



MASSACHUSETTS
DEPARTMENT of
EDUCATION

**Vocational Technical Education
Framework**

**Manufacturing, Engineering, and
Technology Cluster**

Engineering Technology

August 2007

Massachusetts Department of Education
Career/Vocational Technical Education Unit
address 350 Main Street, Malden, MA 02148
telephone 781-338-3910
internet www.doe.mass.edu/cte/
email careervoctech@doe.mass.edu

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 Define and describe types of engineering.

- 2.G.01 Describe different pathways towards a variety of engineering careers.
- 2.G.02 Explain how engineers impact society, the environment, and daily life through their work.
- 2.G.03 Identify the unique components and considerations of the different engineering fields (civil/structural, transportation, electrical, computer, software, manufacturing, mechanical, and biological/environmental/chemical).

Performance Example:

1. Select a product or process (communication for example) and develop a historical time line noting the key inventions, adaptations, and impact that occurred over a centennial time period.

2.H Document and communicate engineering concepts.

- 2.H.01 Write a technical design report.
- 2.H.02 Maintain engineering logs/journals for all projects.
- 2.H.03 Utilize a variety of media formats to convey designs and processes (animation, power point, web page, etc).

2.I Describe different engineering systems.

- 2.I.01 Describe operation and relative strengths and weaknesses of common mechanical systems (simple machines, gears and rations, bearings, couplings, cams, etc).
- 2.I.02 Describe the differences between heat flow mechanisms (conduction, convection, and radiation).
- 2.I.03 Perform heat loss calculations using “K” or “R” values.
- 2.I.04 Calculate and evaluate pneumatic systems and hydraulic systems (operation, mechanical advantage, relative strengths, and weaknesses) for the most appropriate application.
- 2.I.05 Explain surveying and coordination systems.

Performance Example:

1. Use industry standard components to build and control a fully functional electro-mechanical device.

2.J Explain how statics, kinematics, and strengths of materials are important for design and product creation.

- 2.J.01 Construct a free body diagram.
- 2.J.02 Resolve forces into their vector components.
- 2.J.03 Write and solve simple statics equations.
- 2.J.04 Solve complex problems using computerized statics solution packages (ex. MD Solids).
- 2.J.05 Calculate stress and strain in simple parts.
- 2.J.06 Perform moment of inertia calculations.
- 2.J.07 Solve for stress, strain, and deflection in common beam shapes using computer software program.
- 2.J.08 Apply Newton’s laws and motion equations to solve for acceleration and velocity in machine components.

2.K Select and test materials for specified use.

- 2.K.01 Describe and compare various classes of common engineering materials and their properties (solid, liquid, and gas).
- 2.K.02 Identify and differentiate between the five different basic categories of solid engineering materials (organics, metals, polymers, ceramics, and composites).
- 2.K.03 Trace the production of materials from raw material, to finished product, to disposal, to recycling.
- 2.K.04 Identify practical applications of each material category to engineering products and processes.
- 2.K.05 Select suitable materials for a given application.

Performance Example:

1. Select a material to build a load support structure and test to destruction for performance.

2.L Explain the principles of design.

- 2.L.01 List and apply the steps of the design process to projects.
- 2.L.02 Utilize the steps of the design process to solve a given problem or problem(s).
- 2.L.03 Work in teams using brainstorming techniques to create new designs.
- 2.L.04 Describe the role of drawings and CAD models as vital documentation components in the engineering process.

2.M Create sketches.

- 2.M.01 Define and contrast geometric shapes, line types, tools, etc. used in sketching.
- 2.M.02 Apply proper scale, dimensioning, and tolerancing standards to drawing.
- 2.M.03 Execute clear and accurate hand sketches using perspective views.
- 2.M.04 Execute clear and accurate hand sketches using orthographic views.

2.N Utilize computer aided drafting package to create 3D models.

