Maryland
STATE DEPARTMENT OF EDUCATION

Program of Study Guide:
HVACR - DRAFT

Comprehensive guidelines and course standards for the Heating, Ventilation, Air Conditioning, and Refrigeration pathway

Office of College and Career Pathways

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MARYLAND STATE DEPARTMENT OF EDUCATION

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Purpose

The purpose of this document is to communicate the required Career and Technical Education (CTE) academic standards for the HVACR Program of Study. The academic standards in this document are theoretical and performance based. The standards contain content from multiple state departments of education, industry related resources and have been reviewed and vetted by members of the Maryland business and industry community.

In addition to academic standards, the Maryland State Department of Education (MSDE) has incorporated into this document Labor Market Information (LMI) definitions and explanations for the Program of Study; program aligned Industry Recognized Credentials; and Work-Based Learning resources and requirements by course level.

Standards Sources

The following sources collectively support a progression of standards from foundational to advanced HVACR concepts in a high school context, preparing students for industry-aligned certifications like NCCER HVACR and OSHA 30 and providing them with the necessary knowledge and skills for career readiness in HVACR fields.

Here are the key standards sources for HVACR curriculum:

1. **NCCER (National Center for Construction Education and Research)**
   A. **Description:** Comprehensive competency-based craft training curriculum including Core curriculum and multiple levels of HVACR training. Includes detailed learning objectives, performance tasks, and assessment materials.
   B. **Use:** Provides the foundational structure for our program, including clear learning progressions and industry-recognized credentials. Aligned with industry needs and updated regularly.
   C. **Source:** Access through NCCER accredited training programs and approved curriculum providers (www.nccer.org)

2. **OSHA Standards (29 CFR 1926 Subpart K)**
   A. **Description:** Federal safety and health regulations for HVACR safety in construction.
   B. **Use:** Ensures program meets required safety training standards and prepares students for workplace requirements.
   C. **Source:** Freely available at www.osha.gov.

Course Descriptions

Course Level	Course Information	Description
Required Core: Course 1	Core Construction Principles SCED: <XX> Grades: 9-12 Prerequisite: None Credit: 1	Construction Fundamentals is a foundational course that introduces essential construction industry knowledge and skills while preparing students for careers in multiple construction trades. Students develop competencies in workplace safety, construction math, hand and power tools, construction drawings, and basic rigging. The course emphasizes comprehensive safety training aligned with OSHA 30 Construction certification requirements. Students also build crucial workplace readiness skills through modules on communication, employability, and material handling. Students can earn both NCCER Core and OSHA 30 Construction certifications upon completion.
Required Core: Course 2	HVACR I SCED: <XX> Grades: 10-12 Prerequisite: Core Construction Principles Credit: 1	In HVACR Technology I, Students develop proficiency in working with various piping materials including plastic, copper, cast iron, and steel, while learning proper measurement, cutting, and joining techniques. The curriculum covers essential topics such as HVACR safety, tools and equipment usage, basic mathematics, and drawing interpretation. Students gain hands-on experience with drain, waste, and vent (DWV) systems, water distribution systems, and HVACR fixtures. The course emphasizes proper installation techniques, code requirements, and industry best practices. Upon completion, students will be able to identify and properly use HVACR tools, install basic HVACR systems, and understand fundamental HVACR principles and safety protocols.

Course Level	Course Information	Description
Optional Flex: Course 1	HVACR II SCED: <XX> Grades: 11-12 Prerequisite: HVACR I Credit: 1	Students master advanced piping calculations, including various types of offsets and rolling measurements. The course covers the interpretation of commercial drawings, installation of sophisticated drainage systems, and comprehensive testing procedures for both DWV and water supply systems. Students learn to work with advanced components such as water heaters, fuel gas systems, and electrical circuits in HVACR applications. Special emphasis is placed on structural considerations, insulation requirements, and firestopping techniques. The curriculum includes extensive hands-on practice with valve installation, system testing, and troubleshooting. Upon completion, students will be prepared to tackle complex HVACR installations, perform advanced calculations, and handle commercial HVACR applications while adhering to relevant codes and safety standards.
Optional Flex: Course 2	Career Connected Learning I SCED: <XX> Grades: 11-12 Prerequisite: HVACR I Credit: 1	This flexible, work-based learning course introduces students to real-world applications of classroom knowledge and technical skills through on-the-job experiences and reflective practice. Students engage in career exploration, skill development, and professional networking by participating in youth apprenticeships, registered apprenticeships, pre-apprenticeships, internships, capstone projects, or other approved career-connected opportunities. Variable credit (1–3) accommodates the required on-the-job training hours and related instruction. By integrating industry standards, employability skills, and personalized learning goals, Career Connected Learning I equips students to make informed career decisions, develop a professional portfolio, and build a strong foundation for success in postsecondary education, training, or the workforce.

