COP

Heating, Ventilation, Air Conditioning, and Refrigeration

Massachusetts Department of Elementary and Secondary Education

Career/Vocational Technical Education (CTE)

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Strand 1: Safety and Health Knowledge and Skills

1.A Define health and safety regulations.

1.A.01a	Identify and apply OSHA and other health and safety regulations that apply to specific tasks and jobs in the occupational area.
1.A.02a	Identify and apply EPA and other environmental protection regulations that apply to specific tasks and jobs in the occupational area.
1.A.03a	Identify and apply Right-To-Know (Hazard Communication Policy) and other communicative regulations that apply to specific tasks and jobs in the occupational area.
1.A.04a	Explain procedures for documenting and reporting hazards to appropriate authorities.
1.A.05a	List penalties for non-compliance with appropriate health and safety regulations.
1.A.06a	Identify contact information for appropriate health and safety agencies and resources.
1.A.07c	Describe the history, function and importance of the Occupational Safety and Health Administration (OSHA).
1.A.08	Identify and define the Code of Massachusetts Regulation 522 CMR 5.00 Heating Boilers, 522 CMR 6.00 Low Pressure Heating Boilers & 522 CMR 9.00.

1.B Demonstrate health and safety practices.

1.B.01a	Identify, describe and demonstrate the effective use of Material Safety Data Sheets (MSDS).
1.B.02a	Read chemical, product, and equipment labels to determine appropriate health and safety considerations.
1.B.03a	Identify, describe and demonstrate personal, shop and job site safety practices and procedures.
1.B.04a	Demonstrate safe dress and use of relevant safety gear and personal protective equipment (PPE), including wrist rests, adjustable workspaces and equipment, gloves, boots, earplugs, eye protection, and breathing apparatus.
1.B.05a	Illustrate appropriate safe body mechanics, including proper lifting techniques and ergonomics.
1.B.06a	Locate emergency equipment in your lab, shop, and classroom, including (where appropriate) eyewash stations, shower facilities, sinks, fire extinguishers, fire blankets, telephone, master power switches, and emergency exits.
1.B.07a	Demonstrate the safe use, storage, and maintenance of every piece of equipment in the lab, shop, and classroom.
1.B.08a	Describe safety practices and procedures to be followed when working with and around electricity.
1.B.09a	Properly handle, store, dispose of, and recycle hazardous, flammable, and combustible materials.
1.B.10a	Demonstrate proper workspace cleaning procedures.
1.B.11c	Identify and describe ladder and scaffold safety practices and procedures.
1.B.12c	Identify and describe mechanical platform lift and material handling equipment safety practices and procedures.

1.B.13c Use and maintain fall arrest systems.
1.B.14c Identify and describe standard precautions for blood borne pathogens and the procedures for responding to and reporting exposure.
1.B.15 Explain safety considerations when working with pressure vessels.

1.C Demonstrate responses to situations that threaten health and safety.

1.C.01a Illustrate First Aid procedures for potential injuries and other health concerns in the occupational area.
1.C.02a Describe the importance of emergency preparedness and an emergency action plan.
1.C.03a Illustrate procedures used to handle emergency situations and accidents, including identification, reporting, response, evacuation plans, and follow-up procedures.
1.C.04a Identify practices used to avoid accidents.
1.C.05a Identify and describe fire protection, precautions and response procedures.
1.C.06a Discuss the role of the individual and the company/organization in ensuring workplace safety.
1.C.07a Discuss ways to identify and prevent workplace/school violence.

Strand 2: Technical Knowledge and Skills

2.A Read and interpret prints.

2.A.01c Explain the basic layout of a set of prints as well as the importance of the accompanying job specifications document.
2.A.02c Recognize and identify basic print terms, abbreviations, line types, symbols and notes.
2.A.03c Interpret and follow drawing dimensions.
2.A.04c Determine true measurements from a print using an Architect's scale.
2.A.05c Read and interpret plan, elevation, section and detail views and schedules.
2.A.06c Identify, develop and complete material quantity takeoff sheets.
2.A.07c Discuss how state and/or local code requirements apply to prints.
2.A.08 Use a construction print to calculate heat loss/gain of a structure (manual J standards).

2.B Explain the fundamentals of Heating, Ventilation, Air-Conditioning and Refrigeration.

2.B.01 Illustrate the historical development of the HVAC&R industry.
2.B.02 Explain the importance of the HVAC&R in modern society.

2.C Apply the principles of electricity.

