Silicon Valley Career Technical Education

Heating Ventilation and Air Conditioning (HVAC)

Course Outline

Course Description

SVCTE Heating, Ventilation and Air Conditioning (HVAC) is a year-long 519-hour course where students learn concepts related to the repair of refrigerators, residential air conditioning, home heating systems, light commercial refrigerators, air conditioning and heating units. Students also perform advanced heating, ventilation, and air conditioning troubleshooting, repair and installation of systems. Students obtain hands-on work experience by working throughout the campus, working closely with the SVCTE facilities and crew. Upon meeting class standards and requirements, each student is eligible for internship and/or job placement through industry contacts and employment opportunities in addition to obtaining an SVCTE certificate of completion. Each student that meets class requirements will receive their own set of professional tools to take with them upon successful completion of course.

Course Details

Length of Program and Academic Credits Earned:
Year-long 3 hour course = 519 hours total (~261/semester)
30 total credits (15/semester):
- 20 non-a–g elective credits (10/semester)
- 10 UC "c" math credits (5/semester)

Pre-Requisites:
- High School Junior or Senior, or 16 years or older

CTE Classification:
- **Industry Sector:** Building and Construction Trades
- **Industry Pathway:** Mechanical Systems Installation and Repair
- **CA Basic Education Data System (CBEDS) Code:** 5516

Internships & Community Classroom:
- Student with a "B" or better average good standing in class may have an opportunity to participate in an internship at a local business
- Students may have an opportunity to participate in a variety of hand-on experiential projects on SVCTE campus

Certifications & State Tests:
- SVCTE Certificate of Completion awarded with "C" or better average for both semesters.
- Green Awareness Certification (optional)
- EPA Certification (optional)

Community College Articulations

Students completing the HVAC course with a grade of "B" or better may be granted college credits at the following community college:

San Jose City College – 4.0 Units

More info and application form: www.sjcc.edu/academics/departments-divisions/air-conditioning-refrigeration-technology

Possible Education & Career Pathways

For more career information: www.onetonline.org

College & Career Pathways:	Career Opportunities	O*NET Codes
Post-Secondary: Students with a high school diploma and having successfully completed this course have a number of entry-level career opportunities, as well as continuing their education.	• Refrigeration Mechanics and Installers • Heating and Air Conditioning Mechanics and Installers • Sales Representatives, Services, All Other	49-9021.02 49-9021-01 41-3099.00
Continuing Education: Including Community College, Training Programs, Certifications, etc: • Apprenticeship Program • Associate of Applied Science (AAS) in HVAC	• Refrigeration Mechanics and Installers • Heating and Air Conditioning Mechanics and Installers • Sales Representatives, Services, All Other • Geothermal Technicians	49-9021.02 49-9021-01 41-3099.00 49-9099.01
University Majors & Degrees: • BA or BS in Mechanical Engineering	• Energy Engineers • Mechanical Engineers	17-2199.03 17-2141.00
Post-Baccalaureate Degrees: • Masters or Doctorate in Engineering	• Energy Engineers • Mechanical Engineers	17-2199.03 17-2141.00

Unit 1: Career Readiness & Professionalism (Recurring) — 104 hours

Students will develop personal and professional skills in the classroom that will transfer to the workplace.

- Time management and organization
- Interpersonal skills
- Work with a variety of technology
- Creative thinking and problem solving
- Job search skills including: resume, job applications and effective interview skills
- Teamwork
- Uniform expectations
- Punctuality

Standards Alignments:
CCSS: RLST 11-12.3, 11-12.5; **WS** 11-12.7
NGSS: SEP 4, 8

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Key Assignment:** Students will participate in mock interviews with industry professionals, peers and instructors to increase their communication, interpersonal and employability skill-set. **Assessment:** rubric, observation of role playing, peer and self- assessment	2.1, 2.2, 2.3, 2.4, 2.5 3.1, 7.7	
✓ **Key Assignment:**Students will prepare a portfolio including a cover letter and resume through workshop, self and peer editing, and teacher instruction and demonstration. **Assessment:** rubric, observation, peer and self- assessment	2.4 ,11.5	

Unit 2: Class Orientation — 20 hours

Students will become oriented to the classroom through a series of hands-on activities, including safety standards that will be implemented and reinforced throughout the year.