- 2.N.01 Create a simple solid model (single parts).
- 2.N.02 Edit a simple solid model (single parts).
- 2.N.03 Create section and auxiliary views.
- 2.N.04 Integrate model parts into working assembly.
- 2.N.05 Manipulate and animate working assembly.
- 2.N.06 Create feature based geometry (holes, slots, rounds).
- 2.N.07 Perform Boolean operations (union, subtractions, intersection).
- 2.N.08 Construct and label exploded assembly drawings.
- 2.N.09 Analyze and evaluate parametric models.

Performance Example:

1. Create a 3D model and record drawings of an existing multi-part mechanism (bike, guitar, hair dryer, inhaler, etc).

2.O Develop computer models for manufacturing processes.

- 2.O.01 Store, retrieve, copy, and output drawing files depending upon system setup.
- 2.O.02 Utilize instructor identified 2D computer sketching functions.

- 2.O.03 Incorporate various coordinate systems in the construction of 2D geometrical shapes.
- 2.O.04 Calculate the x and y coordinates given a radius and angle.
- 2.O.05 Apply editing techniques to produce accurate sketches.
- 2.O.06 Apply sketch constraints.
- 2.O.07 Analyze drawings with appropriate inquiry functions.
- 2.O.08 Create assembly models through the integration of individual parts and sub-assemblies.
- 2.O.09 Generate an assembly drawing, which include Views, Balloons, and Bill Of Materials (BOM).
- 2.O.10 Identify the wide array of industry-wide prototyping methods in use.
- 2.O.11 Identify the need for rapid-prototyping.
- 2.O.12 Prepare a prototype model from a drawing database.

Performance Example:

1. Create a documentation package for a child's toy that has multiple parts and components.

2.P Evaluate models.

- 2.P.01 Extract and analyze mass properties (volume, density, moment of inertia, etc).
- 2.P.02 Evaluate function and operation of assembly (motion, interference, etc) using animation features.

2.Q Determine reliability and liability of a design.

- 2.Q.01 Identify critical components of a design whose failure could leave the designers open to liability.
- 2.Q.02 Interpret and select means for achieving reliability in your design (Mean Time Before Failure (MTBF), safety factor, redundancy of components, premium materials, etc).
- 2.Q.03 Explain ethical challenges facing engineers in the design, redesign, or repair of products.

Performance Example:

1. Create a case study and debate the liability, reliability issues, etc. of the design of a toy listed as a 'dangerous toy' by consumer groups.

2.R Describe electrical current and electron theory.

- 2.R.01 Label the parts of an atom.
- 2.R.02 Explain what classifies a material as an insulator or conductor.
- 2.R.03 Define the difference between direct and alternating currents.
- 2.R.04 Describe a resistor and what its function is in circuit design.

2.S Select electronic components that best meet design requirements.

- 2.S.01 Identify resistors using code.
- 2.S.02 Demonstrate how diodes operate and their function.
- 2.S.03 Explain and demonstrate how transistors function.
- 2.S.04 Describe the differences between different display devices (LED (light emitting diodes), seven segment display, LCD (liquid crystal display).
- 2.S.05 Identify different types of capacitors and their voltage polarity requirements.

2.S.06 Describe the function of sensors in electronic circuitry (temp., optical, etc).

2.T Identify the fundamentals of digital electronics.

2.T.01 Use engineering notations and prefixes: Mega, Kilo, milli, micro, nano, pico, micro-micro.

2.T.02 Measure resistance using multimeters.

2.T.03 Identify basic circuit components (source, load, control, conductors).

2.T.04 Read schematics.

2.T.05 Describe the difference between series, parallel, and series-parallel circuits.

2.T.06 Describe difference between open and closed loop control.

2.T.07 Describe type and function of different switches.

2.U Utilize formulas and mathematical operations to perform calculations for measurements.

2.U.01 Calculate voltage and current in simple circuits using Ohm's law.

2.U.02 Calculate current and voltage using Kirchhoff's law.

