



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

## **Vocational Technical Education Framework**

### **Manufacturing, Engineering, and Technology Cluster**

#### ***Telecommunications – Fiber Optics***

**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.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 Discuss the relationship between health, safety and productivity.

### **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 Apply principles of 'world class' operations (industry quality standard operation).**

- 2.A.01c Explain lean techniques as applied to manufacturing/engineering and technical processes.
- 2.A.02c Identify and apply the concepts of total quality management appropriate to the field.
- 2.A.03c Develop, implement, and assess plan for continuous improvement.

#### **Performance Example:**

1. The student can apply principles of total quality management techniques when carrying out their work. This will include development of benchmarks by teaming methods, use of documentation, graphing in measurement of outcomes, and understanding the need for change in processes when outcomes require it.

### **2.B Demonstrate and apply the design process.**

- 2.B.01c List the attributes of design in a variety of technical fields (biotechnology, manufacturing, environmental, power and energy, transportation, etc).
- 2.B.02c Use the design process to identify, problem solve, and evaluate a solution.
- 2.B.03c Read and interpret detail prints or technical processes.

#### **Performance Example:**

1. Select an invention or technological process that interests you and relates to your field of study (shop). Answer the following questions by applying the "Product Development Lifecycle" (hand-out with model has distributed by your instructor), to this invention or process. What was the need at the time for this product/process? Were any alternate solutions proposed? Please explain. Were any new products/processes developed as a result of this invention? Please explain. List some different prototypes that were developed for the product/process, and identify any relevant documentation. Please include appropriate pictures, diagrams, drawings, etc. Identify the different design development cycles for this invention (product/process).

### **2.C Demonstrate skills in problem solving, diagnostics, and troubleshooting.**

- 2.C.01c Identify the components and process of the system(equipment).
- 2.C.02c Identify the problem or source of the problem.
- 2.C.03c Develop solutions using a structured problem solving process.
- 2.C.04c Use appropriate testing equipment and tools for diagnosing the problem.
- 2.C.05c Implement the correct strategies to remedy the problem.

#### **Performance Example:**

1. Students use appropriate software to produce a flow chart of the design or workflow process. Student teams then use problem solving approaches, including brainstorming techniques, to identify possible solutions to a problem (or set of problems). Working individually, students produce a report that would diagnose the actual problem, suggest solutions and corrections and propose strategies to prevent reoccurring problems.

## **2.D Maintain equipment and machinery.**

- 2.D.01c Identify appropriate person(s) for maintenance and repair of equipment.
- 2.D.02c Monitor equipment indicators to insure that equipment is operating correctly.
- 2.D.03c Demonstrate ability to maintain equipment.
- 2.D.04c Develop and maintain a written log for service and repair of equipment.
- 2.D.05c Maintain electronic devices and gauges as specified by manufacturer.

### **Performance Example:**

1. Develop a preventative maintenance system and implement it for your shop area.

## **2.E Demonstrate and apply manufacturing process management techniques.**

- 2.E.01c Identify customer needs.
- 2.E.02c Identify resources needed (supplies, personnel, equipment).
- 2.E.03c Identify and create/provide needed standard operational procedures (SOPs).
- 2.E.04c Monitor process using process control data .
- 2.E.05c Explain inventory control and the implications to production and performance.
- 2.E.06c Test product to verify that it meets customer specifications, regulations, etc.
- 2.E.07c Demonstrate process used to document and ensure compliance.
- 2.E.08c Insure timely delivery of product to customer.

### **Performance Example:**

1. Identify and develop a process for project development and apply it to the completion of a product/drawing/etc.

## **2.F Use measurement devices.**

- 2.F.01c Define attributes, units, and systems of measurement used in MET fields.
- 2.F.02c Apply a variety of techniques, tools, and formulas for determining measurements.
- 2.F.03c Identify appropriate electronic device/gauge for specific tasks.
- 2.F.04c Calibrate and use electronic devices and/or gauges accurately.
- 2.F.05c Use measurement systems to solve problems.