2.C.01 Define and apply electrical safety, regulations and procedures.
2.C.02 Define and apply Ohm's Law.
2.C.03 Define the properties of electrical conductors and insulators.
2.C.04 Define and wire series, parallel and series/parallel circuits.
2.C.05 Test and troubleshoot electrical circuits and devices using electrical meters.
2.C.06 Illustrate concepts relating to direct current (DC) and alternating current (AC), and how they pertain to volts, amperes, ohms,

impedances, and watts.

2.C.07 Illustrate concepts relating to resistive, capacitive, and inductive loads.

2.C.08 Summarize characteristics of basic switches.

2.C.09 Interpret NEC and Massachusetts electrical codes.

2.C.10 Define wire feeder and branch circuits as listed within NEC and Massachusetts codes.

2.C.11 Determine correct wire size and voltage drop for electrical circuits.

2.C.12 Determine if existing load centers are adequate to supply additional loads.

2.C.13 Determine voltage and current ratings of electrical devices.

2.C.14 Define and apply the principles of electrical circuit protection.

2.C.15 Define and apply electrical grounding principles.

2.C.16 Define and recognize the application of various types of electric motors.

2.C.17 Define, develop and apply schematics and other wiring diagrams.

2.C.18 Define and identify factory and field wiring, high and low voltage, details, and legends on wiring diagrams.

2.D Install electrical controls and systems.

2.D.01 Define and apply electrical control safety.

2.D.02 Define and apply electrical controls and systems with regard to low and line voltage applications.

2.D.03 Install, service, and wire isolation and line transformers.

2.D.04 Install, service, and wire relays.

2.D.05 Install, service, and wire contactors and motor starters.

2.D.06 Install, service, and wire sequencers and timers.

2.D.07 Install, service, and wire overloads.

2.D.08 Identify, test, and install start and run capacitors.

2.D.09 Install, service, and wire high and low pressure switches.

2.D.10 Install, service, and wire heating and cooling thermostats and sub-bases.

2.D.11 Install, service, and wire solenoid valves.

2.D.12 Define, test, and troubleshoot electrical motors.

2.D.13 Maintain and repair electric motors.

2.D.14 Draw and define power distribution systems and voltage systems including: 120/240 Single Phase (Residential/Small Commercial), 277/480 Single and Three-Phase Commercial (High WYE), 120/208 Single and Three-Phase Commercial (Low WYE).

2.D.15 Define and install solid-state devices.

2.D.16 Define the principles of Central Processing Unit (CPU) based control systems, Direct Digital Control (DDC) and Programmable Logic Controllers (PLC).

2.E Identify and install piping, fittings, and materials.

2.E.01 Define characteristics of, identify, and install copper pipe and fittings.

2.E.02 Define characteristics of, identify, and install black iron pipe, fittings, and malleable fittings.

2.E.03 Define characteristics of, identify, and install Polyvinyl Chloride (PVC) pipe and fittings.

2.E.04 Define characteristics of, identify, and install aluminum tubing.

2.E.05 Define characteristics of, identify, and install steel tubing.

2.E.06 Define characteristics of, identify, and install brass fittings.

2.E.07 Define characteristics of, identify, and install hangers, supports, and fasteners.
2.E.08 Define characteristics of, identify, and install isolators.
2.E.09 Define characteristics of, identify, and install expansion joints and loops.
2.E.10 Define characteristics of, identify, and install flanges, gaskets and other joining systems.
2.E.11 Define procedures of and apply techniques in cutting.
2.E.12 Define procedures of and apply techniques in reaming.
2.E.13 Define procedures of and apply techniques in flaring.
2.E.14 Define procedures of and apply techniques in swaging.
2.E.15 Define procedures of and apply techniques in bending.
2.E.16 Define procedures of and apply techniques in threading.
2.E.17 Define procedures of and apply techniques in annealing.
2.E.18 Define procedures of and apply techniques in fluxing.
2.E.19 Define characteristics of and identify the composition of a variety of solders and alloys.
2.E.20 Apply different soldering and brazing techniques to HVAC&R applications.
2.E.21 Define characteristics of, set-up, and properly use a variety of gas torches and regulators.
2.E.22 Define characteristics of, set-up, and apply nitrogen purge in brazing applications.
2.E.23 Define characteristics of and apply refrigerant piping schemes and sizing.
2.E.24 Define characteristics of and apply pipe insulation for appropriate applications.
2.E.25 Define characteristics of and apply epoxy compounds and adhesives to appropriate applications.
2.E.26 Define, install, and service condensate drain systems to National, State and local codes.