2.U.03 Measure the value of capacitors using instrumentation.

2.U.04 Measure current in both series and parallel circuits.

2.U.05 Measure voltage in both series and parallel circuits.

2.U.06 Draw and label a digital waveform (signal generators, wave types, square, sawtooth, sine).

2.U.07 Find rise and fall time, and frequency using an oscilloscope.

2.U.08 Perform conversions between binary and decimal, hexadecimal and binary, and hexadecimal and decimal.

2.U.09 Use schematics and symbolic algebra to represent digital gates as part of a solution to a design problem (logic symbols: And, Or, Not, Nand, Nor gates).

Performance Example:

1. Design and build an alarm circuit that utilizes two different alarm signals (light and sound, two diff sounds, etc.)

2.V Create Boolean expressions, logic circuit diagrams and truth tables as part of a design solution.

2.V.01 Create Boolean expressions and truth tables.

2.V.02 Select min term and max term expressions (sum-product, product-sum).

2.V.03 Use DeMorgan's theorem to convert a SOP to a POS in order to save resources in the production of circuits.

2.V.04 Formulate and use a Karnaugh Map.

2.V.05 Describe duality of logic functions.

2.W Design a circuit.

2.W.01 Develop a word problem.

2.W.02 Construct a truth table.

2.W.03 Create a logic equation.

2.W.04 Simplify the logic equation.

2.W.05 Simulate the circuit.

2.W.06 Construct the circuit.

- 2.W.07 Troubleshoot problems with a circuit.
- 2.W.08 Design circuits using reprogrammable logic devices.
- 2.W.09 Create PLD logic files.

Performance Example:

1. Create a circuit that will display a message (time, temp., etc).

2.X Create Flip-Flops.

- 2.X.01 Construct and test simple latches and flip-flops from discrete gates.
- 2.X.02 Interpret, design, draw and evaluate circuits using logic symbols (triggers, latches, flip-flops).
- 2.X.03 Create timing diagrams and truth tables for J-K flip-flop.
- 2.X.04 Analyze timing diagrams.

2.Y Identify families and specifications.

- 2.Y.01 Locate logic families in a reference catalog.
- 2.Y.02 Read spec sheets on an individual IC to determine suitability for use in a given circuit.
- 2.Y.03 Explain timing requirements of ICs.

2.Z Apply microprocessors.

- 2.Z.01 Formulate a flow chart to correctly apply basic programming concepts.
- 2.Z.02 Design and create a program to evaluate data and make decisions using external digital and analog sensors.
- 2.Z.03 Create an interface that inspects, evaluates, and manages program parameters during the operation of the program.

2.AA Interfacing with motors.

- 2.AA.01 Describe different types of motors.
- 2.AA.02 Select, size and implement interface devices to control motor (external devices).
- 2.AA.03 Run, test, evaluate, and redesign motors.

Performance Example:

1. Design and build an automated control system (door opener, automatic window shade, lighting control, etc).

2.BB Identify mechanical components.

- 2.BB.01 Identify and sketch the mechanical components to a robot.
- 2.BB.02 Describe ways an end effector is specific to a process.
- 2.BB.03 Design and develop an end effector.
- 2.BB.04 Analyze the advantages and disadvantages of the various drive systems used in robotics.

2.CC Develop and program a robot.

- 2.CC.01 Define a robot.
- 2.CC.02 Classify different types of robots.
- 2.CC.03 Evaluate the positive impact robots have on manufacturing and society as a whole.
- 2.CC.04 Design and build a working model of a robot.
- 2.CC.05 Identify and report specifications and work envelopes of robots.
- 2.CC.06 Program a robot to perform several tasks.

- 2.CC.07 Program a robot to solve a materials handling problem.
- 2.CC.08 Recognize the need for end of arm tooling and how this tooling affects the robots operation.

