



MASSACHUSETTS
DEPARTMENT of
EDUCATION

**Vocational Technical Education
Framework**

**Manufacturing, Engineering, and
Technology Cluster**

Robotics and Automation Technology

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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.03 C 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 blue 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 maintained and repair of equipment.
- 2.D.02c Monitor equipment indicators to insure that it 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 Use process control data to monitor process.
- 2.E.05c Understand 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 Document process to insure 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 apply 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 Draw a Basic Mechanical Component Using Free-Hand Drawing Techniques.

- 2.G.01 Demonstrate knowledge of mathematical analysis for generating a free hand drawing.
- 2.G.02 Produce a free hand drawing of a mechanical component by applying proportions and direct variation principles.
- 2.G.03 Produce sketches by integrating proper sketching techniques and styles.
- 2.G.04 Select and produce the appropriate pictorial style to best communicate solutions in the design process.
- 2.G.05 Formulate pictorial sketches to develop ideas, solve problems, and understand relationships during the design process.
- 2.G.06 Create sketches utilizing both the additive and subtractive methods to assess underlying geometric and perceptual principles.
- 2.G.07 Select a sketching method that is efficient in its use of color, form, and symbols representing abstract data.
- 2.G.08 Augment pictorial sketches with shading to improve communication.
- 2.G.09 Evaluate and select the necessary views to graphically communicate design solutions.
- 2.G.10 Interpret annotated sketches in the design analysis process.
- 2.G.11 Integrate annotated sketches in presentations, portfolio, and documentation process.

Performance Example:

1. Develop properly annotated sketches to accurately convey data in a design solution.

2.H Draw a Basic 2-D Mechanical Component Using CAD Program.

- 2.H.01 Define various geometric shapes and relationships and use appropriate geometry tools to draw basic shapes.
- 2.H.02 Distinguish and define geometric constraints.
- 2.H.03 Identify the following geometric constraints in given three-dimensional models: horizontal, vertical, parallel, perpendicular, tangent, concentric, collinear, coincident, and equal.
- 2.H.04 Use the appropriate form of the Cartesian Coordinate system to measure and plot a model.
- 2.H.05 Demonstrate knowledge and understanding of conceptual modeling.
- 2.H.06 Demonstrate knowledge and understanding of graphical modeling.
- 2.H.07 Demonstrate knowledge and understanding of physical modeling.

- 2.H.08 Demonstrate knowledge and understanding of mathematical modeling.
- 2.H.09 Demonstrate knowledge and understanding of computer modeling.

Performance Example:

1. Draw a 2-dimensional sketch using a CAD package and apply the appropriate geometrical and dimensional constraints to the sketch.

2.I Draw a Basic 3-D Mechanical Component Using CAD Program.

- 2.I.01 Produce a three-dimensional drawing of an object.
- 2.I.02 Demonstrate correct use of work features and how they are applied while constructing a solid model.
- 2.I.03 Demonstrate proper use of work planes, axes, and points in the development of a computer model.
- 2.I.04 Using the computer and a parametric modeling program, design and create a unique model of an object while applying the following functions: extrude, revolve, pattern, shell, and others, as needed.

Performance Example:

1. Draw a 3-dimensional sketch using a CAD package and apply the appropriate geometrical and dimensional constraints to the sketch.

2.J Develop Assembly and Animation Drawings.

- 2.J.01 Demonstrate an understanding and application of the base component effectively in the assembly environment.
- 2.J.02 Place and create components in the assembly modeling environment.
- 2.J.03 Create circular and rectangular patterns of components within an assembly model.
- 2.J.04 Perform part manipulation during the creation of an assembly model.
- 2.J.05 Explore and demonstrate assembly-modeling skills to solve a variety of design problems.
- 2.J.06 Apply assembly constraints to successfully construct a multi-part object.
- 2.J.07 Utilize part libraries effectively during the assembly modeling process.
- 2.J.08 Employ sub-assemblies during the production of assemblies.
- 2.J.09 Apply drive constraints to simulate a range of motion of components in an assembly.
- 2.J.10 Apply adaptive design concepts during the development of sketches, features, parts, and assemblies.

Performance Example:

1. Use the appropriate CAD package to develop a 3-D assembly model and generate the appropriate animation drawings.

2.K Demonstrate knowledge of Basic Principles of Electronic Components.

- 2.K.01 Identify Electronic Components.
- 2.K.02 Identify Resistors and Potentiometers.
- 2.K.03 Identify Capacitors.
- 2.K.04 Identify Inductors and Transformers.
- 2.K.05 Identify Diodes.
- 2.K.06 Identify Transistors (FETs, SCRs, and UJT).
- 2.K.07 Identify Lamps and LEDs.