2.F Identify and use refrigeration tools and testing instruments.

2.F.01 Identify and properly use the appropriate refrigeration hand and power tools.
2.F.02 Identify and properly use proper manifold gauge procedures.
2.F.03 Identify and properly use charging cylinder & electronic scales procedures.
2.F.04 Identify and properly use vacuum pump and micron gauge procedures.
2.F.05 Identify and properly use refrigeration leak detectors methods and procedures.
2.F.06 Identify and properly use diagnostic techniques using analog and digital multi-meters.
2.F.07 Describe and properly use a variety of appropriate diagnostic tools including temperature measuring devices, an oil burner combustion test kit, a manometer, meters that measure air flow and velocity, and meters that measure relative humidity (Sling Psychrometer).

2.G Explain refrigeration theory and identify components.

2.G.01 Define and apply refrigeration safety.
2.G.02 Define and apply the principles of thermodynamics / heat transfer.
2.G.03 Define and apply the principles of pressure, fluid, and temperature.

2.G.04 Define characteristics if refrigerant conditions including subcooled, saturated, and superheated.
2.G.05 Define and illustrate the mechanical refrigeration cycle.
2.G.06 Define and apply classifications, properties, and different applications of refrigerants.
2.G.07 Define and apply pressure enthalpy charts in determining refrigerant cycles.
2.G.08 Define and identify pressure and temperature drops in the refrigerant cycle.
2.G.09 Define characteristics of, identify, and install various types of compressors.
2.G.10 Analyze the operating conditions of mechanical and electrical compressors.
2.G.11 Define characteristics of, identify, and install various types of condensers.
2.G.12 Define characteristics of, identify, and install various types of metering devices.
2.G.13 Define characteristics of, identify, and install various types of evaporators.
2.G.14 Define characteristics of, identify, and install various types of liquid line components.
2.G.15 Define, characteristics of identify, and install various types of suction line components.
2.G.16 Define characteristics of, identify, and install refrigeration system accessories.
2.G.17 Define characteristics of and apply the operation of refrigerant service valves.
2.G.18 Define characteristics of and identify applications for various refrigerant's oils and lubricants.
2.G.19 Define and apply system evacuation and dehydration/degassing. (i.e. Vacuum Pump-micron gauge).
2.G.20 Define and demonstrate application of EPA rules and regulations regarding the handling of refrigerants such as recovery, recycling, and reclaiming.
2.G.21 Define and perform sub-cooling and superheat measurements.
2.G.22 Identify, install, and adjust refrigerant metering devices.
2.G.23 Define and apply the principles of a one and two column pressure/ temperature refrigeration charts (Saturation Charts).
2.G.24 Define and illustrate applications of ultra low temperature applications.
2.G.25 Install and service domestic and commercial refrigeration systems to National, State, and local codes.

2.H Explain and install air conditioning.

2.H.01 Define and apply air conditioning safety.
2.H.02 Define energy efficiency ratings such as the Energy Efficiency Ratio (EER), Seasonal Energy Efficiency Ratio (SEER), and Coefficient of Performance (COP).
2.H.03 Define and apply concepts based on the physical properties of air.
2.H.04 Define and determine air properties when performing psychrometric measurements such as velocity, volume, pressures (static and total), temperature (wet bulb – dry bulb), and moisture.
2.H.05 Demonstrate the refrigerant charging of air conditioning systems

using manufacturer recommended procedures.

2.H.06 Define and apply the principles of air distribution systems such as stratification of air, drafts, types of duct systems, duct construction, air circulation and dampers, and diffusers, grills, and registers.

2.H.07 Demonstrate processes and procedures used to troubleshoot and adjust humidification accessories.

2.H.08 Define and apply the different standards/codes of measuring indoor air quality (IAQ) such as air-filtration systems, ventilation systems, air-contaminants (pollutants particulates), Ozone, and measuring instruments.

2.H.09 Install and service air-conditioning systems to National, State and local codes.

2.H.10 Install and service air distribution systems to National, State, and local codes.

2.H.11 Install and service dehumidification systems to National, State, and local codes.

2.H.12 Install & service humidification systems to National, State, and local codes.

2.H.13 Install and service air filtration systems to National, State, and local codes.

2.I Explain and install heat pumps and electric resistance heat.

2.I.01 Define and apply heat pump and electric heating safety.

2.I.02 Define and illustrate uses of heat pump operation in all modes.