Performance Example:

1. Using industry standard devices and controls, build and program a fully functioning robotic device that will perform a multi stepped task (travel to a location, pick up an object, move to another position and place the object in a specific receptacle, etc).

2.DD Control Systems.

- 2.DD.01 Describe the basic components of robot controllers.
- 2.DD.02 Demonstrate an understanding of control techniques and computer simulations.
- 2.DD.03 Design and build a feed system with sensors.

2.EE Illustrate common manufacturing processes.

- 2.EE.01 Define the process of casting and molding as it relates to the engineering process.
- 2.EE.02 Identify where material removal would be the appropriate process to use in production (ex. Turning, milling, grinding).
- 2.EE.03 Describe the process of forming (bending, forging, cutting, etc).
- 2.EE.04 Explain how chemicals are used in manufacturing (etching, plating).
- 2.EE.05 Design and complete a basic assembly process resulting in a product.

2.FF Identify categories of and operate CIM manufacturing systems.

- 2.FF.01 Compare and contrast the benefits and drawbacks of the three categories of CIM manufacturing systems.
- 2.FF.02 Recognize the working relationship between the CNC mill and the robot.
- 2.FF.03 Identify the components of a individual components used in selected CIM systems.
- 2.FF.04 Analyze and select components for a CIM system for a specific industrial application.
- 2.FF.05 Describe various applications of a Programmable Logic Controller as related to its use in a CIM system.
- 2.FF.06 Describe the difference between a PLC and a computer with interface.
- 2.FF.07 Operate using all of the safety precautions associated with a fully automated CIM system.
- 2.FF.08 Explain the significance of teamwork and communication when combining the designs of the individual groups into a complete miniature FMS.
- 2.FF.09 Demonstrate how their individual components work together to form a complete CIM system.
- 2.FF.10 Assemble and test their individual component designs by integrating them into a complete miniature FMS built from models.

Performance Example:

1. Design and produce a product (flashlight, hammer, name plate, clamp, bracelet, etc).

2.GG Create a schedule for production.

- 2.GG.01 Define requirements for a project.
- 2.GG.02 Create specifications (or follow if given) for a project.
- 2.GG.03 Establish milestones for a project.
- 2.GG.04 Develop a time line for a project.
- 2.GG.05 Identify critical path components.
- 2.GG.06 Implement schedule in engineering production process.

2.HH Develop methods and plan of production.

- 2.HH.01 Determine method to be used to create the product (molding, machining, etc).
- 2.HH.02 Define efficient order of fabrication operation.
- 2.HH.03 Identify parts and materials for product.
- 2.HH.04 Make parts not readily available to specifications.
- 2.HH.05 Assemble product.

Performance Example:

1. Schedule, plan and develop a robot for local, state, or national competition using proper design and manufacturing procedures.

2.II Research New Technologies.

- 2.II.01 Define nanotechnology.
- 2.II.02 Define sensor technology.

2.JJ Complete an engineering project in at least two areas.

- 2.JJ.01 Identify a problem to be solved.
- 2.JJ.02 Generate possible solutions.
- 2.JJ.03 Select best solution.
- 2.JJ.04 Design and build using design and development tools and techniques.
- 2.JJ.05 Evaluate/test product/process to requirements.
- 2.JJ.06 Apply findings from evaluation/test to re-design and build as required.

Performance Examples:

1. Student identifies a problem with the seats in a vehicle. Following the engineering process, they create, test and present a solution to the problem
2. Student sees a need for a new product. Following the engineering process, the student creates, tests and presents the product identifying the strengths and usefulness of the product.