- 2.K.08 Identify miscellaneous electronic components (switches, speakers, amplifiers, etc).

Performance Example:

1. Given a set of various electronic components, identify each and briefly describe their function and application.

2.L Use Electronic Measuring Devices and Processes.

- 2.L.01 Measure electrical current through various points of an electric circuit (series, parallel, s/p combination).
- 2.L.02 Measure the voltage drop between two points and at various locations of an electric circuit (series, parallel, s/p combination).
- 2.L.03 Determine the resistance of a resistor by using the three methods listed below: a) Direct measurement by using an ohmmeter, b) Color Code Method, c) Ohm's Law.
- 2.L.04 Determine the power consumption of an electrical device by using a) Direct power measurement, b) Calculation method utilizing voltage and current measurements.
- 2.L.05 Use an oscilloscope to calculate voltages and frequency.

Performance Example:

1. Given an electronic circuit and appropriate electronic measuring devices, determine the voltage, current, resistance and power consumption at various points of the circuit.

2.M Build and Test Basic Electronic Circuits.

- 2.M.01 Construct a simple electrical circuit and investigate Ohm's Law.
- 2.M.02 Construct a series circuit and perform current and voltage measurements at various parts of the circuit.
- 2.M.03 Construct a parallel circuit and perform current and voltage measurements at various parts of the circuit.
- 2.M.04 Construct a series-parallel combination circuit and perform current and voltage measurements at various parts of the circuit.
- 2.M.05 Determine the value of a resistor in a circuit using Kirchhoff's Law of Voltages.
- 2.M.06 Determine the value of an unknown resistance in a circuit using Kirchhoff's Law of Current.
- 2.M.07 Construct circuits using various potentiometer configurations and measure current and voltages at various points of the circuit.
- 2.M.08 Determine voltage distribution and current in a Voltage Divider Circuit under load.
- 2.M.09 Construct a Wheatstone Bridge and use it to perform resistance measurements.
- 2.M.10 Construct a circuit and verify Thevenin's Theorem.
- 2.M.11 Construct a circuit and verify Norton's Theorem.

Performance Example:

1. Given various electronic components and a set of specifications, construct a simple working circuit, and perform the appropriate analysis by using Kirchhoff's Laws of Current & Voltages, Thevenin's and Norton's Theorems, Ohm's Law.

2.N Build, Test and Use Electromagnetic Devices.

- 2.N.01 Develop a map of the magnetic field around a current-carrying conductor.
- 2.N.02 Perform a profile analysis of the force-field around an electromagnet.
- 2.N.03 Determine the effect of Permeability on field strength.
- 2.N.04 Determine the effect of current on field strength.
- 2.N.05 Determine the effect of distance on field strength.
- 2.N.06 Analyze the operation of an electromechanical device (i.e. buzzer, speaker, microphone, relay, motor, generator, etc.).
- 2.N.07 Build a circuit using a relay to provide memory function.

Performance Example:

Use various electromagnetic devices to build, test, and analyze a memory circuit.

2.O Design, Build, Test, and Analyze Electronic Circuits Using Inductors, Capacitors and Transformers.

- 2.O.01 Determine factors that affect mutual inductance.
- 2.O.02 Determine the characteristics of an autotransformer.
- 2.O.03 Design and build a RL circuit and measure its impedance at different frequencies.
- 2.O.04 Design and build a circuit using capacitors, determine its RC constant, and profile the effect of frequency on its capacitive reactance.
- 2.O.05 Develop a profile of the effect of a short L/R Time Constant.
- 2.O.06 Compute and verify RC Time Constants for various RC combinations.

Performance Example:

1. Design, build, test and analyze an electronic circuit using inductors, capacitors and transformers

2.P Build and Test Resonance Circuits.

- 2.P.01 Design and build a series LC Circuit, and determine its resonant frequency.
- 2.P.02 Design and build a series Resonant Circuit and determine its response curve, Q, and Bandwidth.
- 2.P.03 Design and build a parallel LC Circuit, and determine its resonant frequency.
- 2.P.04 Design and build a parallel Resonant Circuit and determine its response curve, Q, and Bandwidth.

Performance Example:

1. Design, build, test and analyze a RLC circuit and determine its resonance frequency, time constant, Q value, Bandwidth and response curve.

2.Q Design, Build, and Test Electronic Circuits Using Diodes, Transistors, Rectifiers, and ICs.

- 2.Q.01 Use an Ohmmeter to test diodes.
- 2.Q.02 Determine a diode's voltage-current relationship for forward and reverse biasing.
- 2.Q.03 Produce a profile detailing voltage-current relationship of diodes under various load conditions.
- 2.Q.04 Develop the profile of the behavior of a Half-Wave Rectifier.
- 2.Q.05 Develop the profile of the behavior of a Full-Wave Rectifier.