Course Level	Course Information	Description
Optional Flex: Course 3	Career Connected Learning II SCED: <XX> Grades: 11-12 Prerequisite: Career Connected Learning I Credit: 1	Building on the foundational experiences of Career Connected Learning I, this advanced work-based learning course provides students with deeper on-the-job practice, leadership opportunities, and refined career exploration. Students continue to enhance their technical and professional skills, expanding their industry networks and aligning personal goals with evolving career interests. Variable credit (1–3) remains aligned with the required training hours and related instruction. Through elevated responsibilities and skill application, Career Connected Learning II prepares students to confidently transition into higher-level postsecondary programs, apprenticeships, or the workforce.

Dual Enrollment and Career Connected Learning Experiences Must be Aligned to the CTE Core.

Industry-Recognized Credentials and Work-Based Learning

Industry-Recognized Credentials – The standards in this document are aligned to the following certifications:
By the end of Core Construction Principles: NCCER Core + OSHA 30 **By the end of HVACR I:** HVACR Level 1 Certificate **By the end of HVACR II:** HVACR Level 2 Certificate **Optional Credentials (via the Flex Course options):** Apprenticeship

Work-Based Learning Examples and Resources		
Core Construction Principles: **Career Awareness**	**HVACR I:** **Career Preparation**	**HVACR II:** **Career Preparation**
• Industry Visits • Guest Speakers • Participation in Career and Technical Student Organizations • Postsecondary Visits – Program Specific Site Tours • Mock Interviews	• All of Career Awareness plus the following: • Job Shadow • Paid and Unpaid Internships	• Paid and Unpaid Internships • Apprenticeships

Labor Market Information: Definitions and Data

Labor market information (LMI) plays a crucial role in shaping Career and Technical Education (CTE) programs by providing insights into industry demands, employment trends, and skills gaps. This data helps education leaders assess the viability of existing programs and identify opportunities for new offerings. By aligning CTE programs with real-time labor market needs, schools can better prepare students for in-demand careers and ensure that resources are effectively utilized to support pathways that lead to high-quality, sustainable employment.

Standard Occupational Code (SOC) and Aligned Industry:

Indicator	Definition	Pathway Labor Market Data
High Wage[1]	Those occupations that have a 25th percentile wage equal to or greater than the most recent MIT Living Wage Index for one adult in the state of Maryland, and/or leads to a position that pays at least the median hourly or annual wage for the DC-VA-MD-WV Metropolitan Statistical Area (MSA). *Note: A 25th percentile hourly wage of $24.74 or greater is required to meet this definition.*	**Standard Occupational Code:** 49-9021: Heating, Air Conditioning, and Refrigeration Mechanics and Installers **Hourly Wage/Annual Salary:** 25th Percentile: $23.77/$49,442 50th Percentile: $30.09/$62,587 75th Percentile: $38.38/$79,830
High Skill	Those occupations located within the DC-VA-MD-WV Metropolitan Statistical Area (MSA) with the following education or training requirements: completion of an apprenticeship program; completion of an industry-recognized certification or credential; associate's degree, bachelor's degree, or higher.	**Typical Entry-Level Education:** To be a practicing HVACR technician in the state of Maryland you need to be licensed through the Maryland Board of Heating, Ventilation, Air Conditioning, and Refrigeration. This can be accomplished by completing an approved HVACR preparation program, which can included introductory courses in high school.
In-Demand	Annual growth plus replacement, across all Maryland occupations, is 405 openings between 2024-2029.	**Annual Openings**

[1] Living Wage Calculator: https://livingwage.mit.edu/states/24

Labor Market Information Data Source

Lightcast Q4 2024 Data Set. Lightcast occupation employment data are based on final Lightcast industry data and final Lightcast staffing patterns. Wage estimates are based on Occupational Employment Statistics (QCEW and Non-QCEW Employees classes of worker) and the American Community Survey (Self-Employed and Extended Proprietors). Occupational wage estimates are also affected by county-level Lightcast earnings by industry. Foundational data for the state of Maryland is collected and reported by the Maryland Department of Labor.