### **Performance Example:**

1. Using appropriate English and metric (including both linear and angular measurement tools), student reads and recognizes scaling and applies mathematical skills to obtain the measurements. The student will also demonstrate the use and application of basic formulas to prove accuracy of an assigned project. Students can select and use mechanical measuring tools such as micrometers and dial verniers and electronic measuring devices including set up manipulation and operation of these devices as they apply to their technical field (calibrate equipment, understand working range, limits, and problems of devices used in the field). Students can use measurement skills to measure worn components for loss of functionality.

## **2.G Explain the fundamentals of electronics.**

- 2.G.01 Identify and explain the function of various passive components found in DC circuits.
- 2.G.02 Analyze and compute DC circuit parameters using applicable formulas.
- 2.G.03 Construct and demonstrate the testing of proper DC circuit functionality.
- 2.G.04 Identify and explain the function of various passive components found in AC circuits.
- 2.G.05 Analyze and compute AC circuit parameters using applicable formulas.
- 2.G.06 Construct and demonstrate the testing of proper AC circuit functionality.
- 2.G.07 Determine how to set up various electronic/test equipment for AC and DC circuits.
- 2.G.08 Troubleshoot and repair defective components contained in electronic systems.
- 2.G.09 Read and interpret flow, block, wiring, and schematic diagrams.
- 2.G.10 Produce a documentation package for an electronic assembly using CAD software.
- 2.G.11 Identify and explain the function of discrete and integrated semiconductor devices.
- 2.G.12 Construct and demonstrate the testing of various discrete semiconductor devices.
- 2.G.13 Construct and demonstrate the testing of various integrated semiconductor devices.
- 2.G.14 Analyze and compute proper biasing of various discrete semiconductor devices.
- 2.G.15 Analyze and compute circuit parameters of various integrated semiconductor devices.
- 2.G.16 Identify and explain the applications of semiconductors in various electronic circuits.
- 2.G.17 Analyze and compute DC and AC circuit parameters of electronic power supplies.
- 2.G.18 Analyze and compute DC and AC circuit parameters of amplifiers and oscillators.
- 2.G.19 Construct and demonstrate the testing of various active electronic circuits.
- 2.G.20 Determine the factors that affect thermal management of various electronic devices.

## **2.H Demonstrate digital techniques.**

- 2.H.01 Convert between various numbering systems and codes.
- 2.H.02 Analyze digital versus analog signals.
- 2.H.03 Identify and explain the function of logic gates.
- 2.H.04 Identify and explain manufacturer's data sheets and different logic families.
- 2.H.05 Memorize the schematic symbol, truth table, and Boolean expression for each gate.
- 2.H.06 Draw the output-timing diagram of any gate, given the input signal(s).

- 2.H.07 Construct and demonstrate the testing of digital logic gate circuits.
- 2.H.08 Determine how to set up various electronic/test equipment used in digital circuitry.
- 2.H.09 Identify and explain the function of various combinational logic circuits.
- 2.H.10 Design a combinational logic circuit to solve for a given problem.
- 2.H.11 Demonstrate the simplification process of logic design using Boolean algebra.
- 2.H.12 Demonstrate the simplification process of logic design using Karnaugh maps.
- 2.H.13 Construct and demonstrate the testing of combinational logic circuits.
- 2.H.14 Identify and explain the function of flip-flops.
- 2.H.15 Draw the output waveform of any flip-flop, given the truth table and input conditions.
- 2.H.16 Construct and demonstrate the testing of various counter circuit designs.
- 2.H.17 Construct and demonstrate the testing of various shift-register designs.
- 2.H.18 Identify and explain the function of various sequential logic circuits.
- 2.H.19 Construct and demonstrate the testing of 7-segment and LCD displays.
- 2.H.20 Analyze and program PLA's/PLD's.
- 2.H.21 Construct and demonstrate A/D and D/A conversion circuits.

