



**MASSACHUSETTS**  
**DEPARTMENT of**  
**EDUCATION**

**Vocational Technical Education  
Framework**

**Construction Cluster**

***Electricity***

**August 2007**

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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.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 Demonstrate proper application of cabinet, boxes, and fittings for temporary wiring.
- 1.B.16 Test and identify grounding materials and procedures for temporary Power Systems.
- 1.B.17 Demonstrate identification procedures of circuit and feeder disconnects.
- 1.B.18 Observe personnel hygiene and sanitation on the jobsite.
- 1.B.19 Identify and clearly mark safe working clearances around electrical equipment.
- 1.B.20 Identify safe use of flexible cords, cables, and cord-connected equipment.
- 1.B.21 Define electrical Lock Out Tag Out Procedures.
- 1.B.22 Define device and conductor polarity identification.
- 1.B.23 List GFCI applications on jobsites.
- 1.B.24 Identify and observe safety procedures from NFPA 70E.

**Performance Examples:**

1. Toolbox safety talks are part of the weekly or daily instructional routine.
2. Students research a hazardous chemical/material used in the trade and make recommendation regarding appropriate precautions and use.
3. Developing and implementing a “Health and Safety Awareness Campaign” is assigned as a class project with students and/or teams of students responsible for different aspects/components including research, posters and multi-media presentations.
4. Students plan and put on a skit that mimics hazardous and unsafe environments and situations that could be encountered on the job site.

**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 Layout and convert schematic diagrams to wiring diagrams.
- 2.A.09 Layout and convert wiring diagrams to schematic diagrams.
- 2.A.10 Utilize software for Control Circuit drawing.

#### **Performance Examples:**

1. Perform shop/job site projects/work from appropriate sets of prints/drawings.
2. Draw appropriate cross sections and/or details.
3. Develop a material quantity takeoff for the project/job.
4. Prepare an application for an appropriate permit.

### **2.B Demonstrate the use of tools, fasteners, and equipment.**

- 2.B.01 Demonstrate and explain the use of threaded fasteners.
- 2.B.02 Demonstrate and explain the use of non-threaded fasteners.
- 2.B.03 Demonstrate and explain the use and types of anchors.
- 2.B.04 Install fasteners and anchors.
- 2.B.05 Demonstrate safe operation of power and powder actuated tools.

### **2.C Illustrate basic concepts of electrical theory.**

- 2.C.01 Explain what atoms are and how they are constructed.
- 2.C.02 Define voltage and identify the ways in which it can be produced.
- 2.C.03 Explain the difference between conductors and insulators.
- 2.C.04 Define the units of measurement that are used to measure the properties of electricity.
- 2.C.05 Explain how voltage, current, and resistance are related to each other.
- 2.C.06 Using the formula for Ohm's law, calculate an unknown value.
- 2.C.07 Explain the different types of meters and equipment used to measure voltage, current, resistance, and power.
- 2.C.08 Using the power formula, calculate the amount of power used by a circuit.

### **2.D Illustrate advanced concepts of electrical theory.**

- 2.D.01 Explain the basic characteristics of a series, parallel and combination circuit.
- 2.D.02 Calculate, using Kirchhoff's voltage law, the voltage drop in series, parallel, and combination circuits.
- 2.D.03 Calculate, using Kirchhoff's current law, the total current in series, parallel, and combination circuits.

- 2.D.04 Find the total amount of resistance in series, parallel, and combination circuits.
- 2.D.05 Calculate the peak and effective voltage or current values for an AC waveform.
- 2.D.06 Calculate the phase relationship between two AC waveforms.
- 2.D.07 Describe the voltage and current phase relationship in a resistive AC circuit.
- 2.D.08 Describe the voltage and current transients that occur in an inductive circuit.
- 2.D.09 Define inductive reactance and state how it is affected by frequency.
- 2.D.10 Describe the voltage and current transients that occur in a capacitive circuit.
- 2.D.11 Define capacitive reactance and state how it is affected by frequency.
- 2.D.12 Explain the relationship between voltage and current in RL AC, RC AC, LC AC, and RLC AC circuits.
- 2.D.13 Explain true, apparent, and reactive power as they relate to AC circuits.
- 2.D.14 Explain 'power factor' as it relates to AC circuits.
- 2.D.15 Explain the use of surge protection and UPS systems.