- Shop safety
- Curriculum overview
- Shop Set-up

Standards Alignments:
CCSS: LS 11-12.6; **RLST** 11-12.3, 11-12.4
NGSS: SEP 1, 2, 3, 4, 5, 6, 7, 8

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Key Assignment:**In groups, students will explore the HVAC shop investigating and recording all forms of staged violations. Students will then suggest corrective action and present and defend their findings to the class. **Assessment:** safety test, observation, written documentation	5.2, 6.0	
✓ **Key Assignment:**In the same groups as above, students will then make all necessary repairs to bring the shop up to safety standards and present the results to the	5.2, 6.0	

instructor for inspection. **Assessment:** safety test, observation, written documentation		

Unit 3: Invoice Preparation and Service Calls — 40 hours

Customer service is key to the HVAC industry. Students will learn standard customer service procedures and practice these skills throughout the entire course. Tablets will be used to create invoices.

- Invoice writing
- Team collaboration
- iPad/tablet use for invoices
- Customer service techniques
- Employability
- Interpersonal skills
- Phone etiquette
- Industry math

CCSS: LS 11-12.1, 11-12.6; **RLST** 11-12.3, 11-12.4; **WS** 11-12.2, 11-12.4, 11-12.5, 11-12.6; **WHSST** 11-12.7, 11-12.9

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Key Assignment:**Students will individually write a service invoice based on their inspection of equipment and their recommendations for repair, including all mathematically correct estimates. Students will present their invoice to instructor and class and explain their choices. **Assessment:** observation, calculations check, written documentation	2.0, 4.1, 4.4, 4.6 5.0, 6.10, 7.0, 8.0, 9.4, 9.6, 9.7	C 2.1
✓ **Key Assignment:**Students will work in pairs to write a script and role play by taking a customer order and preparing their service invoice, adjusting the script depending on client responses. Students will have the opportunity to provide feedback to allow for reflect upon their customer service technique. **Assessment:** observation, written documentation, peer feedback, self reflection	2.0, 4.6 , 5.0 , 6.10, 7.5	C 2.1

Unit 4: Tubing Principles and Fabrication — 75 hours

Students will learn to follow a specific diagram to correctly fabricate refrigeration tubing while learning the proper techniques for utilizing a tubing bender. Students must use geometry to calculate angles and bend tubing to a specific degree to match a specific blueprint.

- Fabrication of refrigeration tubing
- Blueprint reading
- Remove and install furnace components
- Accurate measurement using a tape measure
- Geometry
- Mathematical calculation

Standards Alignments:

CCSS: G-SRT 8.1; **FTF** 1.1; **RLST** 11-12.3, 11-12.4
NGSS: SEP 1, 2, 3, 4, 5, 6, 7, 8; **CC** 3, 4

Key Assignments	CTE Anchor	CTE Pathway

	Standards	Standards
✓ **Key Assignment:**Following a blueprint and/or diagram, students will demonstrate proper usage of a tubing bender, swedge tool and flaring tool to correctly bend tubing to match the blueprint specifications. Students will demonstrate their tube bending skill to the instructor to show mastery. **Assessment:** observation and written documentation, fabrication	5.0, 6.0	C 5.0
✓ **Key Assignment:**To foster in-depth understanding of measurement, students will use a conventional tape measure and develop a measuring device to accurately perform a series of required measurements. **Assessment:** observation and written documentation, fabrication	5.0, 6.0	C 5.0
✓ **Key Assignment:**Students will utilize a tubing bender to accurately bend refrigeration tubing into a 45 and 90 degree angle. They will calculate the loss or gain of tubing as it is bent and record the rate of loss/gain for each bend. **Assessment:** observation and written documentation, fabrication review	5.0, 6.0	C 5.0

Unit 5: Gas Pipe Sizing and Calculation of BTU (British Thermal Unit) — 40 hours

Students will learn how to determine pipe size, calculate the volume of gas required for each appliance with input and output, and determine length of pipe necessary per a blueprint /drawing.

