gov</a>
<b>Coordinating Work-Based Learning:</b>	Teachers who hold an active work-based learning (WBL) Certificate issued by the Tennessee Department of Education may offer appropriate student placement. To learn more, please visit <a href="http://www.tn.gov/education/cte/work_based_learning.shtml">http://www.tn.gov/education/cte/work_based_learning.shtml</a> .
<b>Available Student Industry Certifications:</b>	Students completing the course through an NCCER accredited program may receive module credit for NCCER.
<b>Dual Credit or Dual Enrollment Opportunities:</b>	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
<b>Teacher Endorsement(s):</b>	501, 502, 527, 567, 580, 592
<b>Required Teacher Certifications/Training:</b>	TBD
<b>Teacher Resources:</b>	<a href="http://www.tn.gov/education/cte/ArchitectureConstruction.shtml">http://www.tn.gov/education/cte/ArchitectureConstruction.shtml</a>

### Course Description

*Plumbing Systems* prepares students for careers in plumbing across a variety of residential and commercial settings. Upon completion of this course, proficient students will be able to implement safety procedures and tools to perform operations with plumbing systems. Students will be able to explain how drain, waste, and vent (DWV) systems, water distribution systems, and plumbing fixtures

work and apply proper tools and procedures to perform operations with plumbing piping, including measuring, cutting, joining, supporting, and hanging various types of pipe. Students will read and interpret drawings, specifications, and diagrams to determine materials needed to complete a plumbing project. Standards in this course also introduce basic maintenance and troubleshooting procedures and expand on principles of the construction industry, delving deeper into business and project management. Students will continue compiling artifacts for inclusion in their portfolios, which they will carry with them throughout the full sequence of courses in this program of study. Standards in this course are aligned with Tennessee State Standards for English Language Arts & Literacy in Technical Subjects, Tennessee State Standards in Mathematics, and Tennessee State Standards in Chemistry I, Physics, Physical Science, and Environmental Science, as well as the National Center for Construction Education and Research (NCCER) Curriculum.\*

## Program of Study Application

This is one of three potential applied knowledge courses at the third level in the *Mechanical, Electrical, & Plumbing Systems* program of study. This course can feed into a fourth-level *Construction Practicum* course in which students apply the skills learned throughout the program of study toward the completion of an in-depth, semester- or year-long Work-Based Learning (WBL) apprenticeship or internship. For more information on the benefits and requirements of implementing these programs in full, please visit the Architecture & Construction website at <http://www.tn.gov/education/cte/ArchitectureConstruction.shtml>.

## Course Standards

### Safety

- 1) Identify safety hazards on a jobsite and demonstrate practices for safe working. Accurately read, interpret, and demonstrate adherence to safety rules, including but not limited to rules pertaining to electrical safety, Occupational Safety and Health Administration (OSHA) guidelines, and state and national code requirements. Be able to distinguish between the rules and explain why certain rules apply. Recognize and employ universal construction signs and symbols such as colors, flags, stakes, and hand signals that apply to construction workplace situations. Research and evaluate construction company safety plans from local industry. Explain the need for jobsite security to prevent liability. Drawing from examples, create and implement a jobsite safety program in the class to ensure safe practices and procedures including jobsite security procedures. (TN Reading 3, 4, 6; TN Writing 2, 4)
- 2) Maintain safety records and demonstrate adherence to industry-standard practices regarding general machine safety, tool safety, equipment safety, electrical safety, and fire safety to protect all personnel and equipment. For example, when operating tools and equipment, regularly inspect and carefully employ the appropriate personal protective equipment (PPE), as recommended by Occupational, Safety & Health Administration (OSHA) regulations. Incorporate safety procedures when operating tools and equipment, such as hand and power tools, ladders, scaffolding, and lifting equipment. Complete safety test with 100 percent accuracy. (TN Reading 3, 4)



- 3) Follow procedures to work safely around materials. Adhere to responsibilities for employees in material safety as outlined by the Hazard Communication Standard (HazCom), such as locating and interpreting material safety data sheets (MSDS). For example, obtain an MSDS for a given material from a supplier in the community. Demonstrate safe procedures to move materials by planning the movement, properly lifting, stacking, and storing materials, and selecting proper materials-handling equipment. Describe hazards involved with plumbing work, including working in confined spaces. (TN Reading 3, 4)

