

Course Outline

Building and Construction Trades

REVISED: August/2017

Job Title
HVAC Technician

72-85-60

Career Pathway:
Mechanical Systems Installation
and Repair

HVAC/1

Industry Sector:
Building and Construction Trades

Credits: 15

Hours: 180

O*NET-SOC CODE:
49-9021.01

Course Description:

This competency-based course is the first in a sequence of three designed for heating, ventilating, and air-conditioning (HVAC). It provides students with project-based experiences in residential and commercial heating systems. Technical instruction includes an orientation, resource management, trade mathematics, and employability skills. Emphasis is placed on the basic theories and applications of electricity and thermodynamics, and the operational, troubleshooting, and maintenance techniques used for heating systems. The competencies in this course are aligned with the California High School Academic Content Standards and the California Career Technical Education Model Curriculum Standards.

CBEDS Title:
Heating, Ventilation, and Air
Conditioning (HVAC) Systems

Prerequisites:

Enrollment requires a reading level of 6.0 as measured by the TABE D 9/10.

CBEDS No.:
5516

NOTE: For Perkins purposes this course has been designated as an **introductory** course.

This course cannot be repeated once a student receives a Certificate of Completion.



COURSE OUTLINE COMPETENCY-BASED COMPONENTS

A course outline reflects the essential intent and content of the course described. Acceptable course outlines have six components. (Education Code Section 52506). Course outlines for all apportionment classes, including those in jails, state hospitals, and convalescent hospitals, contain the six required elements:

(EC 52504; 5CCR 10508 [b]; Adult Education Handbook for California [1977], Section 100)

COURSE OUTLINE COMPONENTS

LOCATION

GOALS AND PURPOSES

Cover

The educational goals or purposes of every course are clearly stated and the class periods are devoted to instruction. The course should be broad enough in scope and should have sufficient educational worth to justify the expenditure of public funds.

The goals and purpose of a course are stated in the COURSE DESCRIPTION. Course descriptions state the major emphasis and content of a course, and are written to be understandable by a prospective student.

PERFORMANCE OBJECTIVES OR COMPETENCIES

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Objectives should be delineated and described in terms of measurable results for the student and include the possible ways in which the objectives contribute to the student's acquisition of skills and competencies.

Performance Objectives are sequentially listed in the COMPETENCY-BASED COMPONENTS section of the course outline. Competency Areas are units of instruction based on related competencies. Competency Statements are competency area goals that together define the framework and purpose of a course. Competencies fall on a continuum between goals and performance objectives and denote the outcome of instruction.

Competency-based instruction tells a student before instruction what skills or knowledge they will demonstrate after instruction. Competency-based education provides instruction which enables each student to attain individual goals as measured against pre-stated standards.

Competency-based instruction provides immediate and continual repetition and In competency-based education the curriculum, instruction, and assessment share common characteristics based on clearly stated competencies. Curriculum, instruction and assessment in competency-based education are: explicit, known, agreed upon, integrated, performance oriented, and adaptive.

COURSE OUTLINE COMPETENCY-BASED COMPONENTS
(continued)

COURSE OUTLINE COMPONENTS

LOCATION

INSTRUCTIONAL STRATEGIES

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Instructional techniques or methods could include laboratory techniques, lecture method, small-group discussion, grouping plans, and other strategies used in the classroom.

Instructional strategies for this course are listed in the TEACHING STRATEGIES AND EVALUATION section of the course outline. Instructional strategies and activities for a course should be selected so that the overall teaching approach takes into account the instructional standards of a particular program, i.e., English as a Second Language, Programs for Adults with Disabilities.

UNITS OF STUDY, WITH APPROXIMATE HOURS ALLOTTED FOR EACH UNIT

Cover

The approximate time devoted to each instructional unit within the course, as well as the total hours for the course, is indicated. The time in class is consistent with the needs of the student, and the length of the class should be that it ensures the student will learn at an optimum level.

pp. 7-14

Units of study, with approximate hours allotted for each unit are listed in the COMPETENCY AREA STATEMENT(S) of the course outline. The total hours of the course, including work-based learning hours (community classroom and cooperative vocational education) is listed on the cover of every CBE course outline. Each Competency Area listed within a CBE outline is assigned hours of instruction per unit.