- Measurements and load calculations based on pipe sizing charts
- UPC (Universal Plumbing Code) book pipe sizing charts
- BTU calculation
- Calculation of volume
- Floor plan illustration to design a gas system

Standards Alignments:

CCSS: G-SRT 8.1; **F-TF** 1.1; **G-CO** 11-12.1
NGSS: SEP 1, 2, 3,4, 5, 6, 7, 8; **ETS** 1.A, 1.B, 1.C, 2.A, 2.B, 1-2, 1-3, 1-4; **CC** 3, 4, 5

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Key Assignment:** Given a teacher constructed scenario, students will individually draw and label a scale blueprint with requested appliances and gas load to determine sizes of piping necessary to correctly complete the job. **Assessment:** observation and written documentation	5.0, 8.1, 8.2 ,8.7	C 5.1, C 5.2, C 5.9
✓ **Key Assignment:** Students will each draw a blueprint of their own home and identify/label the gas system and appliances in the home with calculations made from charts provided by the instructor. Their blueprint must include illustrations to distinguish between sizes of piping in different areas of their home. Blueprints will be	5.0, 8.1, 8.2, 8.7	C 5.1, C 5.2, C 5.9

displayed for a gallery walk to view and critique peer work. **Assessment:** observation, calculations check, written documentation, critique, gallery walk		
✓ **Key Assignment:** Students will use mathematical operations (addition, multiplication, division) to calculate and determine length and size of pipe by volume of gas lines going to equipment in class. They will chart their findings and submit to instructor for evaluation and feedback. **Assessment:** observation, calculations check, and written documentation	5.0, 8.1, 8.2, 8.7	C 5.1, C 5.2, C 5.9

Unit 6: Air Balancing and Air Flow Calculations — 40 hours

Correctly calculating airflow and air balancing is essential for any HVAC technician. Students will learn the math necessary to:

- Air volume tables
- Air balancing
- Cubic feet calculations
- Ductwork size determination

Standards Alignments:

CCSS: G-SRT 8.1; **F-TF** 1.1; **G-CO** 11-12.1
NGSS: SEP 1, 2, 3, 4, 5, 6, 7, 8; **ETS** 1.A, 1.B, 1.C, 2.A, 2.B, 1-2, 1-3, 1-4; **PS** 3, 3.B, 4.C; **CC** 3, 4, 5

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Key Assignment:** Students will use a Pitot tube and a Magnehelic Gauge attached to a running furnace to accurately measure air volume to determine sizes of duct systems using conversion calculations. They will chart these findings using a chart or spreadsheet and double check for accuracy using peer editing before submitting to instructor for feedback and commentary. **Assessment:** observation, chart review, calculations check, written documentation	4.4, 4.6, 5.0, 6.3, 6.4, 6.10	C 11.0
✓ **Key Assignment:** Utilizing the findings of movement of air through the equipment on a traverse graph with measurements taken, students will individually create a graph (on paper or computer) demonstrating the volume of air flow by size of the furnace and duct system. **Assessment:** observation, graph and calculations check, written documentation	4.4, 4.6, 5.0, 6.3, 6.4, 10.1, 10.3	C 11.0
✓ **Key Assignment:** Students will draw their own home and design an HVAC system to properly heat and cool the space. They will perform and show all necessary math calculations, material and locations of all components and tubing. They will each create a presentation to share their design. **Assessment:** observation, gallery walk and written documentation	4.4, 4.6, 5.0, 6.3, 6.4, 10.1, 10.3	C 11.0

Unit 7: Basic Electrical Circuits — 100 hours

Students learn basic principles of electricity and concepts to determine amps, current, watts, and voltage. They learn to calculate the different aspects of electricity using Ohm's Law using the Pire Wheel and Ohms Law Calculator.

- Electricity terms
- Ohm's Law
- Digital electric meter reading tool
- Schematic reading
- Schematic drawing
- Ladder Diagram Drawing

Standards Alignments:

CCSS: G-SRT 8.1; **F-TF** 1.1; **G-CO** 11-12.1; **A-CED** 4
NGSS: SEP 1, 2, 3, 4, 5, 6, 7, 8; **ETS** 1.A, 1.B, 1.C, 2.A, 2.B, 1-2, 1-3, 1-4; **PS** 3, 3.B, 4.C; **CC** 3, 4, 5