### **Tools & Equipment**

- 4) Identify and select the proper tools and accessories, critique the readiness of the tools, use the tools to accomplish the desired tasks, and then return the tools and accessories to their proper storage. Research a new technology recently developed for the plumbing industry. Write persuasively to convince an employer how the use of the technology could benefit the company, citing evidence from resources. For example, describe how a new power tool could improve efficiency for a plumber. (TN Reading 2, 3, 4; TN Writing 1, 7)

### **Construction Industry Principles**

- 5) Locate and assess local requirements for performing plumbing work in Tennessee. Visit the Tennessee Contractor's Licensing Board's website and analyze its policies and requirements. Interpret local plumbing code, and determine inspection procedures and other applicable portions of the law. Explain how such policies impact local construction businesses. (TN Reading 2, 3, 4, 9)
- 6) Describe alternatives to traditional project delivery methods, such as the design-build and construction management-related methods, distinguishing among the roles and relationships of various construction personnel in each scenario. Examine the project delivery method of an actual company. Develop a company profile with supporting graphics the company could share with a client, describing the services provided and explaining the project delivery method used by the company. (TN Reading 2, 3, 4, 5, 7; TN Writing 2, 4)

### **Construction Drawings & Specifications**

- 7) Examine plumbing drawings and identify common plumbing symbols used for the components of pipe assemblies. Read and interpret construction drawings, including detail drawings and equipment schedules, to create a list of materials needed for a given plumbing project. For example, analyze plumbing plans and isometric drawings to determine the materials needed to install a drain, waste, and vent system. (TN Reading 2, 3, 4, 6, 7; TN Writing 2, 9)
- 8) Demonstrate the ability to use an architect's scale to measure a component of a scale drawing. Create drawings commonly used in the plumbing trade, including orthographic and isometric sketches. (TN Math G-MD, G-MG)
- 9) Explain the relationship between construction drawings and specifications. Describe how both the construction drawings and specifications provide information about the plumbing system for a building. For example, examine construction drawings and specifications to determine the



requirements of hangers and supports for a given plumbing piping system. (TN Reading 1, 2, 4, 5, 6, 7)

- 10) Describe processes by which construction professionals obtain clarification from architects regarding construction documents, such as by the use of requests for information (RFI's). Write a request for information (RFI) as would a construction professional to an architect to request clarification for a detail of the construction documents, such as the selection of a product. (TN Reading 6; TN Writing 4)

### **Plumbing Math**

- 11) Apply mathematics concepts to solve plumbing problems, distinguishing which principles apply to a given problem. Concepts should include, but are not limited to:
- Using the basic rules of right triangles, such as the 3-4-5 ratio, to lay out and check square corners. (TN Math G-SRT)
  - Calculating values associated with angles and triangles to determine the run, travel, and rise of an offset. (TN Math G-SRT)

### **Plastic Pipe & Fittings**

- 12) Building on the knowledge of plastic piping from *Mechanical, Electrical, and Plumbing Systems*, distinguish among different types of plastic plumbing pipe, fittings, valves, hanging, and support. Draw on textual evidence and observations to describe the material properties of plastic pipe and create guidelines for proper storage and handling requirements. Compare and contrast the tools, hazards, and procedures for cutting and joining various types of plastic plumbing pipe, including ABS, PVC, CPVC, PE, PEX, and PB. Create a list of the appropriate piping materials, tools, and equipment needed for a given plastic piping application including supports and spacing. (TN Reading 1, 2, 4; TN Writing 4)
- 13) Read and interpret manufacturer's instructions, construction drawings and specifications, and applicable codes to properly install plastic pipe, including measuring, cutting, joining, and supporting plastic pipe. Utilize the appropriate tools, equipment, PPE, and procedures to safely complete installations. Once installed, pressure test plastic pipe according to local plumbing code to verify installation was properly completed. (TN Reading 2, 3)

### **Copper Tube & Fittings**

- 14) Distinguish among different types of copper tube, fittings, valves, hanging, and support. Draw on textual evidence and observations to describe the material properties of copper tube and create guidelines for proper storage and handling requirements. Compare and contrast the tools, hazards, and procedures for cutting and joining various types of copper tube. Create a list of the appropriate piping materials, tools, and equipment needed for a given copper tubing application including supports and spacing. (TN Reading 1, 2, 4; TN Writing 4)
- 15) Read and interpret manufacturer's instructions, construction drawings and specifications, and applicable codes to properly install copper tubing, including measuring, cutting, bending, joining, grooving, and supporting plastic pipe. Utilize the appropriate tools, equipment, PPE, and



procedures to safely complete installations. Once installed, pressure test copper tube according to local plumbing code to verify installation was properly completed. (TN Reading 2, 3, 6, 8)