**2.E Use electrical test equipment.**

- 2.E.01 Perform measurement of current using the ammeter / clamp-on.
- 2.E.02 Perform measurement of voltage using the voltmeter.
- 2.E.03 Perform measurement of resistance using the ohmmeter.
- 2.E.04 Measure circuit properties using the volt-ohm-multimeter (VOM).
- 2.E.05 Measure power using the wattmeter.
- 2.E.06 Explain the operation of and describe the Megohmmeter.
- 2.E.07 Explain the operation of and describe the induction tester / proximity tester.
- 2.E.08 Determine the state of a circuit using a continuity tester.
- 2.E.09 Explain the operation of and describe the voltage tester.
- 2.E.10 Explain the operation of and describe the circuit tracer.
- 2.E.11 Read and convert from one scale to another on all types of common test equipment.
- 2.E.12 Connect a meter using proper meter polarity.
- 2.E.13 Compare and contrast digital and analog meters.

**2.F Explain the MEC and Massachusetts CMRs.**

- 2.F.01 Explain the purpose and history of the National Electrical Code (NEC) and the Massachusetts Electrical Code (MEC) amendments.
- 2.F.02 Describe the layout of the Massachusetts Electrical Code (MEC).
- 2.F.03 Explain how to navigate the MEC.
- 2.F.04 Describe the purpose of the National Electrical Manufacturers' Association (NEMA) and the National Fire Protection Association (NFPA).
- 2.F.05 Explain the role of Nationally Recognized Testing Laboratories..
- 2.F.06 State appropriate Massachusetts Electric Code Amendments (527 CMR 12).
- 2.F.07 State appropriate Electrical Board of Examiners regulations (527 CMR 237).

2.F.08 State appropriate Massachusetts Building Code regulations (780 CMR).

**2.G Install raceways, boxes, and fittings.**

- 2.G.01 Describe various types of cable and raceways.
- 2.G.02 Identify and select various types and sizes of raceways.
- 2.G.03 Identify and select various types and sizes of cables.
- 2.G.04 Identify and select various types of raceway fittings.
- 2.G.05 Identify various methods used to install raceways.
- 2.G.06 Explain MEC raceway requirements.
- 2.G.07 Describe the different types of nonmetallic and metallic boxes.
- 2.G.08 State MEC requirements for box and raceway fill.
- 2.G.09 Calculate the required box size for any number and size of conductors.
- 2.G.10 Demonstrate the radius rule when installing conductors in pull boxes.
- 2.G.11 Properly locate, install, and support boxes of all types.
- 2.G.12 Describe the MEC regulations governing pull and junction boxes.
- 2.G.13 State the MEC requirements for boxes supporting luminaries.
- 2.G.14 Explain how boxes and fittings are selected and installed.
- 2.G.15 Demonstrate procedures for installing raceways and boxes on various surfaces.
- 2.G.16 Demonstrate procedures for installing raceways and boxes underground.
- 2.G.17 Demonstrate procedures for installing raceways and boxes in flush installations.
- 2.G.18 Describe the purpose of conduit bodies.
- 2.G.19 Install the different types of fittings used in conjunction with boxes.
- 2.G.20 Describe the installation rules for installing boxes and fittings in hazardous areas.

**2.H Demonstrate procedures used in raceway bending.**

- 2.H.01 Identify various raceways.
- 2.H.02 Identify the methods of hand bending raceway.
- 2.H.03 Identify the parts of electric and hydraulic benders.
- 2.H.04 Demonstrate process of different bending methods.
- 2.H.05 Determine raceway bends using mathematical formulas.
- 2.H.06 Make 90° bends, back-to-back bends, offsets, kicks, and saddle bends.
- 2.H.07 Cut, ream, and thread conduit.

**2.I Explain factors relating to conductors.**

- 2.I.01 Explain the various sizes and gauges of wire in accordance with American Wire Gauge (AWG) standards.
- 2.I.02 Identify insulation types according to conditions and applications.
- 2.I.03 Describe voltage ratings of conductors and cables.
- 2.I.04 Read and identify markings conductors and cables.
- 2.I.05 Determine the ampacity of a conductor using the tables in the MEC.
- 2.I.06 Select electrical conductors for specific applications.
- 2.I.07 Demonstrate how to size conductors for a load.
- 2.I.08 Explain the application of the MEC ampacity tables.

- 2.I.09 Demonstrate derating conductors for fill, temperature, and voltage drop.
  - 2.I.10 State the purpose of stranded wire.
  - 2.I.11 Describe the different materials from which conductors are made.
  - 2.I.12 Describe the color coding of insulation.
- 2.J Install Conductors.**
- 2.J.01 Describe the procedure and equipment for pulling wire through conduit.
  - 2.J.02 Demonstrate the various methods of installing conductors in raceways.
  - 2.J.03 Install conductors in a raceway system.
  - 2.J.04 Plan and set up for a cable pull.
  - 2.J.05 Explain how mandrels, swabs, and brushes are used to prepare conduit for conductors.
  - 2.J.06 Install a pull-line for a cable-pulling operation.
  - 2.J.07 Explain the operation of power fish tape systems.
  - 2.J.08 Prepare the ends of conductors for pulling.
  - 2.J.09 Describe the types of cable pullers.
  - 2.J.10 Explain how to support conductors in vertical conduit runs.
  - 2.J.11 Demonstrate the installation of cable in cable trays.
  - 2.J.12 Explain the importance of communication during a cable-pulling operation.
  - 2.J.13 Explain the probable causes of stress or tension in cable pulls.
- 2.K Splice and terminate conductors.**
- 2.K.01 Describe how to make a good conductor termination.
  - 2.K.02 Prepare cable ends for terminations and splices.
  - 2.K.03 Select and install lugs and connectors onto conductors.
  - 2.K.04 Train cable at termination points.
  - 2.K.05 Explain the requirements of the MEC in making cable terminations and splices.
  - 2.K.06 Explain why mechanical stress should be avoided at cable termination points.
  - 2.K.07 Describe the importance of using proper bolt torque when bolting lugs onto busbars.
  - 2.K.08 Describe splicing techniques.
  - 2.K.09 Splice conductors using solderless connectors.
  - 2.K.10 Explain how to use hand and power crimping tools.
  - 2.K.11 Describe crimping techniques.
  - 2.K.12 Describe the installation rules for parallel conductors.
  - 2.K.13 Identify and apply manufacturers' specifications to all installations.
  - 2.K.14 Insulate a splice joint.
- 2.L Apply concepts relating to commercial and industrial wiring.**
- 2.L.01 Demonstrate and describe three-phase services.
  - 2.L.02 Describe various types of electric service for commercial and industrial installations.
  - 2.L.03 Explain the purpose of GFPE for services and where they must be installed.