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Key Assignment:** Students will learn electricity concepts by use of Ohm's law and understand how to use this formula as a tool. Measurements are taken on live equipment making findings relevant to the HVAC industry. **Assessment:** observation, calculation check, and written documentation	4.1, 4.3, 4.4, 4.6, 5.0, 6.2, 6.3 ,6.4, 6.5, 6.6, 6.8, 6.10, 10.1	C 7.0, C 8.0
✓ **Key Assignment:** Students will read a wiring diagram, draw and label all electrical components in the style of industry standard schematic drawings, and define all key terms related to their diagram. They will display their diagrams for a gallery walk. Students will comment on peer work using small post-its to offer praise and suggestions. **Assessment:** observation and written documentation, critique, gallery walk	4.1, 4.3, 4.4, 4.6, 5.0, 6.2, 6.3, 6.4, 6.5, 6.6, 6.8, 6.10, 10.1	C 7.0, C 8.0
✓ **Key Assignment:** Students will individually draw a wiring schematic and show all electrical components and terms on paper. They will illustrate the same schematic in a Ladder Diagram drawing demonstrating their ability to use multiple methods to depict electrical circuitry. **Assessment:** observation and written documentation, critique, gallery walk, visual inspection	4.1, 4.3, 4.4, 4.6, 5.0, 6.2, 6.3 ,6.4, 6.5, 6.6, 6.8, 6.10, 10.1	C 7.0, C 8.0

Unit 8: System Pressure — 50 hours

Students will work on live refrigeration systems and check the gas pressure with a manifold gauge set and determine the proper level of gas in the system.

- Manifold gauge use and safety
- Saturation points of a refrigerant

- Pressure and temperature differential
- Superheat and Subcooling

Standards Alignments:
CCSS: RLST 11-12.7, 9, 10
NGSS: SEP 1-8; **ETS** 1.A, 1.B, 1.C, 2.A, 2.B, 1-2, 1-3, 1-4; **PS** 3, 3.B, 4.C; **CC** 3, 4, 5

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Key Assignment:** Using a manifold gauge set and nitrogen tank with a regulator, students will individually fill an empty refrigeration system with nitrogen to 100 PSIG. They will work with a partner to check each other's work before demonstrating competency to the instructor. **Assessment:** observation, visual inspection, peer feedback	4.1, 4.3, 4.4, 4.6, 5.0, 6.2, 6.3 ,6.4, 6.5, 6.6, 6.8, 6.10, 10.1	C 3.0, C 4.0
✓ **Key Assignment:** Using a manifold gauge, digital thermometer, and PT chart, students will be assigned a live refrigeration system to asses. They will calculate the amount of gas in the system, fill system to its proper level and record findings in a handwritten chart or computer generated chart using a spreadsheet or software tool such as Word Smartstart. **Assessment:** observation, chart and written documentation	4.1, 4.3, 4.4, 4.6, 5.0, 6.2, 6.3 ,6.4, 6.5, 6.6, 6.8, 6.10, 10.1	C 3.0, C 4.0
✓ **Key Assignment:** Students will calculate a specific pressure with the use of a digital thermometer and manifold gauge set and determine range of superheat and subcooling and with the use of a scale tell and record amount of gas needed to fill system to proper running pressure. **Assessment:** observation, scale and calculation check	4.1, 4.3, 4.4, 4.6, 5.0, 6.2, 6.3 ,6.4, 6.5, 6.6, 6.8, 6.10, 10.1	C 3.0, C 4.0

Unit 9: Relay Fundamentals — 50 hours

Students will wire and troubleshoot electrical circuits and wiring control boards through a series of hands-on activities in the lab.

- Relay fundamentals
- Bench test components
- Wiring diagram reading
- Troubleshooting control circuits
- wiring of control circuits with relays

Standards Alignments:
CCSS: RLST 11-12.7, 11-12.9, 11-12.10
NGSS: SEP 1, 2, 3, 4, 5, 6, 7, 8; **ETS** 1.A, 1.B, 1.C, 2.A, 2.B, 1-2, 1-3, 1-4; **PS** 3, 3.B, 4.C; **CC** 3, 4, 5

Key Assignments	CTE Anchor Standards	CTE Pathway Standards
✓ **Key Assignment:** Using a digital multimeter students will check and evaluate current, amps, and voltage going through the component to assess that component is functioning to industry standards. Students will check readings against the systems specifications and if not working properly, students will propose corrective action and document their findings. **Assessment:** observation, system checks, oral defense, written documentation	4.1, 4.3, 4.4, 4.6, 5.0, 6.2, 6.3 ,6.4, 6.5, 6.6, 6.8, 6.10, 10.1	C 7.0, C 8.0, C 9.0
✓ **Key Assignment:** Students will work in teams to design and build a functioning control circuit utilizing relays and contactors on electrical practice boards. Students will test for functionality and document their process. **Assessment:** observation, system checks, oral defense, written documentation	4.1, 4.3, 4.4, 4.6, 5.0, 6.2, 6.3 ,6.4, 6.5, 6.6, 6.8, 6.10, 10.1	C 7.0, C 8.0, C 9.0
✓ **Key Assignment:** Students will read wiring diagrams to assist in wiring and troubleshooting electrical control boards. Students will identify key components and specifications and suggest potential problematic areas and propose a course of action for repair. **Assessment:** observation, system checks, oral defense, written documentation	4.1, 4.3, 4.4, 4.6, 5.0, 6.2, 6.3 ,6.4, 6.5, 6.6, 6.8, 6.10, 10.1	C 7.0, C 8.0, C 9.0