### **Cast-Iron Pipe & Fittings**

- 16) Distinguish among different types of cast-iron pipe, fittings, valves, hanging, and support. Draw on textual evidence and observations to describe the material properties of cast-iron pipe and create guidelines for proper storage and handling requirements. Compare and contrast the tools, hazards, and procedures for cutting and joining hub-and-spigot cast-iron pipe and no-hub cast-iron pipe. Create a list of the appropriate piping materials, tools, and equipment needed for a given cast-iron piping application including supports and spacing. (TN Reading 1, 2, 4; TN Writing 4)
- 17) Read and interpret manufacturer's instructions, construction drawings and specifications, and applicable codes to properly install plastic pipe, including measuring, cutting, joining, and supporting plastic pipe. Utilize the appropriate tools, equipment, PPE, and procedures to safely complete installations. Once installed, test cast-iron piping according to local plumbing code to verify installation was properly completed. (TN Reading 2, 3)

### **Carbon Steel Pipe & Fittings**

- 18) Distinguish among different types of steel pipe, fittings, valves, hanging, and support. Draw on textual evidence and observations to describe the material properties of steel pipe and create guidelines for proper storage and handling requirements. Compare and contrast the tools, hazards, and procedures for cutting and joining steel pipe. Create a list of the appropriate piping materials, tools, and equipment needed for a given steel piping application including supports and spacing. (TN Reading 1, 2, 4; TN Writing 4)
- 19) Read and interpret manufacturer's instructions, construction drawings and specifications, and applicable codes to properly install steel pipe, including measuring, cutting, joining, and supporting steel pipe. Utilize the appropriate tools, equipment, PPE, and procedures to safely complete installations. (TN Reading 2, 3)

### **Plumbing Fixtures**

- 20) Describe the features and operating principles of various types of plumbing fixtures, including sinks, lavatories, faucets, bathtubs, showers, and water closets. Analyze the operational procedures of two different water closets, such as a siphon-action water closet and a blow-out water closet. Compare and contrast the functions and benefits of each, citing resources to make a recommendation for a client based on the specific needs of a project. (TN Reading 1, 2, 3, 4, 7; TN Writing 2, 4, 9; TN Physical Science 2)

### **Drain, Waste, & Vent (DWV) Systems**

- 21) Study a schematic plan of a typical community sewer system. Citing evidence from a technical description or actual observation of a system, explain how waste moves through a drain, waste, and vent system from the fixture to the environment. Create a graphic illustration to represent



the movement of waste from one component to the others in the system. For example, create a basic diagram of how the waste generated by a clean-up sink in the classroom travels to the local sewage treatment plant. (TN Reading 2, 3, 4, 7)

- 22) Demonstrate understanding of the specific roles of various plumbing components in a drain, waste, and vent system by sketching a system model. Label the components, and include a written description of the function of each. Be able to describe the physical principles involved such as gravity and pressure. (TN Reading 2, 3, 4, 5, 7; TN Writing 2; TN Physical Science 1, 4)
- 23) Analyze the function of a trap by examining a drain, waste, and vent system whose trap has lost its seal. Diagnose and explain the cause and determine the appropriate solution, citing evidence from textbooks or technical manuals in order to justify why the chosen solution is preferable or more effective than another. (TN Reading 1, 2, 4, 5; TN Writing 2, 9)

### **Water Distribution Systems**

- 24) Study a schematic plan of a typical municipal water distribution system. Citing evidence from a technical description or actual observation of a system, explain how water travels from a water treatment plant to a fixture in a residence. Create a graphic illustration to represent the movement of water from one component to the others in the system. For example, sketch an isometric drawing of a simple water distribution system and label its components. (TN Reading 1, 2, 3, 4, 7; TN Writing 2, 9)