Methodology for High Wage Calculations

To combine labor market data across multiple Standard Occupational Classifications (SOCs), a weighted average approach was used to ensure accurate representation of the marketplace. Median wages for each SOC were weighted based on their respective employment levels, reflecting the relative demand for each occupation. This method ensures that occupations with higher employment contribute proportionately to the overall wage calculation. Additionally, job openings from all relevant SOCs were summed to determine the total projected demand. For example, if Mechanical Engineers account for 67% of total employment and Electrical Engineers for 33%, their respective wages are weighted accordingly, and job openings are aggregated to provide a comprehensive view of labor market opportunities. This approach delivers a balanced and accurate representation of both wages and employment demand for the program.

Methodology for In-Demand Calculations

The baseline for annual job openings, taking into account new positions and replacement positions, was determined by taking the average of all annual job openings between 2024 and 2029 across all 797 career sectors at the 5-digit SOC code level. For the 2024-2029 period, average job openings (growth + replacement) is 405.

Course Standards: Core Construction Principles

1. **GENERAL REQUIREMENTS.** This course is recommended for students in Grades 9-12.

2. **INTRODUCTION**
   A. Career and Technical Education (CTE) instruction provides content aligned with challenging academic standards and relevant technical knowledge and skills for students to further their education and succeed in current or emerging professions.
   B. The Construction Career Cluster prepares students for careers in designing, planning, and building sustainable infrastructure. This field includes architects, engineers, construction managers, and skilled trades professionals.
   C. The HVACR Program of Study prepares students for a career in the HVACR trade through a comprehensive three-course sequence. Students learn to safely install, maintain, and repair heating, ventilation, air conditioning, and refrigeration systems. They master workplace safety protocols, tool usage, and trade mathematics before progressing to electrical system fundamentals and circuit analysis. Students develop hands-on skills in pipe fitting, soldering, brazing, and ductwork installation. The program advances to complex system components including compressors, heat pumps, and air quality equipment. Students learn to perform maintenance, troubleshoot systems, manage refrigerants safely, and provide professional customer service. Upon completion, they can diagnose problems, conduct repairs, and maintain HVACR systems according to industry standards.
   D. Core Construction Principles introduces students to the essential fundamentals of the construction industry with a focus on HVACR systems career preparation. This foundational course aligns with NCCER Core certification and OSHA safety standards, emphasizing construction safety, basic math operations, hand and power tool operations, blueprint reading, and material handling. Students develop critical workplace skills through modules covering communication, employability skills, and construction drawings.
   E. Students will participate in at least two Career-Connected Education and Work-Based Learning experiences in this course, which might include informational interviews or job shadowing relevant to the program of study.
   F. Students are encouraged to participate in extended learning experiences through aligned Career and Technical Student Organizations (CTSOs). CTSOs are a cocurricular requirement in the Carl D. Perkins Act, and alignment to CTSO activities is an expectation for CTE programs in the state of Maryland.

3. **KNOWLEDGE AND SKILLS**
   A. The student demonstrates the necessary skills for career development, maintenance of employability, and successful completion of course outcomes. The student is expected to:
      1. Identify and demonstrate positive work behaviors that enhance employability and job advancement, such as regular attendance, promptness, proper attire, maintenance of a clean and safe work environment, and pride in work.
      2. Demonstrate positive personal qualities such as flexibility, open-mindedness, initiative, active listening, and a willingness to learn.
      3. Employ effective reading, writing, and technical documentation skills.
      4. Solve problems using critical thinking techniques and structured troubleshooting methodologies.
      5. Demonstrate leadership skills and collaborate effectively as a team member.

6. Implement safety procedures, including proper handling of hardware and following OSHA guidelines.
7. Exhibit an understanding of legal and ethical responsibilities in the construction field, following applicable laws and best practices for safety.
8. Demonstrate time-management skills and the ability to prioritize tasks in a technical setting.

B. The student identifies various career pathways in the HVACR field. The student is expected to:

1. Develop a career plan that includes the necessary education, certifications, job skills, and experience for specific roles as an Electrician or in the HVACR field.
2. Create a professional resume and portfolio that reflect skills, projects, certifications, and recommendations.
3. Demonstrate effective interview skills for roles in the HVACR field.

C. The student identifies the issues associated with HVACR hazards found on a jobsite. The student is expected to:

1. Demonstrate safe working procedures in a construction environment.
2. Explain the purpose of the Occupational Safety and Health Administration (OSHA) and how it promotes safety on the job.
3. Identify HVACR hazards and how to avoid or minimize them in the workplace.
4. Explain safety issues concerning lockout and tagout procedures, personal protection using assured grounding and isolation programs, confined space entry, respiratory protection, and fall protection.