Instructional Materials

Textbooks:	Electronic Media/Supplemental Print Materials/Online Resources:
Modern Refrigeration and Air Conditioning 19th edition Althouse,Turnquist,Bracciano : Goodheart /Willcox 2014 ISBN 978-1-61960-119-4 ***Green Awareness*** 1st Edition Ferris State University & HVAC Excellence Esco Press 2008 ISBN 1-930044-26-7	• HVACATSVCTE.BLOGSPOT • "Kahoot" • 'YouTube' Videos

Standards Assessed in this Course

CTE Anchor Standards:

1.0 Academics: Academics standards are aligned to pathways; see below.
2.0 Communications: Acquire and use accurately sector terminology and protocols at the career and college readiness level for communicating effectively in oral, written, and multimedia formats.
3.0 Career Planning and Management: Integrate multiple sources of career information from diverse formats to make informed career decisions, solve problems, and manage personal career plans.
4.0 Technology: Use existing and emerging technology, to investigate, research, and produce products and services, including new information, as required in the sector workplace environment.
5.0 Problem Solving and Critical Thinking: Conduct short, as well as more sustained, research to create alternative solutions to answer a question or solve a problem unique to the sector using critical and creative thinking, logical reasoning, analysis, inquiry, and problem-solving techniques.
6.0 Health and Safety: Demonstrate health and safety procedures, regulations, and personal health practices and determine the meaning of symbols, key terms, and domain-specific words and phrases as related to the sector workplace environment.
7.0 Responsibility and Flexibility: Initiate, and participate in, a range of collaborations demonstrating behaviors that reflect personal and professional responsibility, flexibility, and respect in the sector workplace environment and community settings.
8.0 Ethics and Legal Responsibilities: Practice professional, ethical, and legal behavior, responding thoughtfully to diverse perspectives and resolving contradictions when possible, consistent with applicable laws, regulations, and organizational norms.
9.0 Leadership and Teamwork: Work with peers to promote divergent and creative perspectives, effective leadership, group dynamics, team and individual decision making, benefits of workforce diversity, and conflict resolution.
10.0 Technical Knowledge and Skills: Apply essential technical knowledge and skills common to all pathways in the sector following procedures when carrying out experiments or performing technical tasks.

Building and Construction Trades Sector — Mechanical Systems Installation and Repair Pathway Standards

C1.0 Demonstrate an understanding of the methods and devices used to improve air quality and comfort.
C1.1 Explain the historical development and principles of air-conditioning and refrigeration.
C1.2 Describe the differences between air-conditioning and refrigeration.
C1.3 Explain the impact of heating, air-conditioning, and refrigeration on society.
C1.4 Explain the differences in comfort applications (cooling/heating air) and process applications (improving air quality).
C1.5 Describe the benefits of conditioned air and environments. C1.5 Explain the methods and devices used to improve air quality.
C1.6 List several situations in which the improvement of air quality is essential.
C1.7 Debate current issues and concerns, such as indoor air quality, the ozone layer, and computer technology, in the heating, air-conditioning, and refrigeration industry and in the environment and explain their future ramifications.
C1.8 Describe the purpose and importance of local, state, and federal heating, air conditioning, and refrigeration codes and standards.