## **2.I Discuss network topologies and install copper cabling.**

- 2.I.01 Describe several types of copper network cables and connectors used with them.
- 2.I.02 Identify and name various tools used in network cabling.
- 2.I.03 Compare and contrast pros and cons of various types of network cabling.
- 2.I.04 Discuss the operation of a telephone and draw its block diagram.
- 2.I.05 Properly install and test RJ-11/plug patch cables and jacks.
- 2.I.06 Identify various punch blocks and properly wire and test for connectivity.
- 2.I.07 Describe cabinet and chassis hubs, agents, consoles, wiring closets, and cross-connect devices.
- 2.I.08 Describe, explain, and test different types of grounds.
- 2.I.09 Explain the difference between spike, surge, and sag voltage levels.
- 2.I.10 Describe the structure, electrical characteristics, and test parameters of UTP/STP cables.
- 2.I.11 Properly install and test UTP/RJ-45 patch cables.
- 2.I.12 Properly terminate and test UTP cables to 110 and 210 punch down /edge connectors.
- 2.I.13 Properly install and test a connector on a 150-ohm, STP cable.
- 2.I.14 Properly install and use a UDC to RJ-45 adapter.
- 2.I.15 Describe the layers and electrical characteristics of various coaxial cables.
- 2.I.16 Properly install and test both a thicknet and a thinnet tap.
- 2.I.17 Determine acceptability of various copper cables using a variety of test equipment.
- 2.I.18 Identify and describe various network topologies.

- 2.I.19 Identify and describe symbology used and how to read blueprints.
- 2.I.20 Describe what a LAN is, different types and key components of a network system.

**Performance Example:**

1. Given a diagram, wire a network together and demonstrate that the network meets specification and troubleshoot any faults.

**2.J Define theories and applications of fiber optic cabling.**

- 2.J.01 Discuss various portions of the magnetic spectrum.
- 2.J.02 Discuss the basic principles of light and its transmission.
- 2.J.03 Explain how light is transmitted in fiber optic cable.
- 2.J.04 Define the terms refractive index and acceptance angle relative to fiber optic cable.
- 2.J.05 Summarize in your own words, Snell's Law.
- 2.J.06 Describe fiber optic cable characteristics.
- 2.J.07 Describe the structures of various plastic and glass fiber optic cables.
- 2.J.08 Explain the phrase "total internal reflection" relative to fiber optic cable.
- 2.J.09 Identify tools, parts, and safety procedures for fiber optic cable assembly.
- 2.J.10 Demonstrate fiber optic cable/connector assemblies.
- 2.J.11 Prepare, install and test connectors used in plastic fiber optic cabling.
- 2.J.12 Prepare, install and test connectors used in glass fiber optic cabling.
- 2.J.13 Describe how to inspect fiber optic cable terminations using a microscope.
- 2.J.14 Prepare, install, and test a mechanical splice.
- 2.J.15 Explain fiber optic system design, installation, and testing.
- 2.J.16 Discuss what a loss budget is and its importance in fiber optic system design.
- 2.J.17 Discuss the basic steps in planning a fiber optic system installation.
- 2.J.18 Explain the operation of an OTDR.
- 2.J.19 Describe and perform an optical continuity test.
- 2.J.20 Perform fiber cable loss testing using a calibrated light source and a power meter.

**Performance Example:**

1. Given a diagram, assemble a fiber optic system and demonstrate that the system meets specifications and troubleshoot any faults.

**2.K Explain the principles of electronic communication.**

- 2.K.01 Define the properties of signals in both acoustic and electrical form.
- 2.K.02 Describe the dimension signal frequency, wavelength, and phase.
- 2.K.03 Calculate the relationships of time vs. frequency, phase vs. distance, and phase vs. time.
- 2.K.04 Calculate power gain and loss in dB units and convert to voltage, current, and power.
- 2.K.05 Calculate reference power levels in dBm and convert to voltage, current, and power.
- 2.K.06 State the S/N ratio required for communication with telephone/audio systems.