EVALUATION PROCEDURES

p. 16

The evaluation describes measurable evaluation criteria clearly within the reach of the student. The evaluation indicates anticipated improvement in performances as well as anticipated skills and competencies to be achieved.

Evaluation procedures are detailed in the TEACHING STRATEGIES AND EVALUATION section of the course outline. Instructors monitor students' progress on a continuing basis, assessing students on attainment of objectives identified in the course outline through a variety of formal and informal tests (applied performance procedures, observations, and simulations), paper and pencil exams, and standardized tests.

REPETITION POLICY THAT PREVENTS PERPETUATION OF STUDENT ENROLLMENT

Cover

After a student has completed all the objectives of the course, he or she should not be allowed to reenroll in the course. There is, therefore, a need for a statement about the conditions for possible repetition of a course to prevent perpetuation of students in a particular program for an indefinite period of time.

ACKNOWLEDGMENTS

Thanks to PAUL PIDOUX and MARCELA BAKER for developing and editing this curriculum. Acknowledgment is also given to ERICA ROSARIO for designing the original artwork for the course covers.

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CALIFORNIA CAREER TECHNICAL EDUCATION MODEL CURRICULUM STANDARDS

Building and Construction Trades Industry Sector

Knowledge and Performance Anchor Standards

1.0 Academics

Analyze and apply appropriate academic standards required for successful industry sector pathway completion leading to postsecondary education and employment. Refer to the Building and Construction Trades academic alignment matrix for identification of standards.

2.0 Communications

Acquire and accurately use Building and Construction Trades 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 Building and Construction Trades 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 Building and Construction Trades 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 Building and Construction Trades 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 Building and Construction Trades 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 as practiced in the SkillsUSA career technical student organization.

10.0 Technical Knowledge and Skills

Apply essential technical knowledge and skills common to all pathways in the Building and Construction Trades sector, following procedures when carrying out experiments or performing technical tasks.

11.0 Demonstration and Application

Demonstrate and apply the knowledge and skills contained in the Building and Construction Trades anchor standards, pathway standards, and performance indicators in classroom, laboratory, and workplace settings, and through the SkillsUSA career technical student organizations.

Building and Construction Trades Pathway Standards

C. Mechanical Systems Installation and Repair Pathway

The Mechanical Systems Installation and Repair pathway provides students with competencies fundamental for preparing for employment or advanced training in heating, ventilation, air-conditioning (HVAC) and appliance installation, maintenance, and repair. The pathway includes preparation for a Class C California License and EPA certification.

Sample occupations associated with this pathway:

- ◆ HVAC Installation and Maintenance Specialist
- ◆ Plumbing Installer
- ◆ Sheet Metal Fabricator
- ◆ Mechanical Engineer/Technician
- ◆ Mechanical Construction Field Manager

- C1.0 Demonstrate an understanding of the methods and devices used to improve air quality and comfort.
- C2.0 Describe the basic components and concepts of heating, air-conditioning, and refrigeration.
- C3.0 Demonstrate an understanding of the scientific theories and physical properties of heat and matter.
- C4.0 Analyze the effects and reactions of fluids, pressures, and temperatures on refrigerants.
- C5.0 Demonstrate skills necessary to fabricate and service the tubing, piping, and fittings utilized in accordance with accepted industry standards.
- C6.0 Demonstrate the skills necessary to service, maintain, and repair heating, air-conditioning, and refrigeration system components and accessories.
- 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.
- C8.0 Troubleshoot electrical control systems, motors, and their components.
- C9.0 Demonstrate a practical knowledge of solid-state electronics.
- C10.0 Demonstrate a practical knowledge of combustion heating systems.
- C11.0 Demonstrate practical knowledge of systems designed to improve air quality.