C1.9	Identify various HVAC professional organizations, associations, and societies, and explain their purposes.
C2.0	**Describe the basic components and concepts of heating, air-conditioning, and refrigeration.**
C2.1	Demonstrate a working knowledge of the four major components of a refrigeration system.
C2.2	Identify and explain the characteristics of vapor compression refrigeration.
C2.3	Explain the advantages and disadvantages of the different refrigerants used in a vapor compression system.
C2.4	Distinguish between split systems and package systems.
C3.0	**Demonstrate an understanding of the scientific theories and physical properties of heat and matter.**
C3.1	Describe and explain freezing point, critical temperature, and absolute zero.
C3.2	Describe matter and heat and their relation to heat transfer.
C3.3	Compare and contrast the characteristics of heat, humidity, and temperature.
C3.4	Distinguish between, and explain the characteristics of, the three different states of matter.
C3.5	Define the differences between latent heat and sensible heat.
C4.0	**Analyze the effects and reactions of fluids, pressures, and temperatures on refrigerants.**
C4.1	Summarize the refrigeration cycle.
C4.2	Define and explain “fluid,” “pressure,” and “temperature.”
C4.3	Utilize pressure and temperature charts.
C4.4	Demonstrate ways to measure and calculate absolute and gauge pressures according to industry standards.
C4.5	Identify and explain the classifications, uses, and properties of different refrigerants.
C4.6	Explain how fluids react and flow in a closed system versus an open system.
C4.7	Identify and classify the color-coding of refrigerant cylinders.
C4.8	Practice proper methods of storing, transferring, and recovering refrigerants.
C4.9	Summarize the effects of contaminants or using an improper refrigerant in a system.
C5.0	**Demonstrate skills necessary to fabricate and service the tubing, piping, and fittings utilized in accordance with accepted industry standards.**
C5.1	Understand the basic codes in the Uniform Plumbing Codes (UPC).
C5.2	Select materials and fittings for use in piping a system.
C5.3	Demonstrate techniques for cutting, deburring, and bending tubing.
C5.4	Connect tubing utilizing proper fittings and connection methods.
C5.5	Demonstrate the ability to identify and select the appropriate materials for the soldering and brazing of tubing.
C5.6	Explain the purposes and procedures for protecting piping materials and fittings from effects of heat.
C5.7	Demonstrate the ability to braze and/or solder tubing, including aluminum.
C5.8	Silver-braze bras, steels, and copper.
C5.9	Fabricate and leak test the piping, tubing, and connections of a heating, air-conditioning, and/or refrigeration unit.
C6.0	**Demonstrate the skills necessary to service, maintain, and repair heating, air-conditioning, and refrigeration system components and accessories.**

C6.1	Explain the types, operation, use, and maintenance requirements of different compressors (e.g., reciprocating, rotary, screw, and scroll).
C6.2	Analyze the operating condition of a compressor.
C6.3	Explain the types, operation, use, and maintenance requirements of condensers and evaporators.
C6.4	Explain the types, operation, use, and maintenance requirements of different metering devices.
C6.5	Evaluate the performance of a metering device.
C6.6	Explain the methods of compression, lubrication, and compressor loading and unloading.
C6.7	Analyze and evaluate the proper operating condition of a compressor.
C6.8	Locate and explain the uses of refrigerant flow accessories.
C6.9	Locate and explain the uses of system accessories (e.g., receivers, solenoids, valves, heat exchangers, filters, and separators).
C6.10	Analyze, troubleshoot, and correct mechanical problems in a heating, air-conditioning, and refrigeration system.
C6.11	Evaluate system performance.
C7.0	**Demonstrate a practical knowledge of basic electricity and skills necessary to service and maintain the electrical components of heating, air-conditioning, and refrigeration equipment.**
C7.1	Explain the principles and properties of electricity.
C7.2	Compare and contrast single-phase versus three-phase electrical distribution.
C7.3	Define and distinguish amps, ohms, volts, and watts.
C7.4	Demonstrate the ways to measure watts, voltage, amperage, and resistance using appropriate instruments while adhering to industry standards.
C7.5	Illustrate and summarize a wiring schematic diagram for a heating or cooling system.
C7.6	Analyze and troubleshoot the protection devices, such as fuses and breakers, in an electrical system.
C7.7	Interpret charts and tables from the National Electrical Codes (NEC).
C8.0	**Troubleshoot electrical control systems, motors, and their components.**
C8.1	Identify and explain the operations of electrical control systems and their components.
C8.2	Install and troubleshoot electrical control systems.
C8.3	Describe the operation and function of different types of electromechanical thermostats.
C8.4	Analyze operational problems with different types of electromechanical thermostats.
C8.5	Describe the electrical and mechanical operations of a basic heat pump.
C8.6	Demonstrate the ability to wire a basic heating, air-conditioning, and/or refrigeration system.
C8.7	Identify and explain the functions of various types of motors and their individual components.
C8.8	Describe the differences between single-phase and three-phase motors.
C8.9	Analyze and test motors using a variety of different methods.
C8.10	Assess an electric motor for proper function and repair as necessary.
C9.0	**Demonstrate a practical knowledge of solid-state electronics.**
C9.1	Explain the basic principles and functions of Direct Digital Control (DDC).
C9.2	Describe basic solid-state circuits and boards.