D. The student integrates core academic skills into HVACR construction practices. The student is expected to:

1. Demonstrate the use of clear communication techniques, both written and verbal, that are consistent with industry standards.
2. Apply mathematical concepts such as operations with whole numbers, fractions, and decimals; working with geometric shapes and calculating their areas/volumes; measurement using both metric and imperial units; converting between measurement systems; working with scale drawings (architectural, engineering, and metric scales); calculating load values and equivalent resistance in HVACR circuits; and determining proper sizing for HVACR components based on mathematical formulas.
3. Use scientific principles including HVACR theory (atomic structure, conductors/insulators, circuit behavior, Ohm's Law), materials science (properties of HVACR materials, material strength), physical science (mechanical advantage, force and motion), and human factors engineering (ergonomics, physiological effects of electricity, respiratory protection), which are all essential for understanding and safely performing HVACR and construction work.

E. The student demonstrates understanding of construction industry fundamentals and career opportunities. The student is expected to:

1. Analyze the current state and key career fields within HVACR related careers.
2. Evaluate the benefits and opportunities available in a construction career.
3. outline the typical career progression path for craft professionals.
4. Develop a plan to pursue a career in the HVACR field.

F. The student implements construction safety protocols and procedures. The student is expected to:

1. Analyze workplace incidents, associated costs, and methods to reduce hazards;.
2. Demonstrate proper fall protection techniques and hazard prevention methods.
3. Identify and mitigate struck-by and caught-in-between hazards.
4. Evaluate HVACR hazards and implement appropriate safety measures.
5. Select and utilize appropriate personal protective equipment (PPE) for specific hazards.
6. Apply safety practices for common job-site hazards.

G. The student applies mathematical principles in construction contexts. The student is expected to:

1. Solve basic arithmetic problems using whole numbers.
2. Calculate measurements and dimensions using fractions.
3. Solve construction-related problems using decimal numbers.
4. Measure lengths accurately using common measuring tools.
5. Convert between units of measurement in both imperial and metric systems.
6. Calculate areas and volumes of common geometric shapes.

H. The student demonstrates proper use and maintenance of hand tools. The student is expected to:

1. Identify and safely operate common hand tools.
2. Select and utilize appropriate measurement and layout tools.
3. Maintain and properly store hand tools common to construction sites.

I. The student demonstrates safe and proper use of power tools. The student is expected to:

1. Identify the tool most appropriate for the job to be performed.
2. Operate industry related tools safely and effectively.
3. Perform maintenance on related industry tools.
4. Demonstrate appropriate storage and safety techniques when tools are not in use.

J. The student interprets construction drawings and specifications. The student is expected to:

1. Identify basic components and features of construction drawings, schematics, and diagrams.
2. Differentiate between various types of construction drawings.

K. The student develops effective workplace communication skills. The student is expected to:

1. Demonstrate effective verbal and non-verbal communication in construction settings.
2. Apply reading and writing skills to construction-related tasks.

L. The student develops professional workplace behaviors and skills. The student is expected to:

1. Understand the importance of consistent attendance, punctuality, and professional communication.
2. Evaluate construction business opportunities and workforce entry strategies.
3. Apply critical thinking skills to solve workplace problems.
4. Demonstrate appropriate social skills in professional settings to include customer service interactions that communicate the problem, potential solutions, and create positive customer experiences.

M. The student implements proper material handling techniques. The student is expected to:

1. Identify and explain specific uses for different industry related materials.
2. Apply safety precautions in material handling operations.
3. Select and operate appropriate material handling equipment.

Course Standards: HVACR I

1. **GENERAL REQUIREMENTS.** This course is recommended for students in Grades 10-12.