- 2.K.07 Define the fundamental and harmonic frequencies of electrical signals.
- 2.K.08 Identify and define the harmonic structure of common signal waveforms.
- 2.K.09 Specify the common forms of waveform distortion applied to signals in electronic circuits.
- 2.K.10 Specify the effects of circuit bandpass/frequency response upon signal waveforms and their harmonic structure.
- 2.K.11 Calculate the effects of linear mixing of two signals through a single circuit.
- 2.K.12 Calculate the % factors of intermod and harmonic distortion in signals and circuits.
- 2.K.13 Calculate the power distribution of intermod signals over their range of frequencies.
- 2.K.14 Apply the concepts of intermod products to the modulation of signals in communication systems.
- 2.K.15 Apply the concepts of intermod products to the frequency conversion of signals.
- 2.K.16 Identify the acoustic and electrical properties of common input and output transducers.
- 2.K.17 Determine the efficiency of transducers from measured specifications.
- 2.K.18 Convert dBspl to electrical signal power.
- 2.K.19 Determine the characteristics of amplifiers including gain, impedance, and power level.
- 2.K.20 Determine the effects of frequency response, noise, and distortion of signals in amplifier circuits.

**Performance Example:**

1. Given a diagram, wire an electronic communications system, demonstrate that it meets specifications and troubleshoot any faults.

**2.L Define the fundamentals of telephone systems.**

- 2.L.01 Specify interconnect and switching of local exchanges and the long-haul networks.
- 2.L.02 Identify the name and function of each part of a telset, C/O, and local facilities.
- 2.L.03 Describe the details of each component in the electronic single-line telset.
- 2.L.04 Identify the name and function of each component of a telset, C/O, and local facilities.
- 2.L.05 Calculate loop resistance, operating voltage, and current available in a single-line telset.
- 2.L.06 Describe the detailed operation of each component in the electronic single-line telset.
- 2.L.07 Identify analog/digital techniques used for signal detection and driving annunciators.
- 2.L.08 Calculate the properties of R, L, and C of transmission lines from their geometry and insulation materials.
- 2.L.09 Calculate the electrical properties upon a transmission line's characteristic impedance.

- 2.L.10 Calculate the electrical properties of coaxial cable from its geometry and materials.
- 2.L.11 Calculate the effects of shunt capacitance upon frequency response and signal loss within transmission lines.
- 2.L.12 Describe how amplifiers are used in transmission circuits to compensate for a line's frequency response and attenuation characteristics.
- 2.L.13 Describe the main blocks that make up a PBX system.
- 2.L.14 Explain how a wireless PBX system works.
- 2.L.15 Describe the concept of a cellular system and the makeup of a cell.
- 2.L.16 Explain how handoffs and roaming work.
- 2.L.17 List the basic circuits of a cellular phone and the purpose of each.
- 2.L.18 List the basic circuits of a cell site and the purpose of each.
- 2.L.19 Describe PCS (Personal Communications Service).
- 2.L.20 Explain the meaning of the terms "dropout" and "dead zones".

**Performance Example:**

1. Given a diagram, wire a telephone system, demonstrate that it meets specifications and troubleshoot any faults.

**2.M Describe the fundamentals of wireless communications and systems.**

- 2.M.01 Identify and explain the characteristics of various modulated waveforms
- 2.M.02 State the functions of a transmitter, a receiver, and a channel in a basic wireless communication system.
- 2.M.03 Calculate and measure % modulation and bandwidth for a given AM signal.
- 2.M.04 Explain the terms modulation, SSB, and SSBSC as related to AM signal characteristics.
- 2.M.05 Identify the block diagrams of a tuned RF receiver and a super heterodyne receiver.
- 2.M.06 Describe the characteristics of angle and pulse modulation.
- 2.M.07 Compare and contrast analog and digital pulse modulation.
- 2.M.08 State the purpose and define the properties of transmission lines.
- 2.M.09 Calculate the of a  $\frac{1}{2}$  wave dipole for a given frequency.
- 2.M.10 Calculate the effective power when given the antenna gain, transmission line loss, and transmitted power.
- 2.M.11 Discuss ground waves, space waves, and sky waves.
- 2.M.12 Explain the benefits of bandwidth and decreased interference with optical transmission systems.
- 2.M.13 List the frequency components of AM, FM, and television signals and typical characteristics and requirements for transmission and reception.
- 2.M.14 Describe how a multi-channel communication system works.
- 2.M.15 Describe the major components of a communication satellite and ground stations.
- 2.M.16 List the basic system requirements and modes of operation for digital data communications.
- 2.M.17 Describe the nature and effects of transmission imperfections.
- 2.M.18 Define the terms aspect ratio, resolution, pixels, and triads as they relate to HDTV.