- 2.Q.06 Develop the profile of the effect of a Zener Diode Regulator Circuit under varying load conditions.
- 2.Q.07 Design, build, and test a circuit using a Silicon Controlled Rectifier as a control device.
- 2.Q.08 Determine the voltage gain of a FET Voltage Amplifier.
- 2.Q.09 Explain the design, operation, and application of an IC component.

Performance Example:

1. Design, build, test and analyze an electronic circuit using diodes, transistors, rectifiers and integrated circuits.

2.R Demonstrate Knowledge of Logic Gates and their Applications.

- 2.R.01 Design, build and use a circuit to count in binary.
- 2.R.02 Design, build and use a circuit to perform as a 4-bit BCD adder, and expand it into a 8-bit adder.
- 2.R.03 Troubleshoot a 4-bit adder.
- 2.R.04 Write the Boolean expression for the logic symbol (and inverted logic symbol) of each gate.
- 2.R.05 Use NAND gates to built each of the other gates.
- 2.R.06 Use NOR gates to build each of the other gates.
- 2.R.07 Troubleshoot basic gates ICs.
- 2.R.08 Design and built a circuit to demonstrate each of the Boolean Theorems.
- 2.R.09 Design and built a circuit to demonstrate each of DeMorgan's Theorems.
- 2.R.10 Design a logic circuit to implement a given truth table by using the Boolean Theorems.
- 2.R.11 Design a logic circuit to implement a given truth table by using a Karnaugh map.
- 2.R.12 Troubleshoot a Combinational Logic Circuit.

Performance Example:

1. Design, built, test, troubleshoot, and analyze a Combinational Logic circuit.

2.S Select and Utilize Measuring Devices.

- 2.S.01 Use various thermometric devices to measure the temperature of a system.
- 2.S.02 Use various pressure measuring devices to monitor the pressure of system.
- 2.S.03 Use various level measuring devices to record the level of a fluid in a fluid system.
- 2.S.04 Use various flow measuring devices to control the flow of a fluid in a fluid system.

Performance Example:

1. Develop calibration curves for thermocouples, u-tube manometers, floaters, orifice plates and weir gages and use to perform measurements in the appropriate system.

2.T Identify the Different Modes and Elements of Process Control.

- 2.T.01 Identify the control elements and actions of a process.
- 2.T.02 Develop a process utilizing each and every mode of control.
- 2.T.03 Analyze an application of temperature control.

- 2.T.04 Analyze an application of pressure control.
- 2.T.05 Analyze an application of flow control.
- 2.T.06 Analyze an application of cascade control.

Performance Example:

1. Identify an industrial process and analyze its control parameters.

2.U Interpret Process Control Symbols and Diagrams.

- 2.U.01 Perform an analysis of a Instrument Identification or Tag Number.
- 2.U.02 Given an instrument, differentiate among general ID system, functional ID, and loop ID.
- 2.U.03 Use appropriate ISA symbols develop a process diagram of a given process control.

Performance Example:

1. Interpret an industrial process (hydraulic and/or pneumatic) given its process schematic drawing.

2.V Identify and Categorize Varying Types of Robotic Manipulators, Power Supplies and Controllers.

- 2.V.01 Determine the degrees of freedom for each type of a manipulator.
- 2.V.02 Determine the work envelop of a robot.
- 2.V.03 Given a robot's plan and elevation views determine its class.
- 2.V.04 Use the LERT system to develop a description of a robot's axes.
- 2.V.05 Given a robotic Workcell, identify and explain the robot's power supply and controller.
- 2.V.06 Identify the path of a given robot.

Performance Example:

1. Given a robotic manipulator, identify its type by using all classification parameters (also use the LERT classification system to identify it).

2.W Design and Build a Hydraulic System.

- 2.W.01 Identify the parts of a typical hydraulic cylinder and demonstrate their proper use.
- 2.W.02 Identify the various types of hydraulic pumps and demonstrate their proper use.
- 2.W.03 Identify the various types of hydraulic accumulators and demonstrate their proper use.
- 2.W.04 Identify the various types of actuators and demonstrate their proper use.
- 2.W.05 Identify the various types of hydraulic motors and demonstrate their proper use.
- 2.W.06 Identify the schematic symbol for each part of a hydraulic system.
- 2.W.07 Identify and demonstrate the proper operation of relief valves, pressure compensated flow control valves. Check valves, direction control valves and servo control valves as used in a hydraulic system.
- 2.W.08 Design, build and operate a hydraulic system.

Performance Example:

1. Design, build, test and operate a hydraulic system in accordance with a set of specifications. Also develop the appropriate schematic drawing.