2.I.03 Define and perform heat pump efficiency test to determine Coefficient of Performance (COP).

2.I.04 Define characteristics of and test motors.

2.I.05 Define characteristics of and test refrigerant controls.

2.I.06 Define characteristics of and test heat pump reversing valves.

2.I.07 Define characteristics of and troubleshoot defrost controls.

2.I.08 Define symptoms of and troubleshoot airflow problems.

2.I.09 Define characteristics of and troubleshoot control and line voltage components.

2.I.10 Define characteristics of and charge heat pump systems to manufacturer specifications.

2.I.11 Define, calculate and troubleshoot supplementary heat.

2.I.12 Define and plot the balance point.

2.I.13 Identify and discuss applications of the different heat pump. classifications such as air-source, grounds-source and water-source.

2.I.14 Install and service heat pumps to National, State and local codes.

2.I.15 Install and service electric resistance heating systems to National, State, and local codes.

2.J Explain and install oil heat.

2.J.01 Define and apply oil heat safety.

2.J.02 Define and apply methods of preparing fuel for combustion.

2.J.03 Define and perform an efficiency test and adjust to manufactures specifications.

2.J.04 Define, size and service nozzle applications for oil guns.

2.J.05 Identify and define parts and operation of an oil gun.

2.J.06 Define characteristics of and service oil pumps and pressure regulating valves.

2.J.07 Define characteristics of cad-cell and other primary controls.

2.J.08 Define characteristics of, rebuild, and test operation of oil burners.
2.J.09 Demonstrate ability to field-test furnace/boiler operation with proper instruments.
2.J.10 Demonstrate the ability to perform temperature readings for troubleshooting purposes and proper installation.
2.J.11 Test and replace boiler/furnace operating and safety controls.
2.J.12 Demonstrate maintenance, troubleshooting procedures, and repair of oil supply systems.
2.J.13 Define and apply the proper operations of starting an oil burner installation.
2.J.14 Define characteristics of and install venting systems for oil appliances.
2.J.15 Define steam heating systems.
2.J.16 Define, maintain and service hydronic pumps and circulators.
2.J.17 Install and service oil-fired boilers & furnaces to National, State and local codes.
2.J.18 Install and service oil-fired hydronic systems to National, State and local codes.

2.K Explain and install gas heat.

2.K.01 Define and apply gas heat safety.
2.K.02 Measure L.P. and natural gas supply and manifold pressures.
2.K.03 Define characteristics of, test, and operate standing pilot ignition systems.
2.K.04 Define characteristics of test, and operate hot surface and electronic ignition systems.
2.K.05 Define characteristics of and test combustion fan motor operation.
2.K.06 Define characteristics of and install venting systems for gas appliances.
2.K.07 Demonstrate the ability to perform temperature readings for troubleshooting purposes and proper installation.
2.K.08 Define characteristics of and test negative and positive pressure switches.
2.K.09 Define properties of, test, and adjust combustion on a gas appliance.
2.K.10 Define characteristics of, test, replace, and adjust gas valves (positive & negatives).
2.K.11 Define potential problems with, test, adjust, and replace operating and safety controls.
2.K.12 Define characteristics of and troubleshoot 80% and 90% + efficiency, gas furnaces.
2.K.13 Install LP/Natural gas conversion kits.
2.K.14 Calculate heat loss for structure (Manual J).
2.K.15 Define characteristics of and service gas-fired steam heating systems.
2.K.16 Define characteristics of, maintain and service hydronic pumps and circulators.
2.K.17 Install and service gas boilers to National, State and local codes.
2.K.18 Install and service 80% and 90+% gas furnaces to National, State, and local codes.
2.K.19 Install and service gas-fired boilers to National, State, and local codes
2.K.20 Install and service gas-fired hydronic systems to National, State, and local codes.

Strand 3: Embedded Academic Knowledge and Skills

3.A English Language Arts

3.A.01c	For informational/expository writing: Write reports based on research that include quotations, footnotes or endnotes, and a bibliography.
3.A.02c	Apply steps for obtaining information from a variety of sources, organizing information, documenting sources, and presenting research in individual projects.
3.A.03c	Identify and use knowledge of common graphic features (charts, maps, diagrams).
3.A.04c	Integrate relevant information gathered from group discussions and interviews for reports.
3.A.05c	Deliver formal presentations for particular audiences using clear enunciation and appropriate organization, gestures, tone, and vocabulary.
3.A.06c	Use general dictionaries, specialized dictionaries, thesauruses, histories of language, books of quotations, and other related references as needed.
3.A.07c	For informational/expository writing: Write well-organized research papers that prove a thesis statement using logical organization, effective supporting evidence, and variety in sentence structure.
3.A.08c	Follow correct procedures for technical documentation.
3.A.09c	Read technical manuals, guides, resource books and technical literature to gain information and solve problems.
3.A.10c	Read, comprehend, and follow written technical directions for repairs, procedures and processes.