CBE
Competency-Based Education

COMPETENCY-BASED COMPONENTS
for the HVAC/1 Course

COMPETENCY AREAS AND STATEMENTS	MINIMAL COMPETENCIES	STANDARDS
<p>A. ORIENTATION AND SAFETY</p> <p>Understand, apply, and evaluate classroom and workplace policies and procedures used in accordance with federal, state, and local safety and environmental regulations.</p>	<ol style="list-style-type: none"> 1. Describe the scope and purpose of the course. 2. Describe the overall course content as a part of the Linked Learning Initiative. 3. Describe classroom policies and procedures. 4. Describe the different occupations in the Energy and Utilities Industry Sector which have an impact on the role of HVAC technicians. 5. Describe the opportunities available for promoting gender equity and the representation of non-traditional populations in the HVAC field. 6. Describe the purpose of the California Occupational Safety and Health Administration (Cal/OSHA) and its laws governing HVAC technicians. 7. Describe the impact of Environmental Protection Agency (EPA) legislation on the Energy and Utilities Industry Sector practices. 8. Describe and demonstrate the procedures for contacting proper authorities for the removal of hazardous materials based on the EPA standards. 9. Describe the National Electrical Code (NEC) and its role in safeguarding the work conditions of HVAC technicians. 10. Describe and demonstrate the use of the Material Safety Data Sheet (MSDS) as it applies to the HVAC field. 11. Describe the role of the Leadership in Energy and Environmental Design (LEED) Green Building Rating System™, American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), and National Association of Home Builders (NAHB) in increasing the use of green and sustainable technology in California. 12. Describe the City of Los Angeles Building and Safety Codes and their applications to the HVAC field. 13. Describe the provisions of the California Title 24 Energy Efficiency Standards (a.k.a. 2008 California Green Building Standards Code) as they relate to the Energy and Utilities Industry Sector. 	<p>Career Ready Practice: 1, 3, 6, 11, 12</p> <p>CTE Anchor: Communications: 2.1 Career Planning and Management: 3.6 Health and Safety: 6.1, 6.2, 6.4, 6.6, 6.9, 6.11 Ethics and Legal Responsibilities: 8.2, 8.3, 8.4 Leadership and Teamwork: 9.4, 9.6 Technical Knowledge and Skills: 10.1, 10.2</p> <p>CTE Pathway: C1.7, C1.8, C1.9</p>

COMPETENCY AREAS AND STATEMENTS	MINIMAL COMPETENCIES	STANDARDS
<p>C. TRADE MATHEMATICS</p> <p>Understand, apply, and evaluate the mathematical requirements in the HVAC field.</p> <p>(15 hours)</p>	<ol style="list-style-type: none"> 1. Describe the practical applications of math in the HVAC field. 2. Describe and demonstrate problem-solving techniques involving whole number problems using arithmetic operations (addition, subtraction, multiplication, and division). 3. Describe and demonstrate problem-solving techniques involving various fraction problems using arithmetic operations. 4. Describe and demonstrate problem-solving techniques involving various decimal problems using addition, subtraction, multiplication, and division. 5. Describe and demonstrate techniques for changing fractions to decimals. 6. Describe and demonstrate techniques for changing decimals to fractions. 7. Describe the English and metric systems of measuring length. 8. Describe the English and metric systems of measuring weight. 9. Describe the English and metric systems of measuring volume or capacity. 10. Describe and demonstrate English and metric problem-solving techniques for various measuring problems using arithmetic operations. 11. Describe and demonstrate English and metric measuring techniques of objects by using tools common to the trade. 12. Express units in ascending and descending powers of ten. 13. Calculate square roots of numbers. 14. Describe and demonstrate problem-solving techniques for geometric problems. 15. Describe and demonstrate problem-solving techniques for algebraic problems. 16. Describe and demonstrate problem-solving techniques using percentages. 17. Describe and demonstrate techniques for reading and interpreting graphs. 18. Describe and demonstrate techniques for using a calculator. 	<p>Career Ready Practice: 1, 3, 5</p> <p>CTE Anchor: Communications: 2.1, 2.3 Problem Solving and Critical Thinking: 5.1, 5.4</p> <p>CTE Pathway: C1.5, C6.5</p>