2. **INTRODUCTION**
   A. Career and Technical Education (CTE) instruction provides content aligned with challenging academic standards and relevant technical knowledge and skills for students to further their education and succeed in current or emerging professions.
   B. The Construction Career Cluster prepares students for careers in designing, planning, and building sustainable infrastructure. This field includes architects, engineers, construction managers, and skilled trades professionals.
   C. The HVACR Program of Study prepares students for a career in the HVACR trade through a comprehensive three-course sequence. Students learn to safely install, maintain, and repair heating, ventilation, air conditioning, and refrigeration systems. They master workplace safety protocols, tool usage, and trade mathematics before progressing to electrical system fundamentals and circuit analysis. Students develop hands-on skills in pipe fitting, soldering, brazing, and ductwork installation. The program advances to complex system components including compressors, heat pumps, and air quality equipment. Students learn to perform maintenance, troubleshoot systems, manage refrigerants safely, and provide professional customer service. Upon completion, they can diagnose problems, conduct repairs, and maintain HVACR systems according to industry standards.
   D. In the HVACR I course students will be introduced to the essential principles and practices of heating, ventilation, air conditioning, and refrigeration systems. The course begins with core concepts including HVACR theory, thermodynamics, and safety protocols, then progresses through mathematical applications specific to the trade. Students learn electrical fundamentals and circuit analysis, followed by comprehensive study of heating and cooling systems. Practical skills include air distribution system installation, piping practices with various materials (copper, plastic, and carbon steel), and specialized joining techniques like soldering and brazing. Throughout the course, students perform hands-on tasks such as measuring pressure and temperature in HVAC systems, installing basic electrical components, assembling ductwork, and creating secure pipe joints. This foundational course prepares students for more advanced HVACR applications by establishing both theoretical knowledge and practical skills required in the field.
   E. Students will participate in at least two Career-Connected Education and Work-Based Learning experiences in this course, which might include informational interviews or job shadowing relevant to the program of study.
   F. Students are encouraged to participate in extended learning experiences through aligned Career and Technical Student Organizations (CTSOs). CTSOs are a cocurricular requirement in the Carl D. Perkins Act, and alignment to CTSO activities is an expectation for CTE programs in the state of Maryland.

3. **KNOWLEDGE AND SKILLS**
   A. The student demonstrates the necessary skills for career development, maintenance of employability, and successful completion of course outcomes. The student is expected to:
      1. Identify and demonstrate positive work behaviors that enhance employability and job advancement, such as regular attendance, promptness, proper attire, maintenance of a clean and safe work environment, and pride in work.

2. Demonstrate positive personal qualities such as flexibility, open-mindedness, initiative, active listening, and a willingness to learn.
3. Employ effective reading, writing, and technical documentation skills.
4. Solve problems using critical thinking techniques and structured troubleshooting methodologies.
5. Demonstrate leadership skills and collaborate effectively as a team member.
6. Implement safety procedures, including proper handling of hardware and following OSHA guidelines.
7. Exhibit an understanding of legal and ethical responsibilities in the construction field, following applicable laws and best practices for safety.
8. Demonstrate time-management skills and the ability to prioritize tasks in a technical setting.

B. The student identifies various career pathways in the HVACR field. The student is expected to:

1. Develop a career plan that includes the necessary education, certifications, job skills, and experience for specific roles as an Carpenter or in the HVACR field.
2. Create a professional resume and portfolio that reflect skills, projects, certifications, and recommendations.
3. Demonstrate effective interview skills for roles in the HVACR field.

C. The student identifies the issues associated with HVACR hazards found on a jobsite. The student is expected to:

1. Demonstrate safe working procedures in a construction environment.
2. Explain the purpose of the Occupational Safety and Health Administration (OSHA) and how it promotes safety on the job.
3. Identify HVACR hazards and how to avoid or minimize them in the workplace.
4. Explain safety issues concerning lockout and tagout procedures, personal protection using assured grounding and isolation programs, confined space entry, respiratory protection, and fall protection.

D. The student integrates core academic skills into HVACR construction practices. The student is expected to:

1. Demonstrate the use of clear communication techniques, both written and verbal, that are consistent with industry standards.
2. Apply mathematical concepts including basic geometric principles, measuring techniques, and conversion between different measurement systems. Students learn to calculate pipe lengths, fitting allowances, and end-to-end dimensions for basic pipe installations. Mathematical concepts are applied to determine proper sizing for water supply lines, pipe grade calculations for drainage systems, and basic material takeoff calculations from construction drawings.
3. Use scientific principles including physical properties of different piping materials (plastic, copper, cast iron, and steel) and their applications. The curriculum covers fundamental concepts of water pressure, flow, and gravity in relation to drain, waste, and vent (DWV) systems. Basic principles of hydraulics are introduced through the study of water distribution systems. Students learn about the effects of temperature on different materials and basic principles of water treatment and distribution.

E. The student demonstrates understanding of HVACR principles and career paths. The student is expected to:

1. Explain the basic principles of heating, ventilation, air conditioning, and refrigeration.
2. Apply principles that guide HVACR installation and service techniques.
3. Analyze HVACR career paths and training processes.