3.B Mathematics

3.B.01c	Use a ruler, protractor, and compass to draw polygons and circles.
3.B.02c	Given the formulas, convert from one system of measurement to another. Use technology as appropriate.
3.B.03c	Solve linear equations using tables, graphs, models, and algebraic methods.
3.B.04c	Compare, order, estimate, and translate among integers, fractions and mixed numbers (i.e., rational numbers), decimals, and percents.
3.B.05c	Recognize and solve problems involving angles formed by transversals of coplanar lines. Identify and determine the measure of central and inscribed angles and their associated minor and major arcs. Recognize and solve problems associated with radii, chords, and arcs within or on the same circle.
3.B.06c	Find linear equations that represent lines either perpendicular or parallel to a given line and through a point, e.g., by using the "point-slope" form of the equation.
3.B.07c	Demonstrate the ability to visualize solid objects and recognize their projections and cross sections.
3.B.08c	Calculate perimeter, circumference, and area of common geometric figures such as parallelograms, trapezoids, circles, and triangles.
3.B.09c	Solve everyday problems that can be modeled using systems of linear equations or inequalities. Apply algebraic and graphical methods to the solution. Use technology when appropriate. Include mixture, rate, and work problems.

3.B.10c	Apply properties of angles, parallel lines, arcs, radii, chords, tangents, and secants to solve problems.
3.B.11c	Use dimensional analysis for unit conversion and to confirm that expressions and equations make sense.
3.B.12	Demonstrate an understanding of the relationship between various representations of a line. Determine a line's slope and x- and y-intercepts from its graph or from a linear equation that represents the line. Find a linear equation describing a line from a graph or a geometric description of the line, e.g., by using the "point-slope" or "slope y-intercept" formulas. Explain the significance of a positive, negative, zero, or undefined slope.
3.B.13	Find the approximate value for solutions to problems involving square roots and cube roots without the use of a calculator.
3.B.14	Use estimation to judge the reasonableness of results of computations and of solutions to problems involving real numbers.
3.B.15	Select, create, and interpret an appropriate graphical representation (e.g., scatterplot, table, stem-and-leaf plots, box-and-whisker plots, circle graph, line graph, and line plot) for a set of data and use appropriate statistics (e.g., mean, median, range, and mode) to communicate information about the data. Use these notions to compare different sets of data.
3.B.16	Identify figures using properties of sides, angles, and diagonals. Identify the figures' type(s) of symmetry.
3.B.17	Draw congruent and similar figures using a compass, straightedge, protractor, and other tools such as computer software. Make conjectures about methods of construction. Justify the conjectures by logical arguments.
3.B.18	Solve simple triangle problems using the triangle angle sum property and/or the Pythagorean theorem.
3.B.19	Solve a variety of equations and inequalities using algebraic, graphical, and numerical methods, including the quadratic formula; use technology where appropriate. Include polynomial, exponential, logarithmic, and trigonometric functions; expressions involving absolute values; trigonometric relations; and simple rational expressions.
3.B.20	Use matrices to solve systems of linear equations. Apply to the solution of everyday problems.
3.B.21	Use symbolic, numeric, and graphical methods to solve systems of equations and/or inequalities involving algebraic, exponential, and logarithmic expressions. Also use technology where appropriate. Describe the relationships among the methods.
3.B.22	Use dimensional analysis for unit conversion and to confirm that expressions and equations make sense.
3.B.23	Relate geometric and algebraic representations of lines, simple curves, and conic sections.
3.B.24	Measure temperatures and pressures using Fahrenheit, Celsius, Pounds per square inch, inches of mercury and microns.