### **Basic Maintenance & Repair Process**

- 25) Identify and demonstrate basic troubleshooting strategies appropriate for evaluating plumbing systems and devices. For example, in a drain system, develop and implement a troubleshooting strategy to test and remedy a clogged drain. (TN Reading 3)
- 26) Identify routine maintenance procedures that should be performed on plumbing systems for a given building. Create a timeline of recommended maintenance procedures for a client, justifying why each procedure is necessary by highlighting its preventive or cost-efficient characteristics. For example, create a schedule of items to inspect and clean in order to keep a plumbing system running efficiently. (TN Reading 2, 3, 4, 7; TN Writing 4)

### **Green Practices in Plumbing**

- 27) Define the term *efficiency* in the context of the plumbing profession and plumbing systems. Research and identify strategies used in the design of plumbing systems and plumbing work practices to increase the efficiency of plumbing systems. Drawing on resources such as those from the U.S. Green Building Council and EPA Energy Star, create a recommendation for a client outlining green plumbing strategies for a given building. (TN Reading 2, 3, 4, 7, 9; TN Writing 2, 7, 8; TN Environmental Science 5)



## Business & Project Management

- 28) Examine the components of a subcontract and explain the function of each component. For example, explain the responsibility of the subcontractor if damages are incurred due to delays caused by the subcontractor. (TN Reading 2, 4, 6)
- 29) Establish and implement specific goals to manage project assignments in a timely manner, including organizing teams to effectively manage assignments, monitoring and reporting on project progress, and evaluating a completed project according to client requirements. For example, inspect and critique a team member's work, providing constructive feedback for improvement. Similarly, respond to constructive feedback from a team member to improve project outcomes and meet project goals. (TN Reading 2, 6; TN Writing 2)
- 30) Interpret construction drawings and applicable local plumbing codes to determine the correct materials, tools, and equipment needed to complete a plumbing project. Plan and implement the steps needed to complete the project, adhering to inspection procedures and employing safe practices throughout. Draw from print and electronic examples to create a material list, cost estimation, project schedule, and inspection checklist for a project, applying the components of the documents to the given project. (TN Reading 2, 3; TN Writing 4)
- 31) Produce clear and coherent writing for communication in the plumbing industry. Create a service order for a given plumbing project. Explain the service order to a peer, as would a service technician to a client. (TN Writing 4)
- 32) Log daily activities completed during a plumbing project. Document important facts concisely in a personal daily report as would a plumber to a supervisor, including daily progress, equipment and materials used, personnel involved, and other occurrences. (TN Reading 3; TN Writing 2, 5, 10)

## Portfolio

- 33) Update materials from coursework to add to the portfolio started in *Fundamentals of Construction and Mechanical, Electrical, & Plumbing Systems*. Continually reflect on coursework experiences and revise and refine the career plan generated in prior courses. Include photographs or illustrations and written descriptions of sequential progress in construction projects. (TN Writing 2, 4, 5, 6)

## Standards Alignment Notes

\*References to other standards include:

- TN Reading: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 11-12 Students (page 62).
  - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standard 10 at the conclusion of the course.



- TN Writing: [Tennessee State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects](#); Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 11-12 Students (pages 64-66).
  - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standard 3 at the conclusion of the course.
- TN Math: [Tennessee State Standards for Mathematics; Math Standards for High School: Number and Quantity, Geometry](#) (pages 58-83).
  - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project based activities or collaborate on lesson planning. Students who are engaging in activities listed above should be able to demonstrate quantitative and geometric reasoning as applied to specific technical concepts. In addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.
- TN Chemistry I: Tennessee Science: [Chemistry I](#) standard 2 may provide additional insight and activities for educators.
- TN Physics: Tennessee Science: [Physics](#) standard 2 may provide additional insight and activities for educators.
- TN Physical Science: Tennessee Science: [Physical Science](#) standards 1 and 2 may provide additional insight and activities for educators.
- TN Environmental Science: Tennessee Science: [Environmental Science](#) standard 5 may provide additional insight and activities for educators.
- NCCER Curriculum: [National Center for Construction Education and Research](#)
  - Note: NCCER accreditation is required to offer NCCER credentials to students. Instructors trained through the NCCER Instructor Certification Training Program (ICTP) may use the NCCER curricula to teach the listed standards. By doing so, their students will receive a certificate of completion for NCCER Plumbing Level One and be placed in NCCER's National Registry Database.
- P21: Partnership for 21st Century Skills [Framework for 21st Century Learning](#)
  - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.