F. The student applies mathematical concepts to HVACR applications. The student is expected to:

1. Use industry relevant tools to measure distance, volume, and flow.
2. Calculate and convert those measurements between US standard and metric systems.
3. Conduct basic mathematical calculations using those measurements.
4. Solve algebraic equations relevant to HVACR applications.
5. Identify and analyze geometric figures in HVACR systems.

G. The student demonstrates understanding of line voltage electrical systems in HVACR. The student is expected to:

1. Analyze power generation and distribution fundamentals for line voltage (120V-480V) applications.
2. Apply electrical safety practices and PPE requirements specific to line voltage work.
3. Calculate voltage, amperage, resistance, and power in line voltage HVACR circuits.
4. Evaluate line voltage electrical components including contactors, relays, and overloads.
5. Interpret line voltage sections of HVACR wiring diagrams and schematics to include identification of symbols, witched vs. load and circuit understanding (parallel vs. series).
6. Troubleshoot line voltage faults in HVACR systems using appropriate measuring instruments.

H. The students demonstrates understanding of low voltage electrical systems in HVACR. The student is expected to:

1. Explain control circuit principles and low voltage (under 50V) applications in HVACR.
2. Differentiate between various low voltage control strategies including digital, pneumatic, and electronic.
3. Test low voltage components including thermostats, sensors, and control boards.
4. Diagnose communication protocols used in modern HVACR control systems.
5. Interpret low voltage control sections of HVACR wiring diagrams and schematics.
6. Construct basic low voltage control circuits following manufacturer specifications.

I. The student demonstrates understanding of combustion heating systems. The student is expected to:

1. Analyze fundamental concepts of combustion science and fuel properties.
2. Evaluate combustion efficiency and proper combustion testing procedures.
3. Evaluate the application of heat transfer theory as applicable to combustion heating systems.
4. Install and service gas-fired furnaces according to manufacturer specifications and code requirements.
5. Diagnose combustion-related problems in heating equipment.
6. Apply safety protocols related to fuel handling and combustion processes.

J. The student demonstrates understanding of forced air heating systems. The student is expected to:

1. Troubleshoot forced air heating system components including heat exchangers, blowers, and controls.

2. Evaluate the application of heat transfer theory as applicable to forced air heating systems.
3. Compare and identify the characteristics of different types of forced air systems.
4. Maintain air distribution systems for proper heating operation.
5. Assess airflow requirements and duct sizing for efficient system operation.

K. The student demonstrates understanding of hydronic heating systems. The student is expected to:

1. Design basic hydronic heating system layouts based on building requirements.
2. Evaluate the application of heat transfer theory as applicable to hydronic heating systems.
3. Install hydronic system components including boilers, pumps, and terminal units.
4. Test hydronic systems for proper operation, pressure, and flow.
5. Diagnose common hydronic heating system faults and their causes.
6. Evaluate different hydronic heating configurations and their applications.

L. The student demonstrates understanding of cooling systems. The student is expected to:

1. Analyze fundamental concepts of refrigeration cycles.
2. Identify common refrigerants and their characteristics.
3. Install and maintain major cooling system components.
4. Explain the impact of latent heat and humidity on cooling systems.
5. Test common cooling system controls.

M. The student applies knowledge of air distribution systems. The student is expected to:

1. Analyze factors affecting air movement and measurement.
2. Identify and explain the requirements of a building envelope, fresh air requirements and their importance.
3. Install mechanical equipment for air distribution systems.
4. Evaluate different approaches to system design and energy conservation.

N. The student demonstrates copper and plastic piping practices. The student is expected to:

1. Identify types of copper tubing and fittings.
2. Install mechanical joints in copper tubing including safe press fittings.
3. Install joints in various types of plastic piping.
4. Install pressed fittings related to water and refrigeration.

O. The student demonstrates soldering and brazing techniques. The student is expected to:

1. Perform safe soldering processes on copper tubing.
2. Perform safe brazing processes on copper tubing.

P. The student demonstrates carbon steel piping practices. The student is expected to:

1. Identify steel pipe types and fittings.
2. Use tools to cut and thread steel pipe.
3. Install mechanical joints in steel pipe.

Course Standards: HVACR II

1. **GENERAL REQUIREMENTS.** This course is recommended for students in Grades 11-12.

