TN Department of Education | College, Career and Technical Education

HVAC

Primary Career Cluster:	Architecture & Construction
Program Manager:	Candi Norwood, (615) 532-6248, Candi.Norwood@tn.gov
Course Code(s):	6077
Prerequisite(s):	*Mechanical, Electrical, & Plumbing Systems* (6161)
Credit:	1
Grade Level:	11-12
Graduation Requirements:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Architecture & Construction courses.
Programs of Study and Sequence:	This is one of the third-level course options in the *Mechanical, Electrical, & Plumbing (MEP) Systems* program of study.
Aligned Student Organization(s):	SkillsUSA: http://tnskillsusa.com/ Tracy Whitehead, (615) 532-2804, Tracy.Whitehead@tn.gov
Coordinating Work-Based Learning:	Teachers are encouraged to use embedded WBL activities such as informational interviewing, job shadowing, and career mentoring. For information, visit https://www.tn.gov/content/tn/education/career-and-technical-education/work-based-learning.html.
Available Student Industry Certifications:	EPA Section 608 Universal, Universal R-410A, HVAC Excellence Heating, Electrical, Air Conditioning Technology (H.E.A.T), HVAC Excellence Employment Ready Certifications
Dual Credit or Dual Enrollment Opportunities:	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
Teacher Endorsement(s):	501, 502, 523, 532, 567, 592, 598, 701, 707
Required Teacher Certifications/Training:	None
Teacher Resources:	https://www.tn.gov/education/career-and-technical-education/career-clusters/cte-cluster-architecture-construction.html

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.

Program of Study Application

This is one of the third-level course options available in the *Mechanical, Electrical, & Plumbing (MEP) 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 https://www.tn.gov/education/career-and-technical-education/career-clusters/cte-cluster-architecture-construction.html.

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.

2) Continue to 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.

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.

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.

Construction Industry Principles

5) Locate and assess requirements for performing HVAC work including local, state, and national requirements. Interpret HVAC codes, and determine inspection procedures and other applicable portions of the law. Visit the Tennessee Contractor's Licensing Board's website and analyze its policies and requirements. Explain how such policies impact local construction businesses.

6) Consult a variety of sources to 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.

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.

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.

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.

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.

Cooling Systems

11) Describe the relationship between temperature and pressure and relate it to use of refrigerant in cooling systems. Distinguish between absolute pressure and gauge pressure. 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.

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 the gauge manifold and a temperature probe.

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.

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.

15) Explain the various procedures used to recover, recycle, and reclaim 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.

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.

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.

Air Distribution Systems

18) Describe the physical principles involved in air distribution systems, including pressure, velocity, and volume. 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. 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.

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.

20) 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 in a given building, such as properly sealing the ducts, dampers, and vent locations.

21) 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 equivalent length charts and required air volume and duct size charts.

Basic Copper & Plastic Piping

22) 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. Employ tools and procedures to safely measure, cut, and join plastic piping and fittings for HVAC.

23) 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, deburring, and cleaning a tube. Inspect completed joints by safely performing leak testing procedures.

Soldering & Brazing

24) 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.

25) 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.

26) 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.

Carbon Steel Piping

27) 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.

28) 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.

29) 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.

Basic Maintenance & Repair Process

30) 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.

31) 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.

Construction Drawings & Specifications

32) 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.

33) 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.

Business & Project Management

34) Describe the components and purpose of a basic contract document for a residential project, determining the meaning of key terms and other industry-specific words. Recognize the relationship and responsibilities of various parties to a contract. Write a basic contract for a job, such as a HVAC service agreement for work done for a residential client.

35) 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.

36) 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.

37) 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.

38) Utilize technology to write and share periodical reports (weekly, monthly, etc.) to provide others with information about progress during HVAC projects as would a project manager to a supervisor. Summarize activities in a narrative form including overall progress in relationship to a previously planned schedule.

Portfolio

39) 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.

Standards Alignment Notes

*References to other standards include:

- 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.