COMPETENCY AREAS AND STATEMENTS	MINIMAL COMPETENCIES	STANDARDS
<p>D. BASIC ELECTRICAL THEORIES</p> <p>Understand, apply, and evaluate basic electrical theories.</p> <p>(20 hours)</p>	<ol style="list-style-type: none"> 1. Define the following: <ol style="list-style-type: none"> a. matter b. atoms c. electrons d. molecules e. conductors f. insulators g. energy h. work i. electricity j. magnetism k. magnetic polarity l. semiconductors 2. Define and describe the following: <ol style="list-style-type: none"> a. current <ol style="list-style-type: none"> i. direct current (DC) ii. alternating current (AC) b. voltage c. power (a.k.a. watts) d. resistance (a.k.a. ohms) e. current (a.k.a. amperage) f. Watt's Law g. Ohm's Law h. simple circuit i. series circuits j. parallel circuits 3. Describe the following: <ol style="list-style-type: none"> a. refrigeration and air conditioning applications for AC b. refrigeration and air conditioning applications for DC c. three-phase electrical power 4. Describe and demonstrate the following: <ol style="list-style-type: none"> a. calculation of the values of a simple light circuit using Watt's Law b. identification of various power supplies c. analysis of basic electrical problems d. repair of basic electrical problems e. reading of line volt unit wiring diagrams. 	<p>Career Ready Practice: 1, 3, 5, 10</p> <p>CTE Anchor: Communications: 2.1 Problem Solving and Critical Thinking: 5.1, 5.2, 5.3</p> <p>CTE Pathway: C7.1, C7.2, C7.3, C7.4, C7.5, C7.6</p>
<p>E. THERMODYNAMICS</p> <p>Understand, apply, and evaluate the principles of matter and heat.</p>	<ol style="list-style-type: none"> 1. Define the following: <ol style="list-style-type: none"> a. thermodynamics b. potential energy c. kinetic energy d. heat 	<p>Career Ready Practice: 1, 3, 5</p>

COMPETENCY AREAS AND STATEMENTS	MINIMAL COMPETENCIES	STANDARDS
(25 hours)	<ul style="list-style-type: none"> e. temperature f. volume g. pressure h. temperature measurement i. British Thermal Unit (BTU) <ol style="list-style-type: none"> 2. Identify and describe the features of the three states of matter: <ul style="list-style-type: none"> a. solid b. liquid c. vapor 3. Define and describe the following heat transfer methods: <ul style="list-style-type: none"> a. conduction b. convection (natural and forced) c. radiation 4. Define the following: <ul style="list-style-type: none"> a. solidification b. liquefaction c. vaporization d. condensation e. sublimation 5. Define and describe the following: <ul style="list-style-type: none"> a. Conservation: first law of thermodynamics b. Entropy: second law of thermodynamics c. Boyle's Law 6. Describe the following: <ul style="list-style-type: none"> a. differences between heat and temperature b. differences between latent heat and sensible heat c. differences between natural and forced heat convection d. relationship of pressures and fluids at different temperatures e. effects of pressurization on boiling points f. air discharge patterns g. air return patterns h. air flow patterns i. differences between heat pump systems versus other temperature control systems j. thermal efficiency of a heat pump k. component isolation in heat pumps l. auxiliary heat in heat pumps 	<p>CTE Anchor: Communications: 2.1 Problem Solving and Critical Thinking: 5.1, 5.3</p> <p>CTE Pathway: C1.1, C1.2, C1.4, C1.5, C3.4, C3.5, C4.2</p>

COMPETENCY AREAS AND STATEMENTS	MINIMAL COMPETENCIES	STANDARDS
<p>F. HEATING AND CONTROLS</p> <p>Understand, apply, and evaluate the operational techniques used for heating systems.</p> <p>(50 hours)</p>	<ol style="list-style-type: none"> 1. Identify and describe the features and functions of the following: <ol style="list-style-type: none"> a. heating systems <ol style="list-style-type: none"> i. traditional furnaces <ul style="list-style-type: none"> • gas furnaces • electric furnace ii. electric heat pump iii. radiant baseboard heat iv. radiant ceiling or floor heat v. space heaters vi. boilers (a.k.a. steam generator) b. thermostats <ol style="list-style-type: none"> i. low voltage <ul style="list-style-type: none"> • mercury contact • mechanical contact • digital • electronic programmable ii. line voltage c. fan and limit control d. spark ignition e. pilot proving devices 2. Describe and demonstrate the following: <ol style="list-style-type: none"> a. wiring a complete heating system line and low voltage b. testing spark ignition modules c. testing and changing a thermocouple flame sensor d. operating heat pumps e. setting up a programmable thermostat for heating f. diagnosing and solving heat pump problems 	<p>Career Ready Practice: 1, 3, 10</p> <p>CTE Anchor: Communications: 2.1 Problem Solving and Critical Thinking: 5.1, 5.3</p> <p>CTE Pathway: C7.1, C7.2, C7.3, C7.4, C7.5, C7.6, C7.7, C9.5, C10.1, C10.4, C10.5, C10.6, C10.7</p>
<p>G. TROUBLESHOOTING AND MAINTENANCE</p> <p>Understand, apply, and evaluate troubleshooting and maintenance techniques used for heating systems.</p>	<ol style="list-style-type: none"> 1. Identify and describe principles of maintenance and troubleshooting. 2. Describe the following: <ol style="list-style-type: none"> a. ways of troubleshooting problems in a gas furnace b. ways of troubleshooting problems in a gas appliance c. ways of troubleshooting problems in an electric heat pump d. ways of troubleshooting problems in a boiler e. ways of preventing the reoccurrence of a problem 3. Describe and demonstrate the following: <ol style="list-style-type: none"> a. performing maintenance check on a gas furnace b. maintaining electronic air cleaners c. maintaining electric heaters d. maintaining electric heat pump 	<p>Career Ready Practice: 1, 3, 5, 10</p> <p>CTE Anchor: Communications: 2.1 Technology: 4.1, 4.2 Problem Solving and Critical Thinking: 5.1, 5.2, 5.3, 5.4</p>

COMPETENCY AREAS AND STATEMENTS	MINIMAL COMPETENCIES	STANDARDS
(50 hours)	<ul style="list-style-type: none"> e. maintaining a boiler f. installing properly sized disposable filters <p>4. Document and report on the following:</p> <ul style="list-style-type: none"> a. performing maintenance check on a gas furnace b. maintaining electronic air cleaners c. maintaining electric furnaces d. maintaining electric heat pump e. maintaining a boiler f. installing properly sized disposable filters 	<p>Health and Safety: 6.1, 6.6, 6.12</p> <p>Ethics and Legal Responsibilities: 8.1, 8.3, 8.4</p> <p>Technical Knowledge and Skills: 10.5</p> <p>CTE Pathway: C6.10, C7.6, C8.2, C8.6, C8.10, C10.1, C10.2, C10.4, C10.5, C10.6, C10.7</p>
<p>H. EMPLOYABILITY SKILLS</p> <p>Understand, apply, and evaluate the processes involved in seeking, gaining, and maintaining employment.</p>	<ol style="list-style-type: none"> 1. Describe employer requirements for the following: <ul style="list-style-type: none"> a. punctuality b. attendance c. attitude toward work d. quality of work e. teamwork f. timeliness g. communication skills h. computer skills and software applications 2. Identify potential employers through traditional and internet sources. 3. Describe the role of electronic social networking in job search. 4. Design sample résumés and cover letters. 5. Describe the importance of filling out a job application legibly, with accurate and complete information. 6. Complete sample job application forms correctly. 7. Describe the importance of enthusiasm on a job. 8. Describe the importance of appropriate appearance on a job. 9. Describe the importance of the continuous upgrading of job skills. 10. Describe customer service as a method of building permanent relationships between the organization and the customer. 11. Describe and demonstrate appropriate interviewing techniques. 	<p>Career Ready Practice: 1, 2, 3, 7</p> <p>CTE Anchor: Communications: 2.1, 2.3, 2.4 Career Planning and Management: 3.1, 3.2, 3.3, 3.4 Responsibility and Flexibility: 7.4, 7.7 Ethics and Legal Responsibilities: 8.4 Leadership and Teamwork: 9.4 Demonstration and Application: 11.1, 11.5</p> <p>CTE Pathway: C1.2, C1.8, C1.9</p>

COMPETENCY AREAS AND STATEMENTS	MINIMAL COMPETENCIES	STANDARDS
(10 hours)	12. Identify the informational materials and resources needed to be successful in an interview. 13. Design sample follow-up letters. 14. Describe and demonstrate appropriate follow-up procedures.	

SUGGESTED INSTRUCTIONAL MATERIALS and OTHER RESOURCES

TEXTS AND SUPPLEMENTAL BOOKS

Day, Antony R., R.S. Bhathal, Keith Shepherd, and Martin S. Ratcliffe. Heating Systems, Plant and Control. John Wiley & Sons, Limited, 2003.

Herman, Stephen L. and Bennie Sparkman. Electricity and Controls for HVAC/R, 6th Edition. Cengage Learning, 2009.

Incropera, Frank P., David P. DeWitt, and Theodore L. Bergman. Introduction to Heat Transfer. John Wiley & Sons, 2006.

Kissell, Thomas. Electricity, Electronics, and Control Systems. Prentice Hall, 2007.

Raynes, Frank W. Heating Systems. Nabu Press, 2010.

Robertson, C.R. Fundamental Electrical and Electronic Principles. Elsevier Science and Technology, 2008.

Stanfield, Carter and David Skaves. Fundamentals of HVAC/R. Prentice Hall, 2009.

Ward, Ray. Domestic Central Heating Wiring Systems and Controls. Elsevier Science and Technology, 2005.

RESOURCES

Employer Advisory Board members

CTE Model Curriculum Standards

<http://www.cde.ca.gov/ci/ct/sf/documents/buildingconstruct.pdf>

www.americangreenjobs.net

<http://www.renewableenergyjobs.com/>

<http://careers.pennenergyjobs.com>

<http://www.cleantechrecruits.com>

COMPETENCY CHECKLIST

TEACHING STRATEGIES and EVALUATION

METHODS AND PROCEDURES

- A. Lectures and discussions
- B. Multimedia presentations
- C. Demonstrations and participation
- D. Individualized instruction
- E. Peer teaching
- F. Role-playing
- G. Guest speakers
- H. Field trips and field study experiences
- I. Projects

EVALUATION

SECTION A –Orientation and Safety– Pass the safety test with 100% accuracy.

SECTION B – Resource Management – Pass all assignments and exams on resource management with a minimum score of 80% or higher.

SECTION C – Trade Mathematics – Pass all assignments and exams on trade mathematics with a minimum score of 80% or higher.

SECTION D – Basic Electrical Theories – Pass all assignments and exams on basic electrical theories with a minimum score of 80% or higher.

SECTION E – Thermodynamics – Pass all assignments and exams on thermodynamics with a minimum score of 80% or higher.

SECTION F – Heating and Controls – Pass all assignments and exams on heating and controls with a minimum score of 80% or higher.

SECTION G – Troubleshooting and Maintenance – Pass all assignments and exams on troubleshooting and maintenance with a minimum score of 80% or higher.

SECTION H – Employability Skills – Pass all assignments and exams on employability skills with a minimum score of 80% or higher.

Statement for Civil Rights

All educational and vocational opportunities are offered without regard to race, color, national origin, gender, or physical disability.