2. **INTRODUCTION**
   A. Career and Technical Education (CTE) instruction provides content aligned with challenging academic standards and relevant technical knowledge and skills for students to further their education and succeed in current or emerging professions.
   B. The Construction Career Cluster prepares students for careers in designing, planning, and building sustainable infrastructure. This field includes architects, engineers, construction managers, and skilled trades professionals.
   C. The HVACR Program of Study prepares students for a career in the HVACR trade through a comprehensive three-course sequence. Students learn to safely install, maintain, and repair heating, ventilation, air conditioning, and refrigeration systems. They master workplace safety protocols, tool usage, and trade mathematics before progressing to electrical system fundamentals and circuit analysis. Students develop hands-on skills in pipe fitting, soldering, brazing, and ductwork installation. The program advances to complex system components including compressors, heat pumps, and air quality equipment. Students learn to perform maintenance, troubleshoot systems, manage refrigerants safely, and provide professional customer service. Upon completion, they can diagnose problems, conduct repairs, and maintain HVACR systems according to industry standards.
   D. HVACR II focuses on advanced system components, maintenance procedures, and customer service skills. Students learn AC electrical theory through hands-on work with transformers, capacitors, and induction motors. The course covers critical components like compressors, metering devices, and refrigerant systems, including installation and troubleshooting. Students perform maintenance tasks such as belt drive adjustments, gasket replacement, and system inspections. They gain practical experience in heat pump servicing, indoor air quality management, and venting system installation. Additionally, students develop professional customer service skills and learn environmentally safe refrigerant handling procedures. Through hands-on activities, they master tasks like leak detection, system evacuation, and equipment charging.
   E. Students will participate in at least two Career-Connected Education and Work-Based Learning experiences in this course, which might include informational interviews or job shadowing relevant to the program of study.
   F. Students are encouraged to participate in extended learning experiences through aligned Career and Technical Student Organizations (CTSOs). CTSOs are a cocurricular requirement in the Carl D. Perkins Act, and alignment to CTSO activities is an expectation for CTE programs in the state of Maryland.

3. **KNOWLEDGE AND SKILLS**
   A. **The student demonstrates the necessary skills for career development, maintenance of employability, and successful completion of course outcomes. The student is expected to:**
      1. Identify and demonstrate positive work behaviors that enhance employability and job advancement, such as regular attendance, promptness, proper attire, maintenance of a clean and safe work environment, and pride in work.
      2. Demonstrate positive personal qualities such as flexibility, open-mindedness, initiative, active listening, and a willingness to learn.

3. Employ effective reading, writing, and technical documentation skills.
4. Solve problems using critical thinking techniques and structured troubleshooting methodologies.
5. Demonstrate leadership skills and collaborate effectively as a team member.
6. Implement safety procedures, including proper handling of hardware and following OSHA guidelines.
7. Exhibit an understanding of legal and ethical responsibilities in the construction field, following applicable laws and best practices for safety.
8. Demonstrate time-management skills and the ability to prioritize tasks in a technical setting.

B. **The student identifies various career pathways in the HVACR field. The student is expected to:**
   1. Develop a career plan that includes the necessary education, certifications, job skills, and experience for specific roles as an Electrician or in the HVACR field.
   2. Create a professional resume and portfolio that reflect skills, projects, certifications, and recommendations.
   3. Demonstrate effective interview skills for roles in the HVACR field.

C. **The student identifies the issues associated with HVACR hazards found on a jobsite. The student is expected to:**
   1. Demonstrate safe working procedures in a construction environment.
   2. Explain the purpose of the Occupational Safety and Health Administration (OSHA) and how it promotes safety on the job.
   3. Identify HVACR hazards and how to avoid or minimize them in the workplace.
   4. Explain safety issues concerning lockout and tagout procedures, personal protection using assured grounding and isolation programs, confined space entry, respiratory protection, and fall protection.

D. **The student integrates core academic skills into HVACR construction practices. The student is expected to:**
   1. Demonstrate the use of clear communication techniques, both written and verbal, that are consistent with industry standards.
   2. Apply mathematical concepts such as the 3-4-5 ratio method for squaring corners and calculate various types of pipe offsets, including parallel and rolling offsets at different angles (11¼, 22½, 45, 60, and 72 degrees). Students will practice advanced geometric calculations, trigonometric principles for determining offset constants, and more complex grade and elevation calculations. Students perform detailed material takeoffs and apply mathematical principles to commercial HVACR applications.
   3. Use scientific principles including electrical theory including voltage, current, resistance, and power calculations as applied to water heaters and electronic HVACR controls. The students will review thermodynamics in relation to water heater operation and heat transfer through piping systems. Students learn about the chemical properties and behavior of different fuel gases and oils, principles of combustion, and the science behind backflow prevention. The course includes advanced concepts in hydraulics and pneumatics for pressure testing and system design, as well as the scientific principles behind firestopping and insulation.