C9.3	Identify, analyze, and replace solid-state circuit boards.
C9.4	Explain the major functions of a building-management system.
C9.5	Install and program a programmable thermostat.
C10.0	**Demonstrate a practical knowledge of combustion heating systems.**
C10.1	Explain combustion theory.
C10.2	Identify and explain the various types, operations, and functions of various types of gas valves and regulators.
C10.3	Determine the suitable application, and analyze the proper functioning, of gas valves and regulators.
C10.4	Demonstrate the installation, maintenance, testing, and repair of a gas operated heating system.
C10.5	Create a wiring schematic for a gas furnace.
C10.6	Sketch the proper gas flow for a gas furnace.
C10.7	Analyze, troubleshoot, and correct problems in a combustion-type heating system.
C11.0	**Demonstrate practical knowledge of systems designed to improve air quality.**
C11.1	Explain the scientific principles of psychrometrics.
C11.2	Define relative, specific, and absolute humidity.
C11.3	Distinguish between dew point, dry bulb, and wet bulb temperature.
C11.4	Summarize concerns related to indoor air quality.
C11.5	Compare and contrast the benefits of air-filtration, air-handling, and ventilation systems.
C11.6	Create, analyze, and maintain a system designed to improve air quality

Common Core State Standards

Language Standards – LS (Standard Area, Grade Level, Standard #)

LS 11-12.1	Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
LS 11-12.6.	Acquire and accurately use general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Reading Standards for Literacy in Science and Technical Subjects – RLST (Standard Area, Grade Level, Standard #)

RLST 11-12.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text
RLST 11-12.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics.
RLST 11-12.5	Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
RLST 11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
RLST 11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

RLST 11-12.10	By the end of grade 12, read and comprehend science/technical texts in the grades 11-12 text complexity band independently and proficiently.

Writing Standards – WS – (Standard Area, Grade Level, Standard #)

WS 11-12.2	Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.
WS 11-12.4	Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
WS 11-12.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
WS 11-12.6	Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.
WS 11-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects – WHSST – (Standard Area, Grade Level, Standard #)

WHSST 11-12.7.	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
WHSST 11-12.9.	Draw evidence from informational texts to support analysis, reflection, and research.

Math Standards – Algebra – Creating Equations – A-CED – (Standard Area, Grade Level, Standard #)

A-CED 4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R.

Math Standards – Geometry – Similarity, Right Triangles, and Trigonometry – G-SRT – (Standard Area, Grade Level, Standard #)

G-SRT 8.1	Know and use angle and side relationships in problems with special right triangles, such as, 30°, 60°, and 90' triangles and 45°, 45°, and 90° triangles.

Math Standards – Functions – Trigonometric Functions – F-TF (Standard Area, Grade Level, Standard #)

F-TF 1.1	Understand the notion of angle and how to measure it, in both degrees and radians. Convert between degrees and radians.
G-CO 11-12.1	Know precise definitions of angle, circle, perpendicular line, parallel line, and line segment, based on the undefined notions of point, line, distance along a line, and distance around a circular arc.

Next Generation Science Standards

Scientific and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
	PS3: Energy	CC 3. Scale, proportion, and quantity.
	PS3.A: Definitions of Energy	In considering phenomena, it is

SEP 1	Asking questions (for science) and defining problems (for engineering)	PS3.B:	Conservation of Energy and Energy Transfer		critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.
SEP 2	Developing and using models	PS4.C:	Information Technologies and Instrumentation		
SEP 3	Planning and carrying out investigations	ETS 1-2.	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.		
SEP 4	Analyzing and interpreting data			CC 4.	Systems and system models. Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
SEP 5	Using mathematics and computational thinking				
SEP 6	Constructing explanations (for science) and designing solutions (for engineering)	ETS 1-3.	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.		
SEP 7	Engaging in argument from evidence				
SEP 8	Obtaining, evaluating, and communicating information			CC 5.	Energy and matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
		ETS 1-4.	Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.		
		ETS1.A:	Defining and Delimiting Engineering Problems		
		ETS1.B:	Developing Possible Solutions		
		ETS1.C:	Optimizing the Design Solution		