Strand 3: Embedded Academic Knowledge and Skills

3.A English Language Arts

VTE #	Acad #	Standard	Grade	Topic
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-9	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	10.G.1	Identify figures using properties of sides, angles, and diagonals. Identify the figures' type(s) of symmetry.	9/10	Geometry
3.B.19	10.G.2	Draw congruent and similar figures using a compass, straightedge, protractor, and other tools such as computer software. Make conjectures about methods of construction. Justify the conjectures by logical arguments.	9/10	Geometry
3.B.20	10.G.4	Apply congruence and similarity correspondences (e.g., $\triangle ABC \cong \triangle XYZ$) and properties of the figures to find missing parts of geometric figures, and provide logical justification.	9/10	Geometry
3.B.21	10.G.6	Use the properties of special triangles (e.g., isosceles, equilateral, 30° - 60° - 90° , 45° - 45° - 90°) to solve problems.	9/10	Geometry
3.B.22	10.G.7	Using rectangular coordinates, calculate midpoints of segments, slopes of lines and segments, and distances between two points, and apply the results to the solutions of problems.	9/10	Geometry
3.B.23	10.G.9	Draw the results, and interpret transformations on figures in the coordinate plane, e.g., translations, reflections, rotations, scale factors, and the results of successive transformations. Apply transformations to the solutions of problems.	9/10	Geometry
3.B.24	10.G.11	Use vertex-edge graphs to model and solve problems.	9/10	Geometry

3.B.25	10.M.2	Given the formula, find the lateral area, surface area, and volume of prisms, pyramids, spheres, cylinders, and cones, e.g., find the volume of a sphere with a specified surface area.	9/10	Measurement
3.B.26	10.M.3	Relate changes in the measurement of one attribute of an object to changes in other attributes, e.g., how changing the radius or height of a cylinder affects its surface area or volume.	9/10	Measurement
3.B.27	10.M.4	Describe the effects of approximate error in measurement and rounding on measurements and on computed values from measurements.	9/10	Measurement
3.B.28	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.29	12.D.1	Design surveys and apply random sampling techniques to avoid bias in the data collection.	11/12	Data Analysis, Statistics
3.B.30	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.31	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.32	12.D.3	Apply regression results and curve fitting to make predictions from data.	11/12	Data Analysis, Statistics
3.B.33	12.D.4	Apply uniform, normal, and binomial distributions to the solutions of problems.	11/12	Data Analysis, Statistics
3.B.34	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.35	12.D.7	Compare the results of simulations (e.g., random number tables, random functions, and area models) with predicted probabilities.	11/12	Data Analysis, Statistics
3.B.36	12.D.7	Compare the results of simulations (e.g., random number tables, random functions, and area models) with predicted probabilities.	11/12	Data Analysis, Statistics

3.B.37	12.G.1	Define the sine, cosine, and tangent of an acute angle. Apply to the solution of problems.	11/12	Geometry
3.B.38	12.G.2	Derive and apply basic trigonometric identities (e.g., $\sin^2\theta + \cos^2\theta = 1$, $\tan^2\theta + 1 = \sec^2\theta$) and the laws of sines and cosines.	11/12	Geometry
3.B.39	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.40	12.G.4	Relate geometric and algebraic representations of lines, simple curves, and conic sections.	11/12	Geometry
3.B.41	12.M.1	Describe the relationship between degree and radian measures, and use radian measure in the solution of problems, in particular, problems involving angular velocity and acceleration.	11/12	Measurement
3.B.42	12.M.1	Describe the relationship between degree and radian measures, and use radian measure in the solution of problems, in particular, problems involving angular velocity and acceleration.	11/12	Measurement
3.B.43	12.M.2	Use dimensional analysis for unit conversion and to confirm that expressions and equations make sense.	11/12	Measurement
3.B.44	12.P.7	Find solutions to quadratic equations (with real coefficients and real or complex roots) and apply to the solutions of problems.	11/12	Patterns, relations, algebra
3.B.45	12.P.9	Use matrices to solve systems of linear equations. Apply to the solution of everyday problems.	11/12	Patterns, relations, algebra