2.X Design and Build a Pneumatic System.

- 2.X.01 Identify the most commonly used components (including gases) used in a pneumatic system.
- 2.X.02 Identify the various types of compressors and demonstrate their proper use/operation.
- 2.X.03 Identify and demonstrate the proper operation of desiccant dryers, receiver tanks, pressure switches and pressure regulators as used in a pneumatic system.
- 2.X.04 Identify the schematic symbols for compressors, safety release valves, single action spring return cylinders, aftercoolers, receivers, dryers, pilot regulators, slave regulators, exhaust center directional control valves, pressure center directional control valves, lubricators, filters and blocked center directional control valves as used in a pneumatic system.

Performance Example:

1. Design, build, test and operate a pneumatic system in accordance with a set of specifications. Also develop the appropriate schematic drawing.

2.Y Utilize Electronic Motors and Mechanical Drives as Part of an Automated Process.

- 2.Y.01 Identify the various types of electric motors and demonstrate their proper use/operation.
- 2.Y.02 Identify the parts of a basic DC motor and explain their function.
- 2.Y.03 Identify the parts of a basic AC motor and explain their function.
- 2.Y.04 Determine the step angle of various stepper motors.
- 2.Y.05 Determine the gear ratio for a transmission and the torque output of a motor.
- 2.Y.06 Identify the parts of a harmonic drive and their function.
- 2.Y.07 Identify the parts of an encoder and their function.
- 2.Y.08 Design, build and operate an simple electric motor.

Performance Example:

1. Design, build, test and operate an electric motor, determine all the appropriate operational and performance parameters and develop the appropriate performance curve.

2.Z Design and Build Open and Closed Loop Servo Systems.

- 2.Z.01 Identify the various control modes used in servo systems and explain their advantages/disadvantages.
- 2.Z.02 Identify the various feedback devices used in servo systems and describe their operational parameters and characteristics.
- 2.Z.03 Design and build an Open-Loop Servo system.
- 2.Z.04 Design and build a Closed-Loop Servo system.

Performance Example:

1. Design, build, test and operate an open-loop and a closed-loop system in accordance with a set of specifications. Also develop the appropriate flow chart for the process.

2.AA Design and Build a Robot-Controlled Device.

- 2.AA.01 Identify the various robot control devices and explain their function and operational characteristics.
- 2.AA.02 Identify the schematic symbols for NO, NC, combination and NO and NC mushroom head switches.
- 2.AA.03 Identify the schematic symbols for keylock switches, selector switches and indicator lamps.
- 2.AA.04 Identify the schematic symbols for NO and NC contact control relays, NO and NC time delay relay both on and off delay, NO and NC limit switches, NO and NC proximity switches and NO and NC pressure switches.
- 2.AA.05 Identify the schematic symbols for variable resistors, photoresistors and photodiodes.
- 2.AA.06 Identify the schematic symbols for bellows type switches, thermistors and strain gages.
- 2.AA.07 Design and build a mechanical switch controlled system.
- 2.AA.08 Design and build a relay-controlled system.
- 2.AA.09 Design and build a photo-controlled system.
- 2.AA.10 Design and build a strain Cage controlled system.
- 2.AA.11 Design, build and calibrate a thermocouple.
- 2.AA.12 Design and build a temperature-controlled system.

Performance Example:

1. Design, build, test and operate a robotic Workcell in accordance with a set of specifications. Also develop the appropriate schematic drawing.

2.BB Develop an Automated Manufacturing System.

- 2.BB.01 Develop a historical timeline of the NC machine.
- 2.BB.02 Describe the job shop system, flow shop system, and the project shop system. State the uses, and the advantages and disadvantages of these systems.
- 2.BB.03 Design a manufacturing process and outline the value added and non-value added jobs.
- 2.BB.04 Design and manufacture a product using FMS techniques.

Performance Example:

1. Given a set of parameters and specs, design a product utilizing fully automated techniques and the FMS principles.

2.CC Build and Utilize Fiber Optic Sensors.

- 2.CC.01 Identify the components of diffuse-reflective and thru-beam fiber optic sensors and explain their function and operational parameters/characteristics.
- 2.CC.02 Demonstrate the principles of geometric optics that underline fiber optic sensing.
- 2.CC.03 Identify the elements making up a fiber optic cable and explain their function.
- 2.CC.04 Identify the physical characteristics of the thru-beam and diffuse-reflective fiber optic cables.
- 2.CC.05 Design and build a fiber optic sensing device.

Performance Example:

1. Design, build, test and use a fiber optic sensing device in accordance to design and operational specifications.

2.DD Build and Utilize Infrared Sensing Systems.