3.C Science and Engineering/Technology

3.C.01c	Differentiate between weight and mass, recognizing that weight is the amount of gravitational pull on an object.
3.C.02c	Recognize that the measurement of volume and mass requires understanding of the sensitivity of measurement tools (e.g., rulers,

	graduated cylinders, balances) and knowledge and appropriate use of significant digits.
3.C.03c	Identify the factors that affect the rate of a chemical reaction (temperature, concentration) and the factors that can cause a shift in equilibrium (concentration, pressure, volume, temperature).
3.C.04c	Describe the chemical processes known as oxidation and reduction.
3.C.05c	Describe the characteristics of waves (wavelength, frequency, velocity, amplitude).
3.C.06c	Identify and explain the steps of the engineering design process, i.e., identify the problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign.
3.C.07c	Distinguish among tension, compression, shear, and torsion, and explain how they relate to the selection of materials in structures.
3.C.08c	Identify and explain the purposes of common tools and measurement devices used in construction, e.g., spirit level, transit, framing square, plumb bob, spring scale, tape measure, strain gauge, venturi meter, pitot tube.
3.C.09c	Describe how structures are constructed using a variety of processes and procedures, e.g., welds, bolts, and rivets are used to assemble metal framing materials.
3.C.10c	Identify and explain the engineering properties of materials used in structures, e.g., elasticity, plasticity, thermal conductivity, and density.
3.C.11c	Differentiate the factors that affect the design and building of structures, such as zoning laws, building codes, and professional standards.
3.C.12c	Calculate quantitatively the resultant forces for live loads and dead loads.
3.C.13c	Differentiate among conduction, convection, and radiation in a thermal system, e.g., heating and cooling a house, cooking.
3.C.14c	Give examples of how conduction, convection, and radiation are used in the selection of materials, e.g., home and vehicle thermostat designs, circuit breakers.
3.C.15c	Explain the relationship between resistance, voltage, and current (Ohm's Law).
3.C.16c	Identify appropriate units of measurement for current, voltage, and resistance, and explain how they are measured.
3.C.17c	Analyze circuits (find the current at any point and the potential difference between any two points in the circuit) using Kirchoff and Ohm's laws.
3.C.18c	Distinguish between vector quantities (velocity, acceleration, and force) and scalar quantities (speed and mass).
3.C.19c	Distinguish between, and solve problems involving, velocity, speed, and constant acceleration.
3.C.20c	Create and interpret graphs of motion (position vs. time, speed vs. time, velocity vs. time, constant acceleration vs. time).
3.C.21c	Explain the relationship between mass and inertia.
3.C.22c	Interpret and apply Newton's second law of motion to show how an object's motion will change only when a net force is applied.
3.C.23c	Apply quantitatively the law of conservation of mechanical energy to simple systems.

3.C.24c	Describe the relationship among energy, work, and power both conceptually and quantitatively.
3.C.25c	Identify appropriate standard international units of measurement for energy, work, power, and momentum.
3.C.26c	Calculate heat load, using K, R and U factors.
3.C.27c	Explain the concept of BTU.
3.C.28c	Define and interpret elevation and topography components in drawings and technical documents.
3.C.29	Explain how the composition and arrangement of atoms determine a mineral's physical and chemical characteristics.
3.C.30	Use the periodic table to identify metals, nonmetals, metalloids, families (groups), periods, valence electrons, and reactivity with other elements in the table.
3.C.31	Calculate mass-mass, mass-volume, volume-volume, and limiting reactant problems for chemical reactions.
3.C.32	Describe the process by which solutes dissolve in solvents.
3.C.33	Identify and explain the factors that affect the rate of dissolving, (i.e., temperature, concentration, and mixing).
3.C.34	Demonstrate knowledge of pictorial and multi-view drawings (e.g., orthographic projection, isometric, oblique, perspective) using proper techniques.
3.C.35	Demonstrate the use of drafting techniques with paper and pencil or computer-aided design (CAD) systems when available.
3.C.36	Apply scale and proportion to drawings, e.g., 1/4" = 1'0".
3.C.37	Interpret plans, diagrams, and working drawings in the construction of a prototype.
3.C.38	Differentiate between open (e.g., irrigation, forced hot air system) and closed (e.g., forced hot water system, hydroponics) fluid systems and their components such as valves, controlling devices, and metering devices.
3.C.39	Identify and explain sources of resistance (e.g., 45deg. elbow, 90deg. elbow, type of pipes, changes in diameter) for water moving through a pipe.
3.C.40	Explain Bernoulli's Principle and its effect on practical applications, i.e., airfoil design, spoiler design, carburetor.
3.C.41	Explain the relationship between velocity and cross-sectional areas in the movement of a fluid.
3.C.42	Solve problems related to hydrostatic pressure and depth in fluid systems.
3.C.43	Interpret and provide examples that illustrate the law of conservation of energy.
3.C.44	Provide examples of how energy can be transformed from kinetic to potential and vice versa.
3.C.45	Interpret the law of conservation of momentum and provide examples that illustrate it. Calculate the momentum of an object.
3.C.46	Differentiate between specific heat and heat capacity.
3.C.47	Develop a qualitative and quantitative understanding of current, voltage, resistance, and the connection between them.
3.C.48	Conduct investigations to gain evidence that interaction of matter with electromagnetic radiation, electricity, and heat.