- 2.L.04 Calculate and select service-entrance equipment as per MEC rules.
  - 2.L.05 Explain NEMA classifications as they relate to switches and enclosures.
  - 2.L.06 Install wiring devices according to MEC regulations.
  - 2.L.07 Identify and follow MEC regulations governing installation of wiring devices.
  - 2.L.08 Identify and describe safety switches and disconnects.
  - 2.L.09 Install main disconnect switches, panelboards, and overcurrent protection devices.
  - 2.L.10 Identify the circuit loads, number of circuits required, and installation requirements for distribution panels.
  - 2.L.11 Identify and state the function of switchgear.
  - 2.L.12 Identify special locations and equipment.
- 2.M Apply concepts used in residential wiring.**
- 2.M.01 Describe how to determine electric service requirements for dwellings.
  - 2.M.02 Demonstrate and explain the grounding requirements of a residential electric service.
  - 2.M.03 Calculate and size service-entrance equipment.
  - 2.M.04 Demonstrate and state the functions and ratings of single-pole, double-pole, three-way, four-way, and dimmer switches.
  - 2.M.05 Explain how wiring devices are selected and installed.
  - 2.M.06 Select proper wiring methods for various types of residences.
  - 2.M.07 Explain the role of the MEC in residential wiring.
  - 2.M.08 Compute branch circuit loads and explain branch circuit requirements.
  - 2.M.09 Explain the purpose of ground-fault circuit interrupters (GFCI) and arc-fault circuit interrupters (AFCI) and tell where they must be installed.
  - 2.M.10 Describe rules for installing electric space heating and HVAC equipment.
  - 2.M.11 Demonstrate the installation rules for electrical systems around swimming pools, spas, and hot tubs.
  - 2.M.12 Describe the installation and layout of lighting outlets.
  - 2.M.13 Demonstrate the ability to make all installations according to manufacturers' specifications.
- 2.N Demonstrate methods of overcurrent protection.**
- 2.N.01 Explain the importance and necessity of overcurrent protection in electrical circuits.
  - 2.N.02 State the key MEC requirements regarding overcurrent protection.
  - 2.N.03 Determine let-through current values (peak and RMS) when current-limiting overcurrent devices are used.
  - 2.N.04 Demonstrate sizing of overcurrent protection for specific applications.
  - 2.N.05 Define the terms associated with fuses and circuit breakers.
  - 2.N.06 Describe the operation of a circuit breaker and fuse.
  - 2.N.07 Select the most suitable overcurrent device for the application.
  - 2.N.08 Explain the role of the MEC in specifying overcurrent devices.
  - 2.N.09 Describe the operation of single-element and time-delay fuses.
  - 2.N.10 Demonstrate alignment short circuit currents.
  - 2.N.11 State and apply MEC tap rules.

## **2.O Illustrate theories of and applications relating to motors.**

- 2.O.01 Define terms relating to motors.
- 2.O.02 Describe the various types of motor enclosures.
- 2.O.03 Describe how the rated voltage of a motor differs from the system voltage.
- 2.O.04 Describe the basic construction and components of a three-phase squirrel cage induction motor.
- 2.O.05 Describe the basic construction and components of single-phase motors and operating characteristics.
- 2.O.06 Explain the relationships among speed, frequency, and the number of poles in a three-phase induction motor.
- 2.O.07 Describe how torque is developed in an induction motor.
- 2.O.08 Define percent slip and speed regulation.
- 2.O.09 Demonstrate how the direction of a three-phase motor is reversed.
- 2.O.10 Describe the component parts and operating characteristics of a three-phase wound rotor induction motor.
- 2.O.11 Describe the component parts and operating characteristics of a three-phase synchronous motor.
- 2.O.12 Define torque, starting current, and armature reaction as they apply to DC motors.
- 2.O.13 Explain how the direction of rotation of a DC motor is changed.
- 2.O.14 Describe the design and characteristics of a DC shunt, series, and compound motor.
- 2.O.15 Describe dual-voltage motors and their applications.
- 2.O.16 Describe the methods for determining various motor connections.
- 2.O.17 Describe general motor protection requirements as delineated in the MEC.
- 2.O.18 Size branch circuits and feeders for electric motors.
- 2.O.19 Size, select, and install overcurrent protective devices for motors.
- 2.O.20 Size, select, and install overload relays for electric motors.
- 2.O.21 Size motor short circuit protectors.
- 2.O.22 Size multi-motor branch circuits.
- 2.O.23 Size motor disconnects.
- 2.O.24 Demonstrate protecting motor circuits with transformers.
- 2.O.25 Reverse a single-phase motor.

## **2.P Identify and use motor controls.**

- 2.P.01 Demonstrate the operating principles of motor controls and control circuits.
- 2.P.02 Select motor controls for specific applications.
- 2.P.03 Connect a simple control circuit.
- 2.P.04 Connect motor controllers for specific applications.
- 2.P.05 Connect control transformers in conjunction with motor control circuits.
- 2.P.06 Explain MEC regulations governing the installation of motor controls.
- 2.P.07 Install motor control circuits following MEC requirements.
- 2.P.08 Install contactors and relays according to the MEC requirements.
- 2.P.09 Interpret motor control diagrams and schematics.
- 2.P.10 Size and select thermal overload relays and other protective devices for motor controls.
- 2.P.11 Describe how overload relays operate.

- 2.P.12 Describe the operating principles of contactors and relays.
- 2.P.13 Select contactors and relays for use in specific control system.
- 2.P.14 Demonstrate purpose of electrical and mechanical interlocks.
- 2.P.15 Explain how mechanical and solid state controllers operate.
- 2.P.16 Describe manual, semi-automatic and automatic control circuits.
- 2.P.17 Test control circuits.
- 2.P.18 Identify and state the functions of limit switches and relays.
- 2.P.19 Explain applications of PLC, VFD, USD and other computerized controls.

**2.Q Demonstrate procedures used to maintain motors.**

- 2.Q.01 Demonstrate procedures used to test motors and generators.
- 2.Q.02 Demonstrate procedures used to clean and test open-frame motors.
- 2.Q.03 Demonstrate procedures used to lubricate motors that require this type of maintenance.
- 2.Q.04 Collect and record motor data.
- 2.Q.05 Select tools for motor maintenance.
- 2.Q.06 Test motors.
- 2.Q.07 Troubleshoot electric motors.

**2.R Illustrate principles of grounding.**

- 2.R.01 Explain the purpose of grounding according to the MEC.
- 2.R.02 Distinguish between a short circuit and a ground fault.
- 2.R.03 Define the MEC ground-related terms.
- 2.R.04 Distinguish between system grounding and equipment grounding.
- 2.R.05 Size the grounding electrode conductor for various AC systems using the MEC.
- 2.R.06 Explain the MEC requirements for the installation and physical protection of grounding electrode conductors.
- 2.R.07 Explain the function of the grounding electrode system and determine which grounding electrodes shall be used.
- 2.R.08 Size the equipment grounding conductor for raceways and equipment using the MEC.
- 2.R.09 Explain the function of the main bonding jumper in the grounding system and size the main bonding jumper for various applications.
- 2.R.10 Explain the MEC requirements for bonding of enclosures and equipment.
- 2.R.11 Explain the MEC requirements for grounding of enclosures and equipment.
- 2.R.12 Demonstrate effectively grounded and its importance in clearing ground faults and short circuits.
- 2.R.13 Explain the MEC requirements for grounding separately-derived systems, including transformers and generators.
- 2.R.14 Explain the MEC requirements for grounding at more than one building.

**2.S Install and maintain lighting and luminaires.**

- 2.S.01 Identify and define industry terminology for lighting.
- 2.S.02 Recognize ballasts and describe their purpose for use in fluorescent and HID lighting fixture (luminaires).

- 2.S.03 Recognize basic occupancy sensors, photoelectric sensors, and dimmers used to control lighting circuits and describe how each device operates.
- 2.S.04 Select and install contactors and relays for lighting control.
- 2.S.05 Troubleshoot fluorescent and HID lamps and lighting fixtures (luminaires) using checklists.
- 2.S.06 Describe the characteristics of light and how the human eye reacts to light.
- 2.S.07 Recognize the different kinds of lamps and explain the advantages and disadvantages of each type.
- 2.S.08 Properly select and install lamps into lighting fixtures (luminaires).
- 2.S.09 Recognize and install various types of lighting fixtures (luminaires).
- 2.S.10 Classify lighting fixtures by layout, location, fixture type, and type of service.
- 2.S.11 Identify the main lighting requirements associated with lighting systems used in selected applications such as office buildings, schools, theaters, etc.
- 2.S.12 Select the appropriate lighting fixtures for specific lighting applications using manufacturers' lighting fixture catalogs.