- 2.M.19 Explain the fundamental concepts in 2-way radio and GPS systems.
- 2.M.20 Describe the functions of the DBS downlink/uplink facility satellite and receiver.
- 2.M.21 Describe the four major parts of a Bluetooth device and explain the various protocol modes.
- 2.M.22 List the current specifications for Bluetooth devices and explain the terms piconet and scatternet.

**Performance Example:**

1. Given a diagram, construct a wireless communication system, demonstrate that it meets specifications and troubleshoot any faults.

## **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-9th	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	2.4	Integrate relevant information gathered from group discussions and interviews for reports.	Pre-9th	Language
3.A.04c	13.19	Identify and use knowledge of common graphic features (charts, maps, diagrams).	Pre-9th	Reading
3.A.05c	24.5	Formulate open-ended research questions and apply steps for obtaining and evaluating information from a variety of sources, organizing information, documenting sources in a consistent and standard format, and presenting research.	9/10	Composition
3.A.06c	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.07c	24.6	Formulate original, open-ended questions to explore a topic of interest, design and carry out research, and evaluate the quality of the research paper in terms of the adequacy of its questions, materials, approach, and documentation of sources.	11/12	Composition
3.A.08c	3.17	Deliver formal presentations for particular audiences using clear enunciation and appropriate organization, gestures, tone, and vocabulary.	11/12	Language
3.A.09c	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.10c		Follow correct procedures for technical documentation (note: no specific technical documentation/writing standard in English Language Arts Framework. This is often found in post secondary technical program courses and is found vital to many of the vocational technical programs offered across Massachusetts).		Voc
3.A.11c		Read technical manuals, guides, resource books and technical literature to gain information and solve problems.		Voc
3.A.12c		Read, comprehend, and follow written technical directions for repairs, procedures and processes.		Voc

### 3.B Mathematics

VTE #	Acad #	Standard	Grade	Topic
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.M.2	Given the formulas, convert from one system of measurement to another. Use technology as appropriate.	Pre-9th	Measurement
3.B.05c	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.06c	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.07c	10.G.5	Apply properties of angles, parallel lines, arcs, radii, chords, tangents, and secants to solve problems.	9/10	Geometry

3.B.08c	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.09c	10.G.10	Demonstrate the ability to visualize solid objects and recognize their projections and cross sections.	9/10	Geometry
3.B.10c	10.M.1	Calculate perimeter, circumference, and area of common geometric figures such as parallelograms, trapezoids, circles, and triangles.	9/10	Measurement
3.B.11c	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.12c	12.M.2	Use dimensional analysis for unit conversion and to confirm that expressions and equations make sense.	11/12	Measurement
3.B.13c	12.P.8	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.	11/12	Patterns, relations, algebra
3.B.14c	12.P.11	Solve everyday problems that can be modeled using polynomial, rational, exponential, logarithmic, trigonometric, and step functions, absolute values, and square roots. Apply appropriate graphical, tabular, or symbolic methods to the solution. Include growth and decay; joint (e.g., $I = Prt$ , $y = k(w_1 + w_2)$ ) and combined ( $F = G(m_1m_2)/d^2$ ) variation, and periodic processes.	11/12	Patterns, relations, algebra
3.B.15	7.P.6	Use linear equations to model and analyze problems involving proportional relationships. Use technology as appropriate.	Pre-9th	Patterns, relations, algebra