Strand 4: Employability Knowledge and Skills

4.A Develop employability skills to secure and keep employment in chosen field.

- 4.A.01a Evaluate industries, organizations, and careers based on multiple sources of research and information.
- 4.A.02a Assess interest areas to determine potential career pathways, including career ladders.
- 4.A.03a Develop a career plan with alternatives.
- 4.A.04a Complete job applications and related employment documents (e.g. W-4).
- 4.A.05a Create professional cover letters, resumes, and portfolios in a variety of formats (print and electronic).
- 4.A.06a Apply job search skills to seek, evaluate, apply for, and accept employment.
- 4.A.07a Demonstrate good interviewing skills.
- 4.A.08a Demonstrate employability skills needed to get and keep a job.
- 4.A.09a Assess alternative occupational choices (e.g. working conditions, benefits, and opportunities to change).

4.B Communicate in multiple modes to address needs within the career and technical field.

- 4.B.01a Apply strategies to enhance effectiveness of all types of communications in the workplace.
- 4.B.02a Apply reading skills and strategies to work-related documents.
- 4.B.03a Locate information from books, journals, magazines, and the Internet.
- 4.B.04a Apply basic writing skills to work-related communication.
- 4.B.05a Write work-related materials.
- 4.B.06a Explain information presented graphically.
- 4.B.07a Use writing/publishing/presentation applications.
- 4.B.08a Apply basic skills for work-related oral communication.
- 4.B.09a Explain proper telephone etiquette and skills.
- 4.B.10a Lead formal and informal group discussions.
- 4.B.11a Demonstrate effective negotiation and conflict management.
- 4.B.12a Apply active listening skills to obtain and clarify information.
- 4.B.13a Communicate with others in a diverse workforce.

4.C Solve problems using critical thinking.

- 4.C.01a Demonstrate skills used to define and analyze a given problem.
- 4.C.02a Explain the importance and dynamics of individual and teamwork approaches of problem solving.
- 4.C.03a Describe methods of researching and validating reliable information relevant to the problem.
- 4.C.04a Explain strategies used to formulate ideas, proposals and solutions to problems.
- 4.C.05a Select potential solutions based on reasoned criteria.
- 4.C.06a Implement and evaluate solution(s).

4.D Demonstrate positive work behaviors.

- 4.D.01a Identify time management and task prioritization skills.
- 4.D.02a Explain the importance of following workplace etiquette/protocol.
- 4.D.03a Demonstrate willingness to learn and further develop skills.
- 4.D.04a Demonstrate self-management skills.

4.D.05a List causes of stress and effective stress management techniques.
4.D.06a Describe the importance of having a positive attitude and techniques that boost morale.
4.D.07a Show initiative by coming up with unique solutions and taking on extra responsibilities.
4.D.08a Explain the importance of setting goals and demonstrate the ability to set, reach, and evaluate goals.
4.D.09a Explain the importance of taking pride in work accomplished and extrinsic and intrinsic motivators that can be used to increase pride.
4.D.10a Value the importance of professionalism, including reliability, honesty, responsibility, and ethics.
4.D.11a Demonstrate a respect for diversity and its benefit to the workplace.

Strand 5: Management and Entrepreneurship Knowledge and Skills

5.A Analyze basic business practices required to start and run a company/organization.

5.A.01a Define entrepreneurship.
5.A.02a Describe the relationship between suppliers, producers, and consumers.
5.A.03a Compare and contrast types of businesses, including sole proprietorships, small businesses, companies, corporations, governmental agencies, and non-profit organizations.
5.A.04a Describe practices that ensure quality customer service.
5.A.05a Explain the value of competition in business/field.

5.B Manage all resources related to a business/organization.