**2.T Illustrate concepts relating to distribution system transformers.**

- 2.T.01 Describe transformer operation.
- 2.T.02 Explain the principle of self and mutual induction.
- 2.T.03 Describe the operating characteristics of the various types of transformers.
- 2.T.04 Connect a multi-tap transformer for the required secondary voltage.
- 2.T.05 Explain MEC regulations governing the installation of transformers.
- 2.T.06 Compute transformer sizes for various applications.
- 2.T.07 Explain types and purposes of grounding transformers.
- 2.T.08 Identify power transformer connections.
- 2.T.09 Identify specialty transformers.
- 2.T.10 Calculate and install overcurrent protection for transformers.
- 2.T.11 Ground specialty transformers according to MEC requirements.
- 2.T.12 Size and select buck-and-boost transformers.
- 2.T.13 Identify current and potential transformers.
- 2.T.14 Demonstrate and describe reasons for both wye- and delta-connected units.

**2.U Describe and install low voltage and alarm systems.**

- 2.U.01 Identify basic electronic system components and schematic diagrams and ladder logic.
- 2.U.02 Describe the basic materials of solid state devices.
- 2.U.03 Describe and identify the basic types of solid state devices and their use in circuits.
- 2.U.04 Explain the operating principles of fire and security alarm systems.
- 2.U.05 Identify the components of fire and security alarm systems.
- 2.U.06 Install and connect components of fire and security alarm systems.
- 2.U.07 Explain start-up procedures for fire and security systems.
- 2.U.08 Explain the various codes and regulations related to alarm systems (i.e. NFPA 72).
- 2.U.09 Identify and install Class 1, 2, and 3 low voltage systems.

- 2.U.10 Explain the MEC rules in Article 725 as they relate to various low voltage circuits.
- 2.U.11 Explain the cable hierarchy for cable as they relate to fire, communications and other cable systems in a building.
- 2.U.12 Prepare, install, terminate, and test teledata wiring.

## **Strand 3: Embedded Academic Knowledge and Skills**

### **3.A English Language Arts**

<b>VTE #</b>	<b>Acad #</b>	<b>Standard</b>	<b>Grade</b>	<b>Topic</b>
3.A.01c	19.21	For informational/expository writing: Write reports based on research that include quotations, footnotes or endnotes, and a bibliography.	Pre-9	Composition
3.A.02c	24.4	Apply steps for obtaining information from a variety of sources, organizing information, documenting sources, and presenting research in individual projects:	Pre-9th	Composition
3.A.03c	13.19	Identify and use knowledge of common graphic features (charts, maps, diagrams).	Pre-9th	Reading
3.A.04c	2.4	Integrate relevant information gathered from group discussions and interviews for reports.	Pre-9th	Language
3.A.05c	3.17	Deliver formal presentations for particular audiences using clear enunciation and appropriate organization, gestures, tone, and vocabulary.	11/12	Language
3.A.06c	4.27	Use general dictionaries, specialized dictionaries, thesauruses, histories of language, books of quotations, and other related references as needed.	11/12	Language
3.A.07c	19.27	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.	11/12	Composition
3.A.08c		Follow correct procedures for technical documentation.		Voc
3.A.09c		Read technical manuals, guides, resource books and technical literature to gain information and solve problems.		Voc
3.A.10c		Read, comprehend, and follow written technical directions for repairs, procedures and processes.		Voc

**3.B Mathematics**

<b>VTE #</b>	<b>Acad #</b>	<b>Standard</b>	<b>Grade</b>	<b>Topic</b>
3.B.01c	7.G.5	Use a ruler, protractor, and compass to draw polygons and circles.	Pre-9th	Geometry
3.B.02c	7.M.2	Given the formulas, convert from one system of measurement to another. Use technology as appropriate.	Pre-9th	Measurement
3.B.03c	7.P.4	Solve linear equations using tables, graphs, models, and algebraic methods.	Pre-9th	Patterns, relations, algebra
3.B.04c	8.N.1	Compare, order, estimate, and translate among integers, fractions and mixed numbers (i.e., rational numbers), decimals, and percents.	Pre-9th	Numbers
3.B.05c	10.G.3	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.	9/10	Geometry
3.B.06c	10.G.8	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.	9/10	Geometry
3.B.07c	10.G.10	Demonstrate the ability to visualize solid objects and recognize their projections and cross sections.	9/10	Geometry
3.B.08c	10.M.1	Calculate perimeter, circumference, and area of common geometric figures such as parallelograms, trapezoids, circles, and triangles.	9/10	Measurement
3.B.09c	10.P.8	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.	9/10	Patterns, relations, algebra
3.B.10c	12.G.5	Apply properties of angles, parallel lines, arcs, radii, chords, tangents, and secants to solve problems.	9/10	Geometry