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	2	Differentiate between volume and mass. Define density.	Pre-9	Physics/Chem
3.C.20	1.2	Describe the components of the electromagnetic spectrum and give examples of its impact on our lives.		Earth/Space
3.C.21	1.2	Demonstrate knowledge of pictorial and multi-view drawings (e.g., orthographic projection, isometric, oblique, perspective) using proper techniques.		Eng/Tech
3.C.22	1.3	Demonstrate the use of drafting techniques with paper and pencil or computer-aided design (CAD) systems when available.		Eng/Tech
3.C.23	1.4	Apply scale and proportion to drawings, e.g., 1/4" = 1'0".		Eng/Tech
3.C.24	1.5	Interpret plans, diagrams, and working drawings in the construction of a prototype.		Eng/Tech
3.C.25	2.4	Describe the relationship among energy, work, and power both conceptually and quantitatively.		Eng/Tech
3.C.26	3.1	Differentiate between open (e.g., irrigation, forced hot air system) and closed (e.g., forced hot water system, hydroponics) fluid systems and their components such as valves, controlling devices, and metering devices.		Eng/Tech

3.C.27	3.2	Differentiate between specific heat and heat capacity.		Eng/Tech
3.C.28	3.3	Explain the relationship among temperature change in a substance for a given amount of heat transferred, the amount (mass) of the substance, and the specific heat of the substance.		Eng/Tech
3.C.29	3.4	Differentiate between hydraulic and pneumatic systems and provide examples of appropriate applications of each as they relate to manufacturing and transportation systems.		Eng/Tech
3.C.30	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.31	5.4	Determine the voltages and currents in a series circuit and a parallel circuit.		Eng/Tech
3.C.32	5.6	Describe the differences between Alternating Current (AC) and Direct Current (DC).		Eng/Tech
3.C.33	6.1	Identify and explain the applications of light in communications, e.g., reflection, refraction, additive, and subtractive color theory.		Eng/Tech
3.C.34	6.2	Explain how information travels through different media, e.g., electrical wire, optical fiber, air, space.		Eng/Tech
3.C.35	6.3	Compare the difference between digital and analog communication devices.		Eng/Tech
3.C.36	6.4	Explain the components of a communication system, i.e., source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.		Eng/Tech
3.C.37	6.5	Identify and explain the applications of laser and fiber optic technologies, e.g., telephone systems, cable television, medical technology, and photography.		Eng/Tech
3.C.38	7.1	Explain the manufacturing processes of casting and molding, forming, separating, conditioning, assembling, and finishing.		Eng/Tech
3.C.39	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.40	7.3	Explain the process and the programming of robotic action utilizing three axis.		Eng/Tech
3.C.41	1.9	Qualitatively distinguish between static and kinetic friction, what they depend on and their effects on the motion of objects.		Physics
3.C.42	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.43	4.2	Recognize the measurable properties of waves (e.g., velocity, frequency, wavelength) and explain the relationships among them.		Physics
3.C.44	4.4	Distinguish between mechanical and electromagnetic waves.		Physics
3.C.45	4.5	Interpret and be able to apply the laws of reflection and refraction (qualitatively) to all waves.		Physics
3.C.46	4.6	Recognize the effects of polarization, wave interaction, and the Doppler effect.		Physics
3.C.47	4.7	Explain, graph, and interpret graphs of constructive and destructive interference of waves.		Physics
3.C.48	5.1	Recognize the characteristics of static charge, and explain how a static charge is generated.		Physics
3.C.49	5.2	Interpret and apply Coulomb's law.		Physics
3.C.50	5.3	Explain the difference in concept between electric forces and electric fields.		Physics
3.C.51	5.4	Develop a qualitative and quantitative understanding of current, voltage, resistance, and the connection between them.		Physics
3.C.52		Consider environmental, biological and chemical components as they relate and/or apply to the engineering occupation.		Voc
3.C.53		Demonstrate knowledge and apply principles of Aerodynamics.		Voc
3.C.54		Demonstrate knowledge and apply basic principles of Material Sciences.		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.

- 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.