3.B.16	10.D.1	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.	9/10	Data Analysis, Statistics
3.B.17	10.D.3	Describe and explain how the relative sizes of a sample and the population affect the validity of predictions from a set of data.	9/10	Data Analysis, Statistics
3.B.18	12.D.7	Compare the results of simulations (e.g., random number tables, random functions, and area models) with predicted probabilities.	9/10	Data Analysis, Statistics
3.B.19	12.D.2	Select an appropriate graphical representation for a set of data and use appropriate statistics (e.g., quartile or percentile distribution) to communicate information about the data.	11/12	Data Analysis, Statistics
3.B.20	12.D.2	Select an appropriate graphical representation for a set of data and use appropriate statistics (e.g., quartile or percentile distribution) to communicate information about the data.	11/12	Data Analysis, Statistics
3.B.21	12.D.6	Use combinatorics (e.g., "fundamental counting principle," permutations, and combinations) to solve problems, in particular, to compute probabilities of compound events. Use technology as appropriate.	11/12	Data Analysis, Statistics
3.B.22	12.M.2	Use dimensional analysis for unit conversion and to confirm that expressions and equations make sense.	11/12	Measurement

### 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-9th	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-9th	Physics/Chem

3.C.03c	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.04c	1.1	Distinguish between vector quantities (velocity, acceleration, and force) and scalar quantities (speed and mass).		Physics
3.C.05c	1.3	Describe the characteristics of waves (wavelength, frequency, velocity, amplitude).		Earth/Space
3.C.06c	1.3	Distinguish between, and solve problems involving, velocity, speed, and constant acceleration.		Physics
3.C.07c	1.4	Create and interpret graphs of motion (position vs. time, speed vs. time, velocity vs. time, constant acceleration vs. time).		Physics
3.C.08c	1.5	Explain the relationship between mass and inertia.		Physics
3.C.09c	1.6	Interpret and apply Newton's first law of motion.		Physics
3.C.10c	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.11c	2.3	Apply quantitatively the law of conservation of mechanical energy to simple systems.		Physics
3.C.12c	2.4	Describe the relationship among energy, work, and power both conceptually and quantitatively.		Physics
3.C.13c	2.6	Identify appropriate standard international units of measurement for energy, work, power, and momentum.		Physics
3.C.14c	4.1	Differentiate among conduction, convection, and radiation in a thermal system, e.g., heating and cooling a house, cooking.		Eng/Tech
3.C.15c	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.16c	5.3	Explain the relationship between resistance, voltage, and current (Ohm's Law).		Eng/Tech

3.C.17c	5.5	Identify appropriate units of measurement for current, voltage, and resistance, and explain how they are measured.		Eng/Tech
3.C.18c	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.19	1.2	Describe the components of the electromagnetic spectrum and give examples of its impact on our lives.		Earth/Space
3.C.20	1.2	Demonstrate knowledge of pictorial and multi-view drawings (e.g., orthographic projection, isometric, oblique, perspective) using proper techniques.		Eng/Tech
3.C.21	1.3	Demonstrate the use of drafting techniques with paper and pencil or computer-aided design (CAD) systems when available.		Eng/Tech
3.C.22	1.4	Apply scale and proportion to drawings, e.g., 1/4" = 1'0".		Eng/Tech
3.C.23	1.5	Interpret plans, diagrams, and working drawings in the construction of a prototype.		Eng/Tech
3.C.24	2.4	Describe the relationship among energy, work, and power both conceptually and quantitatively.		Eng/Tech
3.C.25	3.2	Differentiate between specific heat and heat capacity.		Eng/Tech
3.C.26	5.2	Identify and explain the components of a circuit including a source, conductor, load, and controllers (controllers are switches, relays, diodes, transistors, integrated circuits).		Eng/Tech
3.C.27	5.4	Determine the voltages and currents in a series circuit and a parallel circuit.		Eng/Tech
3.C.28	5.6	Describe the differences between Alternating Current (AC) and Direct Current (DC).		Eng/Tech
3.C.29	6.2	Explain how information travels through different media, e.g., electrical wire, optical fiber, air, space.		Eng/Tech
3.C.30	6.3	Compare the difference between digital and analog communication devices.		Eng/Tech

3.C.31	6.4	Explain the components of a communication system, i.e., source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.		Eng/Tech
3.C.32	7.2	Differentiate the selection of tools and procedures used in the safe production of products in the manufacturing process, e.g., hand tools, power tools, computer-aided manufacturing, three-dimensional modeling.		Eng/Tech
3.C.33	1.12	Identify appropriate standard international units of measurement for force, mass, distance, speed, acceleration, and time, and explain how they are measured.		Physics
3.C.34	4.2	Recognize the measurable properties of waves (e.g., velocity, frequency, wavelength) and explain the relationships among them.		Physics
3.C.35	4.4	Distinguish between mechanical and electromagnetic waves.		Physics
3.C.36	4.5	Interpret and be able to apply the laws of reflection and refraction (qualitatively) to all waves.		Physics
3.C.37	4.6	Recognize the effects of polarization, wave interaction, and the Doppler effect.		Physics
3.C.38	5.1	Recognize the characteristics of static charge, and explain how a static charge is generated.		Physics
3.C.39	5.2	Interpret and apply Coulomb's law.		Physics
3.C.40	5.3	Explain the difference in concept between electric forces and electric fields.		Physics
3.C.41	5.4	Develop a qualitative and quantitative understanding of current, voltage, resistance, and the connection between them.		Physics

## **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.
- 4.D.12 Demonstrate effective negotiation skills.
- 4.D.13 Manage conflict with management/co-workers/others.
- 4.D.14 Demonstrate appropriate flexibility and adaptability.

## **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.A.06 Describe why industries respond to customer wants and expectations.
- 5.A.07 List differences in how companies deliver products versus delivering services.
- 5.A.08 Describe ways a worker can influence company decision-making.

#### **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.
- 5.B.08 Identify key components of a company "mission statement".
- 5.B.09 Describe the significance of a company's "corporate culture".
- 5.B.10 Cite examples of why a worker should adjust to different management styles.
- 5.B.11 Cite an example of how companies are dependent on the national/global economy.
- 5.B.12 Cite an example of how a company is dependent upon the local economy.
- 5.B.13 Describe the importance of achieving internal and external customer satisfaction.
- 5.B.14 Identify examples of how cultural diversity can affect an industry.

- 5.B.15 Identify key differences in how private companies and government agencies operate.
- 5.B.16 List reasons why written policies are used in industry.
- 5.B.17 Identify resources available from professional organizations.
- 5.B.18 Identify how roles and responsibilities in a family business are different than in larger companies.
- 5.B.19 List benefits a worker can get by participating in meetings.
- 5.B.20 Describe how a company's marketing affects all its employees.

**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.
- 5.C.03 Describe key implications for a company that grants credit.
- 5.C.04 Describe how a company estimates and bids for a contract.
- 5.C.05 Describe how paycheck deductions affect a worker.
- 5.C.06 Describe the importance of cost containment in a company.

**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.
- 5.D.08 Describe the importance of knowing your rights as a worker.
- 5.D.09 List advantages/disadvantages of hourly and salaried pay.
- 5.D.10 List differences between being a self-employed worker and a worker employed by a company.

- 5.D.11 Describe the importance of participating in quality enhancement programs.
- 5.D.12 Explain why a worker is occasionally asked to work longer hours.

**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.
- 5.E.03 Describe the importance of recognizing a worker should contribute special skills through volunteer work.
- 5.E.04 Identify an impact of buying outside the community.
- 5.E.05 Describe the importance of providing for the access needs of the physically challenged.

**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.
- 5.F.06c Recognize organizational and legal consequences of aiding and participating in illegal or inappropriate behavior.

**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.

#### **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).

**Performance Example: .**

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

**6.D Demonstrate the effects a new technology might have on the society.**

- 6.D.01c Describe how new technology in manufacturing, engineering and technology has local, state, federal and global impact.
- 6.D.02c Discuss the role of society in the development and use of technology.

**Performance Example:**

1. Research and write on one technological device describing the history and evolution of the equipment line, effects both positive and negative on society and the environment and develop a closing argument for the existence or removal of this technology based on the facts gathered.