3.B.11c	12.M.2	Use dimensional analysis for unit conversion and to confirm that expressions and equations make sense.	11/12	Measurement
3.B.12	10.G.5	Solve simple triangle problems using the triangle angle sum property and/or the Pythagorean theorem.	9/10	Geometry
3.B.13	12.G.3	Use the notion of vectors to solve problems. Describe addition of vectors and multiplication of a vector by a scalar, both symbolically and geometrically. Use vector methods to obtain geometric results.	11/12	Geometry
3.B.14	10.P.2	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.	9/10	Patterns, relations, algebra
3.B.15	12.P.13	Describe the translations and scale changes of a given function $f(x)$ resulting from substitutions for the various parameters $a$ , $b$ , $c$ , and $d$ in $y = a(b(x + c/b)) + d$ . In particular, describe the effect of such changes on polynomial, rational, exponential, logarithmic, and trigonometric functions.	11/12	Patterns, relations, algebra
3.B.16	10.N.1	Identify and use the properties of operations on real numbers, including the associative, commutative, and distributive properties; the existence of the identity and inverse elements for addition and multiplication; the existence of $n^{\text{th}}$ roots of positive real numbers for any positive integer $n$ ; and the inverse relationship between taking the $n^{\text{th}}$ root of and the $n^{\text{th}}$ power of a positive real number.	9/10	Numbers
3.B.17	10.N.2	Simplify numerical expressions, including those involving positive integer exponents or the absolute value, e.g., $3(24 - 1) = 45$ , $4 3 - 5  + 6 = 14$ ; apply such simplifications in the solution of problems.	9/10	Numbers

3.B.18	10.N.3	Find the approximate value for solutions to problems involving square roots and cube roots without the use of a calculator, e.g., $\sqrt{3^2 - 1} \approx 2.8$ .	9/10	Numbers
3.B.19	10.N.4	Use estimation to judge the reasonableness of results of computations and of solutions to problems involving real numbers.	9/10	Numbers

### 3.C Science and Engineering/Technology

VTE #	Acad #	Standard	Grade	Topic
3.C.01c	1	Differentiate between weight and mass, recognizing that weight is the amount of gravitational pull on an object.	Pre-9 <sup>th</sup>	Physics/Chem
3.C.02c	3	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.	Pre-9 <sup>th</sup>	Physics/Chem
3.C.03c	9.3.	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).		Chemistry
3.C.04c	11.1	Describe the chemical processes known as oxidation and reduction.		Chemistry
3.C.05c	1.3	Describe the characteristics of waves (wavelength, frequency, velocity, amplitude).		Earth/Space
3.C.06c	1.1	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.		Eng/Tech
3.C.07c	2.1	Distinguish among tension, compression, shear, and torsion, and explain how they relate to the selection of materials in structures.		Eng/Tech
3.C.08c	2.2	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.		Eng/Tech

3.C.09c	2.3	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.		Eng/Tech
3.C.10c	2.4	Identify and explain the engineering properties of materials used in structures, e.g., elasticity, plasticity, thermal conductivity, and density.		Eng/Tech
3.C.11c	2.5	Differentiate the factors that affect the design and building of structures, such as zoning laws, building codes, and professional standards.		Eng/Tech
3.C.12c	2.6	Calculate quantitatively the resultant forces for live loads and dead loads.		Eng/Tech
3.C.13c	4.1	Differentiate among conduction, convection, and radiation in a thermal system, e.g., heating and cooling a house, cooking.		Eng/Tech
3.C.14c	4.2	Give examples of how conduction, convection, and radiation are used in the selection of materials, e.g., home and vehicle thermostat designs, circuit breakers.		Eng/Tech
3.C.15c	5.3	Explain the relationship between resistance, voltage, and current (Ohm's Law).		Eng/Tech
3.C.16c	5.5	Identify appropriate units of measurement for current, voltage, and resistance, and explain how they are measured.		Eng/Tech
3.C.17c	5.6	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.		Eng/Tech
3.C.18c	1.1	Distinguish between vector quantities (velocity, acceleration, and force) and scalar quantities (speed and mass).		Physics
3.C.19c	1.3	Distinguish between, and solve problems involving, velocity, speed, and constant acceleration.		Physics
3.C.20c	1.4	Create and interpret graphs of motion (position vs. time, speed vs. time, velocity vs. time, constant acceleration vs. time).		Physics
3.C.21c	1.5	Explain the relationship between mass and inertia.		Physics

3.C.22c	1.7	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.		Physics
3.C.23c	2.3	Apply quantitatively the law of conservation of mechanical energy to simple systems.		Physics
3.C.24c	2.4	Describe the relationship among energy, work, and power both conceptually and quantitatively.		Physics
3.C.25c	2.6	Identify appropriate standard international units of measurement for energy, work, power, and momentum.		Physics
3.C.26c		Calculate heat load, using K, R and U factors.		Voc
3.C.27c		Explain the concept of BTU.		Voc
3.C.28c		Define and interpret elevation and topography components in drawings and technical documents.		Voc

## **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).

#### **Performance Examples:**

1. Research positions open within a variety of companies and compare/contrast their descriptions, duties, and expectations.
2. Prepare responses to standard interview questions.
3. Participate in a mock-interview with industry professionals.

### **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.

#### **Performance Examples:**

1. Review a professional journal; choose one article to summarize.
2. Call the publisher for free products in journal.
3. Develop an oral presentation regarding an article in a journal.
4. Summarize trends presented in a graph.

**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.

#### **Performance Examples:**

1. Prepare a business plan for a new company in your community.
2. Participate in a discussion with members of a local small-business incubator or chamber of commerce, identifying opportunities and summarizing best practices of new companies.
3. Create an equipment list, with costs, of equipment required for doing specific tasks.
4. Identify local zoning and environmental laws that apply to businesses in your industry.

### **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.

#### **Performance Examples:**

1. Create a plan to keep track of tools and supplies in your classroom/shop.
2. Work as a team to complete a project, including running and participating in problem-solving meetings.
3. Contact a relevant professional organization and request information about its benefits, membership requirements, and costs.
4. Clip print advertisements from local companies, identifying common themes and contrasting different styles.

### **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.

**Performance Examples:**

1. Create and follow a budget for an in-class project.
2. Identify equipment in your shop/lab that are considered as capital.
3. From a pay-stub, determine gross salary, deductions, and net pay for a calendar year.
4. Create a rate card or other list of standardized costs for services provided, based on research of local rates and practices.

**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.

**Performance Examples:**

1. Participate in and summarize a discussion with a member of a labor organization.
2. Participate in and summarize a discussion with a member of a civil rights organization.
3. While participating in a group project, write and follow job descriptions for each member of the team.
4. Evaluate a shop/lab in terms of safety, ergonomics, and workflow.

**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.

**Performance Example:**

1. Participate in a service project or community-centered event

**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.

**Performance Examples:**

1. Research the ethical guidelines set forth by a professional organization related to your industry and participate in a debate over how to apply these guidelines to a variety of situations.
2. Create a portfolio of a variety of completed contracts and their uses.
3. Participate in and summarize a discussion with a lawyer, consumer advocate, or other legal professional.
4. Create a quick reference outline listing legal topics and related resources.

## **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.

#### **Performance Example:**

1. In the development of work-based projects, students demonstrate computer skills inherent in the word processing techniques used, the organization of data, use of photographic representation, research projects, and other relevant project based activities.

### **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.

#### **Performance Example:**

1. Describe how computers are used to increase efficiency, accuracy, and professionalism in the industry.

**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.

**Performance Example:**

1. Student is able to effectively use various technologies in the workplace.