5.B.01a Identify a company's/organization's chain of command and organizational structure.
5.B.02a Define and demonstrate leadership and teamwork skills.
5.B.03a Explain ways a company or organization can market itself, including choosing a name, designing logos and promotional materials, advertising, and the importance of word-of-mouth.
5.B.04a Identify methods to track inventory, productivity, income, expenses, and personnel.
5.B.05a Explain the importance of written operating procedures and policies.
5.B.06a Identify professional organizations and their benefits.
5.B.07a Explain methods to effectively run a meeting.

5.C Describe methods for managing, organizing, retrieving and reporting financial data.

5.C.01a Explain the role of small businesses in the economy.
5.C.02a Extract and extrapolate data from financial documents, such as a pay-stub, budget, tax statement, and financial report.

5.D Apply labor and civil rights law and guidelines to business practice and decisions.

5.D.01a List federal and state mandated employee rights.
5.D.02a Describe proper working conditions for your industry.
5.D.03a Explain the role of labor organizations.
5.D.04a Discuss the importance of diversity and list methods of encouraging

diversity in the workplace.

5.D.05a Describe standard forms of employment contracts applicable to your industry.

5.D.06a State the current minimum wage, as well as wages for common jobs found within the field.

5.D.07a List opportunities for continual professional development.

5.E Evaluate the effects of community relations on companies and the industry.

5.E.01a Describe the role that the industry/organization plays in different communities.

5.E.02a Describe the role that community interests play in a company's/organization's decision-making process.

5.F Apply legal requirements and ethical considerations to business practice and decisions.

5.F.01a Identify laws that regulate businesses/organizations in your field.

5.F.02a Define the requirements for and protections given by copyright and trademark law.

5.F.03a Define the impact of the Americans with Disabilities Act and other civil rights legislation on your business/organization, employees, and customers.

5.F.04a Define ethical business practices for your field.

5.F.05a Identify trade-specific practices that support clean energy technologies and encourage environmental sustainability.

Strand 6: Technological Knowledge and Skills

6.A Demonstrate proficiency in the use of computers and applications as well as an understanding of concepts underlying hardware, software, and connectivity.

6.A.01a Select and utilize the appropriate technology to solve a problem or complete a task.

6.A.02a Demonstrate file management skills (e.g., install new software, compress and expand files as needed, download files as appropriate).

6.A.03a Differentiate between different operating systems and demonstrate use of at least one to open and switch between programs and files.

6.A.04a Identify and demonstrate resolutions to simple hardware and software problems as they occur (e.g., frozen screen, disk error, printing problems).

6.A.05a Save, retrieve, load, format, and import data into, and export a variety of electronic documents (word processing, spreadsheet, database, AND desktop publishing).

6.A.06a Demonstrate the proper use of a variety of external peripherals and how they connect to a computer.

6.A.07a Illustrate methods of selecting and using search engines.

6.A.08a Send, receive, and manage electronic correspondence and files, in accordance with school policy.

6.A.09a Demonstrate proper use of electronic proofreading tools and explain reasons why these shouldn't be relied upon solely.

6.A.10c Operate computer-driven equipment and machines.

6.A.11c Use installation and operation manuals.
6.A.12c Troubleshoot equipment and machines and access support as needed.

6.B Demonstrate responsible use of technology and an understanding of ethics and safety issues in using electronic media.

6.B.01a Identify ways in which technology is used in the workplace and in society.
6.B.02a Summarize the rights and responsibilities of the school's Acceptable Use Policy.
6.B.03a Explain laws restricting use of copyrighted materials on the Internet.
6.B.04a Discuss the concerns about electronic communications, privacy and security, including protection from spyware and viruses.

6.C Demonstrate ability to use technology for research, problem solving, and communication.

6.C.01a Locate, evaluate, collect, and process information from a variety of electronic sources.
6.C.02a Demonstrate the use of telecommunications and other media to interact or collaborate with peers, experts, and other audiences.
6.C.03a Demonstrate the use of appropriate electronic sources to conduct research (e.g., Web sites, online periodical databases, and online catalogs).
6.C.04a Demonstrate proper style (with correct citations) when integrating electronic research results into a research project.
6.C.05a Collect, organize, analyze, and graphically present data using the most appropriate tools.
6.C.06a Present information, ideas, and results of work using any of a variety of communications technologies (e.g., multimedia presentations, Web pages, videotapes, desktop-published documents).
6.C.07a Identify capabilities of technology resources and describe how they can be used for lifelong learning.
6.C.08a Demonstrate the proper use of electronic tools and office communications equipment (telephone, fax, copier, etc).
6.C.09c Demonstrate the use a variety of industry specific software.
6.C.10c Facilitate group work through management of shared schedule and contact information.