- 2.DD.01 Identify parts of an infrared sensing system.
- 2.DD.02 Identify the various modes of operation of an infrared sensing system and explain their operational characteristics.
- 2.DD.03 Assemble, calibrate (including sensitivity control), and operate a diffuse-reflective infrared sensing system (in all modes of operation).
- 2.DD.04 Design and build an operating model of a burglar alarm system using infrared sensing.

Performance Example:

1. Design, build, test and use an infrared sensing device in accordance to design and operational specifications.

2.EE Apply Proximity Sensors to an Automated Process.

- 2.EE.01 Hardwire and operate an inductive proximity sensor using normal and inverted settings.
- 2.EE.02 Hardwire and operate an inductive proximity sensor in all modes of operations.
- 2.EE.03 Design, build, operate, and test a model inductive proximity sensing system for parts detection.
- 2.EE.04 Hardwire and operate a capacitive proximity sensor using normal and inverted settings.
- 2.EE.05 Hardwire and operate a capacitive proximity sensor in all modes of operations.
- 2.EE.06 Design, build, operate, and test a model capacitive proximity sensing system for parts detection.
- 2.EE.07 Hardwire and operate a photo proximity sensor using normal and inverted settings.
- 2.EE.08 Hardwire and operate a photo proximity sensor in all modes of operations.

Performance Example:

1. Design, build, test and operate a model proximity sensing system for parts detection in accordance to design and operational specifications.

2.FF Apply Limit Sensors/Switches to an Automated Process.

- 2.FF.01 Identify the parts of a limit switch.
- 2.FF.02 Identify the different types of switches (switch operating heads), explain their proper application, and demonstrate correct hardwiring for each.
- 2.FF.03 Identify the operating characteristics of a specific limit switch.
- 2.FF.04 Design trip dogs for specific switches and switch applications (calculations for its correct position in the system must be shown).

Performance Example:

1. Design, build, test and operate a switch control system in accordance to a set of specs.

2.GG Identify the Major Components and Operational Elements of a PLC System.

- 2.GG.01 Develop a block diagram depicting the operational components of a PLC system and their interrelations.
- 2.GG.02 Develop block diagrams for the CPU and MPU internal Registers of a PLC system.
- 2.GG.03 Identify the memory devices available to the PLC, and explain the operational characteristics of each.
- 2.GG.04 Identify the PLC communication systems and explain their function.

Performance Example:

1. Develop a schematic diagram of a typical PLC trainer, identify all its elements and explain their functions.

2.HH Perform Conversions Within the Various Numerical Systems.

- 2.HH.01 Perform conversions from decimal to binary and from binary to decimal.
- 2.HH.02 Perform conversions from binary to hexadecimal and from hexadecimal to binary.
- 2.HH.03 Perform conversions from decimal to hex and from hex to decimal.
- 2.HH.04 Perform conversions to and from the octal system.
- 2.HH.05 Perform conversions to and from the Gray Code.

Performance Example:

1. Design a clock using binary, hex, and octal notation.

2.II Developing Diagrams of a Program/Process.

- 2.II.01 Develop a input Logic Diagram for a process.
- 2.II.02 Develop an output Logic Diagram for a process.
- 2.II.03 Develop a Logic Diagram for a process.
- 2.II.04 Write, edit, and print a Ladder Logic Diagram for a process.
- 2.II.05 Develop a truth table of the sequence of operation for a process.

Performance Example:

1. Given a process, develop its I/O & process logic diagrams, the ladder logic diagram and the truth table.

2.JJ Program a PLC Unit.

- 2.JJ.01 Program I/Os and relays.
- 2.JJ.02 Perform program editing.
- 2.JJ.03 Program timers, counters, sequencers and latching relays.
- 2.JJ.04 Program Master Control Reset and Zone Control.
- 2.JJ.05 Use force functions and shift-register instructions.

Performance Example:

1. Use sequencer technology to write a program for an alarm system in accordance to a set of specs. Use the PLC to simulate the conditions of this process.

2.KK Utilize the PLC to Automate a Process.

- 2.KK.01 Automate motor control.
- 2.KK.02 Automate a punch press.
- 2.KK.03 Automate a clamp and drill routine.
- 2.KK.04 Automate an injection molding system.

- 2.KK.05 Automate a robot gripper control routine.
- 2.KK.06 Automate a palletizing routine.
- 2.KK.07 Automate a batch processing routine.

Performance Example:

1. Design, build, and program an automated process station/facility.

2.LL Calculate Basic Statistical Parameters for a Set of Data.

- 2.LL.01 Differentiate between sample and population data.
- 2.LL.02 Determine mean, media, and mode of a set of data.
- 2.LL.03 Determine the sigma of a set of data.
- 2.LL.04 Determine the R of a set of data.
- 2.LL.05 Determine number of defects (np) and % defective (p) for a population.
- 2.LL.06 Determine u, u-bar, and c for a set of data.

Performance Example:

1. Given a set of attribute data, determine the appropriate statistical parameters and graphs in accordance with a set of specifications.

2.MM Applying Probability Theory for a Variety of Events and Developing Acceptance Plans.

- 2.MM.01 Determine probability of a single event.
- 2.MM.02 Determine the probability of two or more events (P of A and B).
- 2.MM.03 Determine the probability of getting one of several events (P of A or B).
- 2.MM.04 Determine the probability of combined events (and/or combinations).
- 2.MM.05 Determine factorials and combinations.
- 2.MM.06 Use probability theory to analyze binomial distributions.
- 2.MM.07 Use the Poisson Distribution to determine probability of number of defects.
- 2.MM.08 Develop a single sampling plan for acceptance/rejection of a lot.
- 2.MM.09 Develop a double sampling plan for acceptance/rejection of a lot.
- 2.MM.10 Develop multiple and sequential sampling plans for acceptance/rejection of a lot.
- 2.MM.11 Develop a standard sampling plan using the MIL-STD-105D Tables.

Performance Example:

1. Given a set of conditions and specifications for a shipment, develop a single, double and multiple acceptance/rejection sampling plan for the lot.

2.NN Perform Data Analysis.

- 2.NN.01 Working with distribution curves.
- 2.NN.02 Drawing distribution curves by knowing x-bar and sigma.
- 2.NN.03 Working with specs and process capability.

Performance Example:

1. Given a set of data and appropriate spec parameters, determine its x-bar, sigma and process capability limits. Develop a distribution curve depicting these parameters.

2.OO Develop Control Charts from a Set of Data.

- 2.OO.01 Develop and analyze a x-bar control chart.
- 2.OO.02 Develop and analyze a R control chart.

- 2.OO.03 Develop and analyze a np control chart.
- 2.OO.04 Develop and analyze a c control chart.
- 2.OO.05 Develop a correlation between distribution curves and control charts.

Performance Example:

1. Given a set of attribute data and a set of measurement data, develop the appropriate control chart for each in accordance with a set of specs. Also, develop their distribution curves and discuss their correlations to the corresponding control charts.

2.PP Apply Communication Techniques and Strategies Used in the Engineering Process.

- 2.PP.01 Conduct a research of the various fields of engineering (scope, elements, educational requirements, prospect).
- 2.PP.02 Identify all possible career paths for engineers.
- 2.PP.03 Identify all elements of the engineering approach to solving a problem.
- 2.PP.04 Identify all elements of engineering communications.
- 2.PP.05 Apply the product development lifecycle to a design process.

Performance Example:

1. Perform a case study analysis regarding the socioeconomic and environmental impacts and the appropriate federal protection laws and regulations.

2.QQ Apply Principles of Engineering Systems.

- 2.QQ.01 Apply simple machines to create mechanical systems in the solution of a design problem.
- 2.QQ.02 Research and evaluate systems undergoing thermodynamic cycles for efficiency and present findings to the class.
- 2.QQ.03 Mathematically calculate and explain the work being done by a specific fluid power device as part of an oral presentation.
- 2.QQ.04 Safely demonstrate proper setup and adjustment of a fluid power system.
- 2.QQ.05 Evaluate and select specific fluid power sources for different functions.
- 2.QQ.06 Estimate current consumption by an electric circuit and be able to compare estimates to accurate measurements they perform.
- 2.QQ.07 Design, diagram and implement a program to control a device they construct to perform a sorting operation.

Performance Example:

1. Select and apply concepts of mechanical, electrical, thermal, pneumatic, hydraulic, and control systems in solving design problems in accordance with given specifications and guidelines.

2.RR Apply Principles of Statics.

- 2.RR.01 Mathematically analyze a simple truss to determine types and magnitude of forces supported in the truss.
- 2.RR.02 Define, describe and analyze the stresses and forces acting on an object.
- 2.RR.03 Design, construct and test a model bridge to support the greatest amount of weight per gram of bridge mass.

- 2.RR.04 Prepare and present a mathematical analysis of a truss design as part of a 5 minute oral presentation about your bridge design.
- 2.RR.05 Use a computer aided engineering package to analyze a shape.
- 2.RR.06 Identify and explain the effects that stress has on a material and explain how the material will react.

Performance Example:

1. Design, build and test a physical model of a bridge in accordance with a set of specifications and guidelines.

2.SS Test and Evaluate Various Materials.

- 2.SS.01 Identify and differentiate the five basic categories of solid engineering materials.
- 2.SS.02 Identify practical applications of each material category to engineered products and processes.
- 2.SS.03 Collect, analyze, and test samples of the four basic materials.
- 2.SS.04 Design an experiment to identify an unknown material.
- 2.SS.05 Formulate conclusions through analysis of recorded laboratory test data for presentations in the form of charts, graphs, written, verbal, and multi-media formats.
- 2.SS.06 Analyze a component of a product and describe the processes used in its creation.
- 2.SS.07 Apply statistical information to an understanding of quality assurance.
- 2.SS.08 Describe and safely conduct destructive and non-destructive material testing and use the data collected through these tests to compute and document mechanical properties.
- 2.SS.09 Analyze a product that breaks and be able to explain how the material failed.

Performance Example:

1. Perform a full stress analysis of a manufactured part in accordance with a set of specs and guidelines.

2.TT Safely Perform Basic Machine Operations (mill, lathe, drill, saws, power tools etc).

- 2.TT.01 Design and manufacture a part using a vertical mill.
- 2.TT.02 Design and manufacture a part using a lathe.
- 2.TT.03 Design and manufacture a part using various power tools.

Performance Example:

1. Design and manufacture a product in accordance with a set of specifications and guidelines using various power tools and machining equipment.

2.UU Demonstrate the Logistics and Applications of a Vision System.

- 2.UU.01 Identify applications of a vision system.
- 2.UU.02 Develop a plan for a complete vision application.
- 2.UU.03 Identify hardware components and their functions.
- 2.UU.04 Identify and explain the various elements of the software package for a vision system.
- 2.UU.05 Identify and explain the basics and idiosyncrasies of the vision system utilized.

Performance Example:

1. Identify the components of a vision system, explain their functions, and set up vision station for proper operation.

2.VV Analyze a Vision Task.

- 2.VV.01 Outline and demonstrate the process for assembly verification.
- 2.VV.02 Outline and demonstrate the process for alignment verification.
- 2.VV.03 Outline and demonstrate the process for presence/absence determination.
- 2.VV.04 Outline and demonstrate the process for dimensional measuring for a part.
- 2.VV.05 Outline and demonstrate the process for angle measurements.

Performance Example:

1. Given the parameters of and specs for a manufactured item, outline and demonstrate the correct processes for analyzing during the pre-acquiring phase of the vision task.

2.WW Use a Vision Development Environment (VDE).

- 2.WW.01 Identify hardware and software tools of the vision processor used and explain each.
- 2.WW.02 Identify and explain the events and operating modes utilized by the vision system.
- 2.WW.03 Identify the components of the PC Interface utilized.
- 2.WW.04 Identify and explain the functions of the Vision Processor Interface utilized.
- 2.WW.05 Identify the components of the file manager and explain their functions.

Performance Example:

1. Outline and demonstrate the correct process for using a Vision Development Environment.

2.XX Write a Program.

- 2.XX.01 Identify the function types and explain their applications.
- 2.XX.02 Describe how statements are incorporated into the functions, and demonstrate proper use of a statement dialogue box.
- 2.XX.03 Outline and demonstrate debugging techniques for a function.

Performance Example:

1. Demonstrate the proper elements in writing and editing a program.

2.YY Use Variables and Data Types.

- 2.YY.01 Identify and explain the various types of variables used.
- 2.YY.02 Identify and explain the various types of variable attributes.
- 2.YY.03 Identify and describe the various data types.
- 2.YY.04 Identify, describe and demonstrate the process for creating new variables with the browser.

Performance Example:

1. Demonstrate the correct processes for using the various types variables and data.

2.ZZ Configure and Use Tools and Tool Groups.

- 2.ZZ.01 Identify vision tools and set tolerances using the tolerance dialog box.
- 2.ZZ.02 Run tools in the tool group.
- 2.ZZ.03 Use the Tool Group Dialog Box.
- 2.ZZ.04 Expand tool groups.

Performance Example:

1. Create an application by developing, configuring, and modifying various vision tools as set by the standards and specs of the application.

2.AAA Acquire and Display Images.

- 2.AAA.01 Develop a plan for image acquisition.
- 2.AAA.02 Configure video and camera for the vision system used.
- 2.AAA.03 Create and configure an acquisition tool.
- 2.AAA.04 Display an image and use image database.

Performance Example:

1. Given a computer floppy disk (3.5") acquire its image and display it with all the appropriate configurations.

2.BBB Use Coordinate Systems, Calibration, Fixtures and Tools.

- 2.BBB.01 Identify the various coordinate systems used with your vision system.
- 2.BBB.02 Use a calibration tool group to perform calibration.
- 2.BBB.03 Create and configure a calibration tool.
- 2.BBB.04 Identify the various types of fixtures and their applications.
- 2.BBB.05 Create a fixture and use it in an application.
- 2.BBB.06 Create and use the Edge Tool in an application.
- 2.BBB.07 Create, configure and use the Search Tool in an application.
- 2.BBB.08 Create, configure and use the Region Tool in an application.
- 2.BBB.09 Create and use the Blob Tool in an application.
- 2.BBB.10 Create, configure and use a Light Meter Tool in an application.
- 2.BBB.11 Create and use the Point, Line, and Circle Tools in an application.
- 2.BBB.12 Create, configure and use Gauging Tools in an application.

Performance Example:

1. Given a computer floppy disk (3.5"), create, configure and use all appropriate fixtures and tools as per set of specs.

2.CCC Build the Operator Interface.

- 2.CCC.01 Outline a plan for the Operator Interface.
- 2.CCC.02 Develop the Operator Interface.
- 2.CCC.03 Calibrate a Touchscreen to the Vision Processor Monitor.

Performance Example:

1. Describe the function and applicability of the Operator Interface, describe the tools provided by the vision system for creating the O.I., and develop a full operator interface for a given object/item.

2.DDD Use Input/Output Tools.

- 2.DDD.01 Create, configure and use the Discrete Output Tool.
- 2.DDD.02 Create, configure and use the Discrete Input Tool.
- 2.DDD.03 Create, configure and use the Serial Output Tool.
- 2.DDD.04 Create, configure and use the Serial Input Tool.

- 2.DDD.05 Create, configure and use the Parser Tool.
- 2.DDD.06 Configure and use Serial Input/Output Ports.

Performance Example:

1. Create, configure and use both Discrete and Serial I/O tools and their appropriate ports.

2.EEE Configure and use the VME Tool.

- 2.EEE.01 Configure VME shared memory.
- 2.EEE.02 Use VMEbus Access in slave and master modes.
- 2.EEE.03 Configure and use the VME Toll.
- 2.EEE.04 Perform a VMEbus configuration troubleshooting.

Performance Example:

1. Describe the VEMbus capabilities of your system. Create and configure both a slave mode and a master mode for a given set of parameters and specs.

2.FFF Deploy an Application.

- 2.FFF.01 Identify the application components for your vision system.
- 2.FFF.02 Create a deployment system.
- 2.FFF.03 Perform changes in the Application.
- 2.FFF.04 Access Excel from a deployed system.

Performance Example:

1. Demonstrate the appropriate technique for creating, modifying, and using a deployment system.

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-9	Geometry
3.B.02c	7.M.2	Given the formulas, convert from one system of measurement to another. Use technology as appropriate.	Pre-9	Measurement
3.B.03c	7.P.4	Solve linear equations using tables, graphs, models, and algebraic methods.	Pre-9	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-9	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-9	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.4	Solve linear equations using tables, graphs, models, and algebraic methods.	Pre-9	Patterns, relations, algebra
3.B.16	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.17	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.18	12.D.7	Compare the results of simulations (e.g., random number tables, random functions, and area models) with predicted probabilities.	11/12	Mathematics
3.B.19	12.D.7	Compare the results of simulations (e.g., random number tables, random functions, and area models) with predicted probabilities.	11/12	Mathematics
3.B.20	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.21	12.M.2	Use dimensional analysis for unit conversion and to confirm that expressions and equations make sense.	11/12	Measurement
3.B.22	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.23	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-9	Physics/Chem
3.C.02c	3	Recognize that the measurement of volume and mass requires understanding of the sensitivity of measurement tools (e.g., rulers, graduated cylinders, balances) and knowledge and appropriate use of significant digits.	Pre-9	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	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.25	3.2	Differentiate between specific heat and heat capacity.		Eng/Tech
3.C.26	3.2	Identify and explain sources of resistance (e.g., 45deg. elbow, 90deg. elbow, type of pipes, changes in diameter) for water moving through a pipe.		Eng/Tech
3.C.27	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.28	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.29	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.30	5.4	Determine the voltages and currents in a series circuit and a parallel circuit.		Eng/Tech

3.C.31	5.5	Explain how to measure voltage, resistance, and current in electrical systems.		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	5.4	Develop a qualitative and quantitative understanding of current, voltage, resistance, and the connection between them.		Physics
3.C.51	2	Differentiate between volume and mass. Define density.		Physics/Chem
3.C.52		Demonstrate knowledge and apply principles of Aerodynamics.		Voc
3.C.53		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 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.
- 5.C.03 Calculate and apply material costs to project design.

- 5.C.04 Research and document labor and production time costs to complete product.
- 5.C.05 Identify factors that affect the final cost of manufacturing a specific part or product or running an automated process.

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.
- 5.E.03 Explain the limits to operation of a manufacturing environment within a given community setting (zoning laws).

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.