E. The student analyzes principles of customer service in HVACR. The student is expected to:

1. Establish positive first impressions with customers.
2. Apply effective communication techniques during service calls.
3. Manage different types of customer interactions professionally.

F. The student conducts HVACR maintenance requirements. The student is expected to:

1. Apply maintenance procedures for various HVACR systems.
2. Diagnose and evaluate common material/component failure.
3. Install gaskets, seals, and belt drives according to specifications.
4. Conduct system and equipment inspections according to maintenance schedules.

G. The student analyzes HVACR site installation. The student is expected to:

1. Evaluate appropriate locations for installing HVACR equipment considering structural requirements, space limitations, and accessibility.
2. Compare various installation sites including indoor utility rooms, attics, basements, concrete slabs, and rooftops based on specific application requirements.
3. Evaluate site-specific safety considerations including equipment isolation, fire safety, and emergency access.
4. Differentiate between residential and commercial site requirements based on equipment size, load calculations, and building codes.
5. Examine existing site conditions to identify potential installation obstacles or modifications required for successful equipment placement.

H. The student evaluates alternating current principles. The student is expected to:

1. Analyze transformer and power distribution systems.
2. Comprehend advanced wiring schematics.
3. Demonstrate troubleshooting procedures according to manufacturer specifications.
4. Test AC circuits and components using appropriate instruments.
5. Demonstrate the ability to wire a functional control circuit with required safety protocols.
6. Evaluate induction motor operation and electrical safety practices.

I. The student synthesizes compressor system operations. The student is expected to:

1. Explain operating principles of HVACR compressors.
2. Perform installation and service procedures.
3. Diagnose and repair common compressor issues.
4. Evaluate system operations and their impact on compressor operations.

J. The student evaluates metering device applications. The student is expected to:

1. Install fixed and adjustable expansion devices.
2. Explain the use and operation of electronic expansion valves.
3. Analyze operating principles of metering components.
4. Adjust devices according to manufacturer specifications.

K. The student analyzes refrigerant and oil properties. The student is expected to:

1. Explain how refrigerant theory is applied to refrigerant systems.
2. Identify characteristics of pure and blended refrigerants.
3. Select appropriate lubricating oils for refrigeration systems.
4. Conduct leak detection tests specific to their application.

5. Apply proper handling and safety procedures.

L. The student evaluates refrigerant handling procedures. The student is expected to:

1. Perform safe evacuation, recovery, and charging procedures of pressurized systems.
2. Apply environmentally safe handling methods.

M. The student analyzes heat pump system operations. The student is expected to:

1. Analyze reverse cycle heating principles.
2. Install and maintain heat pump systems.
3. Troubleshoot heat pump control circuits.

N. The student evaluates indoor air quality factors. The student is expected to:

1. Evaluate factors affecting indoor air quality.
2. Perform air quality surveys using appropriate equipment.
3. Evaluate impact of humidity on indoor air quality and electrostatic environmental concerns.
4. Implement air quality control measures.

O. The student analyzes air quality equipment functions. The student is expected to:

1. Service humidity control devices.
2. Maintain air cleaning equipment.
3. Install energy conservation devices.

P. The student evaluates venting system requirements. The student is expected to:

1. Apply principles of fossil fuel furnace venting.
2. Select appropriate vent systems for gas heating equipment.
3. Install venting systems according to specifications.

Course Standards: Career Connected Learning I and II

Career connected learning is an educational approach that integrates classroom instruction with real-world experiences, enabling high school students to explore potential careers and develop relevant skills before graduation. By participating in work-based learning opportunities—such as apprenticeships, internships, capstone projects, and school-based enterprises—students apply academic concepts in authentic settings, gain practical industry knowledge, and build professional networks. This hands-on engagement helps students connect their studies to future career paths, strengthens their problem-solving and communication skills, and supports a smoother transition into college, vocational programs, or the workforce.

All Career and Technical Education Programs of Study include aspects of work-based learning, and almost all of the programs include two Career Connected Learning (CCL) courses. Below are the course descriptions for CCL I and CCL II. The CCL standards can be found via this link: