



Massachusetts Department of
**ELEMENTARY & SECONDARY
EDUCATION**

COP

Automotive Collision Repair and Refinishing

Massachusetts Department of Elementary and Secondary Education

Career/Vocational Technical Education (CTE)

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Strand 1: Safety and Health Knowledge and Skills

1.A Define health and safety regulations.

- 1.A.01a Identify and apply OSHA and other health and safety regulations that apply to specific tasks and jobs in the occupational area.
- 1.A.02a Identify and apply EPA and other environmental protection regulations that apply to specific tasks and jobs in the occupational area.
- 1.A.03a Identify and apply Right-To-Know (Hazard Communication Policy) and other communicative regulations that apply to specific tasks and jobs in the occupational area.
- 1.A.04a Explain procedures for documenting and reporting hazards to appropriate authorities.
- 1.A.05a List penalties for non-compliance with appropriate health and safety regulations.
- 1.A.06a Identify contact information for appropriate health and safety agencies and resources.

1.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.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 Compare and contrast fasteners.

- 2.A.01c Identify commonly used threaded fasteners.
- 2.A.02c Identify SAE bolt head markings.
- 2.A.03c Identify metric bolt head markings.
- 2.A.04c Identify commonly used nuts.
- 2.A.05c Identify commonly used washers.
- 2.A.06c Explain the need for flat washers and lock washers.
- 2.A.07c Identify and describe machine screws.
- 2.A.08c Identify and describe commonly used snap rings.
- 2.A.09c Explain the concept of fastener torque.
- 2.A.10c Explain how to find fastener torque specifications.
- 2.A.11c Explain when to use a general fastener torque chart.
- 2.A.12c Explain what torque sequence refers to.
- 2.A.13c Describe the various types of torque wrenches.
- 2.A.14c Explain the basic rules to follow when using a torque wrench.

2.B Demonstrate proper measuring procedures.

- 2.B.01c Describe commonly used low precision measuring tools (steel rule, tape measure, ruler, and combination square).
- 2.B.02c Identify an outside caliper and demonstrate its use.
- 2.B.03c Identify an inside caliper and demonstrate its use.
- 2.B.04c Identify a feeler gauge and demonstrate its use.
- 2.B.05c Identify a hole gauge and demonstrate its use.
- 2.B.06c Identify a telescoping/snap gauge and demonstrate its use.
- 2.B.07c Identify a vernier caliper and demonstrate its use.
- 2.B.08c Identify an outside micrometer and demonstrate its use.
- 2.B.09c Identify an inside micrometer and demonstrate its use.
- 2.B.10c Identify a depth indicator gauge and demonstrate its use.
- 2.B.11c Identify a dial indicator and demonstrate its use.

2.C Demonstrate the use of hand tools.

- 2.C.01c Identify types of screwdrivers.
- 2.C.02c Identify types of pliers.
- 2.C.03c Identify types of combination wrenches.
- 2.C.04c Identify open-end wrenches.
- 2.C.05c Identify box end wrenches.
- 2.C.06c Identify types of punches.
- 2.C.07c Identify types of chisels.
- 2.C.08c Identify types of hammers.
- 2.C.09c Identify types of pipe wrenches.
- 2.C.10c Identify types of adjustable wrenches.
- 2.C.11c Identify types of sockets.
- 2.C.12c Identify types of extensions.

- 2.C.13c Identify types of torque wrenches.
- 2.C.14c Identify types of Allen wrenches.
- 2.C.15c Identify various types of files.
- 2.C.16c Identify types of hacksaws.
- 2.C.17c Identify various types of thread cutting taps.
- 2.C.18c Identify various types of thread cutting dies.
- 2.C.19c Identify a tubing cutter.
- 2.C.20c Identify a double flaring tool.
- 2.C.21c Identify an ISO flaring tool.
- 2.C.22c Identify different types of gasket scrapers.
- 2.C.23c Identify types of wire brushes.
- 2.C.24c Identify types of bench vises.

2.D Demonstrate the use of power tools.

- 2.D.01c Drill holes to given specifications using an electric drill.
- 2.D.02c Identify types of drill bits.
- 2.D.03c Describe the difference in drilling speed for different metals.
- 2.D.04c Describe safety procedures to be followed when using an electric drill.
- 2.D.05c Identify and explain the purpose of an air impact wrench.
- 2.D.06c Identify and explain the purpose of impact sockets.
- 2.D.07c Describe maintenance needs of an impact wrench.
- 2.D.08c Describe safety procedures to follow when using an air impact wrench.
- 2.D.09c Identify and explain the purpose of an electric soldering iron.
- 2.D.10c Describe safety procedures to be followed when using an electric soldering iron.
- 2.D.11c List the type of solder to use when soldering electrical component.
- 2.D.12c Identify and explain the purpose of a bench grinder.
- 2.D.13c Describe safety procedures to follow when using a bench grinder.

2.E Inspect and repair frames.

- 2.E.01 Diagnose and measure structural damage using tram and self-centering gauges.
- 2.E.02 Attach frame-anchoring devices.
- 2.E.03 Diagnose and analyze unibody dimensions using universal measuring.
- 2.E.04 Restore corrosion protection to repaired or replaced unibody structural areas.
- 2.E.05 Attach body-anchoring devices; remove or reposition components as necessary.
- 2.E.06 Determine the extent of damage to structural steel and body panels and repair or replace as needed.
- 2.E.07 Identify heat limitations in frame repair.
- 2.E.08 Remove and replace damaged sections of structural panels in accordance with manufacturer's specifications/ procedures.
- 2.E.09 Identify procedures to remove and replace modular glass using manufacturer's specifications/procedures and recommended materials.

2.F Weld and cut metal.

- 2.F.01 Identify weldable and non-weldable materials used in collision repair.
- 2.F.02 Weld and cut high-strength steel and other metals using

- manufacturer's specifications and procedures.
- 2.F.03 Determine the correct welder type, electrode, wire type, diameter, and gas to be used in a specific welding situation.
 - 2.F.04 Set up welding equipment.
 - 2.F.05 Adjust the welder to "tune" for proper electrode stickout, voltage, polarity, flow-rate, and wire-feed required for the material being welded.
 - 2.F.06 Store, handle, and install high-pressure gas cylinders.
 - 2.F.07 Determine work clamp (ground) location and attach.
 - 2.F.08 Weld in the flat, horizontal, vertical, and overhead positions using the proper angle of the gun to the joint and direction of gun travel.
 - 2.F.09 Protect adjacent panels, glass, vehicle interior, etc., from welding and cutting operations.
 - 2.F.10 Protect computers and other electronic control modules during welding procedures according to manufacturer's specifications.
 - 2.F.11 Clean and prepare metal to be welded, assure good metal fit-up, apply weld-through primer if necessary, and clamp as required.
 - 2.F.12 Determine the joint type (butt weld with backing, lap, etc.), for each specific welding operation according to manufacturer's specifications.
 - 2.F.13 Determine the type of weld (continuous, butt weld with backing plug, etc.) for each specific welding operation according to manufacturers' and industry specifications.
 - 2.F.14 Explain the following welds: continuous, stitch, tack, plug, butt-weld with backing, and lap joints.
 - 2.F.15 Identify the causes of splits and sputters, burnthrough, lack of penetration, porosity, incomplete fusion, excessive spatter, distortion and waviness of bead, and make necessary adjustments.
 - 2.F.16 Identify cause of contact tip burn-back and failure of wire to feed, and make necessary adjustments.
 - 2.F.17 Identify cutting processes and equipment for different materials and locations in accordance with manufacturer's/industry specifications.

2.G Prepare and execute a repair plan.

- 2.G.01 Review damage report and analyze damage to determine appropriate methods for overall repair.
- 2.G.02 Develop a repair plan.
- 2.G.03 Protect panels, glass, and parts adjacent to repair area.
- 2.G.04 Soap and water wash entire vehicle; use appropriate cleaner to remove contaminants from those areas to be repaired.
- 2.G.05 Remove corrosion protection, undercoating, sealers, and other protective coatings necessary to perform repairs.
- 2.G.06 Apply safety procedures associated with vehicle components and systems such as ABS, air bags, refrigerants, batteries, tires, oil, anti-freeze, engine coolants, and fuel systems.
- 2.G.07 Apply environmental practices associated with vehicle components and systems such as substrates, fluids, refrigerants, batteries, etc.
- 2.G.08 Inspect, remove, store, and replace exterior trim and molding.

2.H Repair and adjust outer panels.

- 2.H.01 Inspect, remove, replace, and align deck lid, lid hinges and lid latch.
- 2.H.02 Inspect, remove, replace, and align doors, tailgates, hatches, lift gates, latches, hinges, and related hardware.

- 2.H.03 Inspect remove, replace, and align bumper bars, covers, reinforcement guards, isolators, and mounting hardware.
- 2.H.04 Inspect, remove, replace and align front fenders, headers, and other panels.
- 2.H.05 Straighten and rough-out contours of damaged panel to a surface condition for body filling or metal finishing using power tools, hand tools, and weld-on pull attachments.
- 2.H.06 Weld cracked or torn steel body panels; repair broken welds.
- 2.H.07 Restore corrosion protection.
- 2.H.08 Diagnose and repair water leaks, dust leaks, and wind noises; inspect, repair, and replace weather-stripping.

2.I Finish and paint automotive bodies.

- 2.I.01 Remove paint from the damaged area of a body panel.
- 2.I.02 Locate and reduce surface irregularities on a damaged body panel.
- 2.I.03 Demonstrate hammer and dolly techniques.
- 2.I.04 Heat shrink stretched panel to proper contour.
- 2.I.05 Mix body filler.
- 2.I.06 Apply body filler, shaping using a Surform file during curing, reapply, and finish sand.

2.J Repair mechanical and electrical components.

- 2.J.01 Identify suspension system fasteners that should not be reused.
- 2.J.02 Inspect alignment, adjust tension, and replace power steering pump belts.
- 2.J.03 Inspect and replace power steering hoses and fittings.
- 2.J.04 Inspect, clean, and replace a battery.
- 2.J.05 Inspect, clean, and repair or replace battery cables, connectors, and clamps.
- 2.J.06 Aim headlamp assemblies and fog/driving lamps; determine needed repairs.
- 2.J.07 Check operation of power side windows and power tailgate window.
- 2.J.08 Inspect brake lines and fittings for leaks, dents, kinks, rust, cracks or wear; tighten loose fittings and supports; replace brake lines (double flare and ISO types), hoses, fittings, and supports.
- 2.J.09 Inspect flexible brake hoses for leaks, kinks, cracks, bulging or wear; remove or replace hoses, tighten loose fittings and supports, and associated safety issues.
- 2.J.10 Reinstall wheel and torque lug nuts according to manufacturers' specifications.
- 2.J.11 Remove and reinstall caliper mounting assembly, clean and inspect for wear and damage.
- 2.J.12 Identify ABS components and theory.
- 2.J.13 Identify the proper procedures for handling brake dust.
- 2.J.14 Check for bent or damaged brake system components.
- 2.J.15 Repair electrical circuits, wiring, and connectors by using schematics, according to manufactures specifications.
- 2.J.16 Identify and comply with environmental concerns relating to refrigerants and coolants.
- 2.J.17 Inspect A/C components for damage .
- 2.J.18 Identify suspension types and components.
- 2.J.19 Disarm SRS in accordance with manufacturer's specifications/procedures.

- 2.J.20 Identify SRS components and inspect for damage.
- 2.J.21 Verify that the SRS is operational.
- 2.J.22 Identify and replace emission, belt routing, and vacuum data decals.

2.K Repair plastics and use adhesives

- 2.K.01 Identify the types of plastics.
- 2.K.02 Determine repairability of types of plastics.
- 2.K.03 Identify the types of plastics repair procedures.
- 2.K.04 Clean and prepare the surface of plastic parts.
- 2.K.05 Repair plastic parts with urethane or epoxy adhesives, using reinforcements if necessary.
- 2.K.06 Repair holes and cuts in rigid and flexible plastic parts using backing materials and adhesives.
- 2.K.07 Prepare repaired areas for refinishing.
- 2.K.08 Repair a damaged rigid / flexible plastic part using a plastic welder.

2.L Paint and refinish automotive bodies.

- 2.L.01 Select and use a NIOSH approved personal sanding respirator.
- 2.L.02 Inspect condition and ensure operation.
- 2.L.03 Perform proper maintenance in accordance with OSHA Regulation 1910.134 and applicable state and local regulation.
- 2.L.04 Select and use a NIOSH approved (Fresh Air Make-up System) personal painting/refinishing respirator system.
- 2.L.05 Perform proper maintenance in accordance with OSHA Regulation 1910.134 and applicable state and local regulation.
- 2.L.06 Select and use the proper personal safety equipment for surface preparation, spray gun and related equipment operation, paint mixing, matching and application, paint defects, and detailing (gloves, suits, hoods, eye and ear protection, etc).
- 2.L.07 Soap and water wash entire vehicle; use appropriate cleaner to remove contaminants.
- 2.L.08 Dry or wet sand areas to be refinished.
- 2.L.09 Featheredge broken areas to be refinished.
- 2.L.10 Apply suitable metal treatment or primer.
- 2.L.11 Mask trim and protect other areas that will not be refinished.
- 2.L.12 Mix primer, primer-surfacer, or primer-sealer.
- 2.L.13 Apply primer onto surface of repaired area.
- 2.L.14 Apply two-component finishing filler to minor surface imperfections.
- 2.L.15 Dry or wet sand area to which primer-surfacer has been applied.
- 2.L.16 Dry sand area to which two-component finishing filler has been applied.
- 2.L.17 Remove dust from area to be refinished, including cracks or moldings of adjacent areas.
- 2.L.18 Clean area to be refinished using a final cleaning solution.
- 2.L.19 Restore corrosion-resistant coatings, caulking, and seam sealers to repaired areas.
- 2.L.20 Prepare adjacent panels for blending.
- 2.L.21 Check and adjust spray gun operation for HVLP (high volume, low pressure) or LVLP (low volume, low pressure) guns.
- 2.L.22 Set-up (fluid needle, nozzle, and cap), adjust, and test spray gun using fluid, air, and pattern control valves.
- 2.L.23 Determine type and color of paint already on vehicle by manufacturers' vehicle information label.

- 2.L.24 Shake, stir, reduce, catalyze/activate, and strain paint according to manufacturer's recommended procedures.
- 2.L.25 Apply finish using appropriate spray techniques (gun arc, gun angle, gun distance, gun speed, and spray pattern overlap) for the finish being applied.
- 2.L.26 Apply single stage topcoat for refinishing.
- 2.L.27 Apply basecoat/clearcoat for panel blending or partial refinishing.
- 2.L.28 Apply basecoat/clearcoat for overall refinishing.
- 2.L.29 De-nib, buff, and polish finishes where necessary.
- 2.L.30 Identify the types of rigid, semi-rigid, or flexible plastic parts to be refinished, determine the materials, preparation and refinishing procedures.
- 2.L.31 Identify and mix paint using a formula.
- 2.L.32 Tint color using formula to achieve a blendable match.
- 2.L.33 Identify blistering (raising of the paint surface); determine the cause(s) and correct the condition.
- 2.L.34 Identify a dry spray appearance in the paint surface; determine the cause(s) and correct the condition.
- 2.L.35 Identify the presence of fish-eyes (crater-like opening) in the finish; determine the cause(s) and correct the condition.
- 2.L.36 Identify lifting; determine the cause(s) and correct the condition.
- 2.L.37 Identify clouding (mottling and streaking in metallic finishes); determine the cause(s) and correct the condition.
- 2.L.38 Identify orange peel; determine the cause(s) and correct the condition.
- 2.L.39 Identify overspray; determine the cause(s) and correct the condition.
- 2.L.40 Identify solvent popping in freshly painted surface; determine the cause(s) and correct the condition.
- 2.L.41 Identify sags and runs in the paint surface; determine the cause(s) and correct the condition.
- 2.L.42 Identify sanding marks (sandscratch swelling); determine the cause(s) and correct the condition.
- 2.L.43 Identify tape tracking; determine the cause(s) and correct the condition.
- 2.L.44 Identify poor adhesion; determine the cause(s) and correct the condition.
- 2.L.45 Identify dirt or dust in the paint surface; determine the cause(s) and correct the condition.
- 2.L.46 Identify finish damage caused by bird droppings, tree sap, and other natural causes; correct the condition.
- 2.L.47 Identify finish damage caused by airborne contaminants (acids, soot and other industrial-related causes); correct the condition.
- 2.L.48 Identify buffing-related imperfections (swirl marks, wheel burns); correct the condition.
- 2.L.49 Apply decals, transfers, tapes, woodgrains, pinstripes (painted and taped), etc.
- 2.L.50 Buff and polish finish to remove defects and perform any repairs required.
- 2.L.51 Clean interior, exterior, and glass.
- 2.L.52 Clean body openings (door jambs, edges, etc.).
- 2.L.53 Remove overspray.

Strand 3: Embedded Academic Knowledge and Skills

3.A English Language Arts

- 3.A.01c Integrate relevant information gathered from group discussions and interviews for reports.
- 3.A.02c Identify and use knowledge of common graphic features (charts, maps, diagrams).
- 3.A.03c Write reports based on research that include quotations, footnotes or endnotes, and a bibliography.
- 3.A.04c Apply steps for obtaining information from a variety of sources, organizing information, documenting sources, and presenting research in individual projects.
- 3.A.05c For informational/expository writing: Write well-organized research papers that prove a thesis statement using logical organization, effective supporting evidence, and variety in sentence structure.
- 3.A.06c 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.
- 3.A.07c Deliver formal presentations for particular audiences using clear enunciation and appropriate organization, gestures, tone, and vocabulary.
- 3.A.08c Use general dictionaries, specialized dictionaries, thesauruses, histories of language, books of quotations, and other related references as needed.
- 3.A.09c Comprehend and use problem-solving techniques and decision trees that are contained in service manuals and databases to determine cause-and-effect relationships.
- 3.A.10c Interpret charts, tables, or graphs to determine the manufacturer's specifications for systems operation to identify out-of-tolerance systems and subsystems.
- 3.A.11c Read technical manuals, guides, resource books and technical literature to gain information and solve problems (Operator's manual, service manuals and databases etc.).
- 3.A.12c Read, comprehend, and follow written technical directions for repairs, procedures and processes. (Shop manuals, etc.)
- 3.A.13c Write warranty reports and work orders to include information regarding problem resolution and the results of the work performed for the customer or manufacturer.

3.B Mathematics

- 3.B.01c Use a ruler, protractor, and compass to draw polygons and circles.
- 3.B.02c Given the formulas, convert from one system of measurement to another. Use technology as appropriate.
- 3.B.03c Solve linear equations using tables, graphs, models, and algebraic methods.
- 3.B.04c Use linear equations to model and analyze problems involving proportional relationships. Use technology as appropriate.
- 3.B.05c Given the formulas, convert from one system of measurement to another. Use technology as appropriate.
- 3.B.06c Compare, order, estimate, and translate among integers, fractions

- and mixed numbers (i.e., rational numbers), decimals, and percents.
- 3.B.07c Select, create, and interpret an appropriate graphical representation (e.g., scatterplot, table, stem-and-leaf plots, box-and-whisker plots, circle graph, line graph, and line plot) for a set of data and use appropriate statistics (e.g., mean, median, range, and mode) to communicate information about the data. Use these notions to compare different sets of data.
- 3.B.08c Demonstrate the ability to visualize solid objects and recognize their projections and cross sections.
- 3.B.09c Recognize and solve problems involving angles formed by transversals of coplanar lines. Identify and determine the measure of central and inscribed angles and their associated minor and major arcs. Recognize and solve problems associated with radii, chords, and arcs within or on the same circle.
- 3.B.10c Find linear equations that represent lines either perpendicular or parallel to a given line and through a point, e.g., by using the "point-slope" form of the equation.
- 3.B.11c Calculate perimeter, circumference, and area of common geometric figures such as parallelograms, trapezoids, circles, and triangles.
- 3.B.12c 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.
- 3.B.13c Describe the effects of approximate error in measurement and rounding on measurements and on computed values from measurements.
- 3.B.14c Solve everyday problems that can be modeled using systems of linear equations or inequalities. Apply algebraic and graphical methods to the solution. Use technology when appropriate. Include mixture, rate, and work problems.
- 3.B.15c Write simple proofs of theorems in geometric situations, such as theorems about congruent and similar figures, parallel or perpendicular lines. Distinguish between postulates and theorems. Use inductive and deductive reasoning, as well as proof by contradiction. Given a conditional statement, write its inverse, converse, and contrapositive.
- 3.B.16c Design surveys and apply random sampling techniques to avoid bias in the data collection.
- 3.B.17c 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.
- 3.B.18c Describe a set of frequency distribution data by spread (variance and standard deviation), skewness, symmetry, number of modes, or other characteristics. Use these concepts in everyday applications.
- 3.B.19c 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.
- 3.B.20c Compare the results of simulations (e.g., random number tables, random functions, and area models) with predicted probabilities.
- 3.B.21c Apply properties of angles, parallel lines, arcs, radii, chords, tangents, and secants to solve problems.
- 3.B.22c 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.
- 3.B.23c Use dimensional analysis for unit conversion and to confirm that expressions and equations make sense.
- 3.B.24c 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.
- 3.B.25c Find solutions to quadratic equations (with real coefficients and real or complex roots) and apply to the solutions of problems.
- 3.B.26c Solve a variety of equations and inequalities using algebraic, graphical, and numerical methods, including the quadratic formula; use technology where appropriate. Include polynomial, exponential, logarithmic, and trigonometric functions; expressions involving absolute values; trigonometric relations; and simple rational expressions.
- 3.B.27c Use matrices to solve systems of linear equations. Apply to the solution of everyday problems.
- 3.B.28c Apply mathematical operations and processes to determine conformance with the manufacturer's specifications for location, proportion, mixture, system and sub-system analysis, alignment, etc.
- 3.B.29c Compute mentally whether the observed measurement is out-of-tolerance when comparing the observed measurement to the manufacturer's specifications.
- 3.B.30c Determine the proper sequence of arithmetic operations that are needed to arrive at a solution that can be compared to other specifications when comparing system measurements or tolerances to the manufacturer's specifications and apply them.
- 3.B.31c Measure and/or test with tools designed for English or metric measurements, then convert the result to the manufacturer's system used for specifying the correct measurement or tolerance.
- 3.B.32c Solve problems that involve determining whether the proportion of the existing volume or mixture compares to the manufacturer's specifications and is within the recommended tolerance.

3.C Science and Engineering/Technology

- 3.C.01c Differentiate between weight and mass, recognizing that weight is the amount of gravitational pull on an object.
- 3.C.02c Recognize that the measurement of volume and mass requires understanding of the sensitivity of measurement tools (e.g., rulers, graduated cylinders, balances) and knowledge and appropriate use of significant digits.
- 3.C.03c Calculate mass-mass, mass-volume, volume-volume, and limiting reactant problems for chemical reactions. (as they relate to compounds used in an automobile).
- 3.C.04c Explain the relationship between temperature and average kinetic energy.
- 3.C.05c Use the combined gas law to determine changes in pressure, volume, or temperature.
- 3.C.06c Describe the chemical processes known as oxidation and reduction.
- 3.C.07c Explain how a typical battery, such as a lead storage battery or a dry

- cell, works.
- 3.C.08c Identify and explain the steps of the engineering design process, i.e., identify the problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign.
- 3.C.09c Differentiate between open (e.g., irrigation, forced hot air system) and closed (e.g., forced hot water system, hydroponics) fluid systems and their components such as valves, controlling devices, and metering devices.
- 3.C.10c Identify and explain sources of resistance (e.g., 45deg. elbow, 90deg. elbow, type of pipes, changes in diameter) for water moving through a pipe.
- 3.C.11c 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.
- 3.C.12c Differentiate between hydraulic and pneumatic systems and provide examples of appropriate applications of each as they relate to manufacturing and transportation systems.
- 3.C.13c Solve problems related to hydrostatic pressure and depth in fluid systems.
- 3.C.14c Differentiate among conduction, convection, and radiation in a thermal system, e.g., heating and cooling systems.
- 3.C.15c Give examples of how conduction, convection, and radiation are used in the selection of materials, e.g., home and vehicle thermostat designs, circuit breakers.
- 3.C.16c Explain how environmental conditions influence heating and cooling of buildings and automobiles.
- 3.C.17c Identify and explain the tools, controls, and properties of materials used in a thermal system, e.g., thermostats, R Values, thermal conductivity, temperature sensors.
- 3.C.18c Identify and explain the components of a circuit including a source, conductor, load, and controllers (controllers are switches, relays, diodes, transistors, integrated circuits).
- 3.C.19c Explain the relationship between resistance, voltage, and current (Ohm's Law).
- 3.C.20c Determine the voltages and currents in a series circuit and a parallel circuit.
- 3.C.21c Explain how to measure voltage, resistance, and current in electrical systems.
- 3.C.22c Describe the differences between Alternating Current (AC) and Direct Current (DC).
- 3.C.23c 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.
- 3.C.24c Distinguish between, and solve problems involving, velocity, speed, and constant acceleration.
- 3.C.25c Create and interpret graphs of motion (position vs. time, speed vs. time, velocity vs. time, constant acceleration vs. time).
- 3.C.26c Qualitatively distinguish between static and kinetic friction, what they depend on and their effects on the motion of objects. (apply lubrication principles to the reduction of friction, voc).

- 3.C.27c Identify appropriate standard international units of measurement for force, mass, distance, speed, acceleration, and time, and explain how they are measured.
- 3.C.28c Describe the relationship among energy, work, and power both conceptually and quantitatively.
- 3.C.29c Interpret the law of conservation of momentum and provide examples that illustrate it. Calculate the momentum of an object.
- 3.C.30c Identify appropriate standard international units of measurement for energy, work, power, and momentum.
- 3.C.31c Differentiate between specific heat and heat capacity.
- 3.C.32c 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.
- 3.C.33c Recognize that matter exists in four phases, and explain what happens during a phase change.
- 3.C.34c Identify appropriate units of measurement for current, voltage, and resistance, and explain how they are measured.
- 3.C.35c Describe electromagnetism coil and explain electromagnetism magnetic fields and forces.
- 3.C.36c State and explain the application of Pascal's law.
- 3.C.37c Describe force torque.
- 3.C.38c Describe viscosity.
- 3.C.39 Describe the electromagnetic spectrum in terms of wavelength and energy, and be able to identify specific regions such as visible light.
- 3.C.40 Recognize and explain the ways in which the direction of visible light can be changed.
- 3.C.41 Compare and contrast the nature, behavior, concentration and strength of acids and bases.
- 3.C.42 Identify and explain the applications of light in communications, e.g., reflection, refraction, additive, and subtractive color theory.
- 3.C.43 Explain the criticality of metals with different hardness, depending on the function and location of the medal and how fillers and finishes adhere.
- 3.C.44 Explain the chemical reactions that occur in system seals, compounds, contamination, deterioration, oxidation on auto finishes, and other effects to automotive parts and finishes.
- 3.C.45 Explain the role of additives or catalysts play in mixing finishes or fillers.
- 3.C.46 Explain how various forms of energy are dissipated through out the body based on the momentum of the vehicle at the time of impact.
- 3.C.47 Explain the principles of force used for realignment.

Strand 4: Employability Knowledge and Skills

- 4.A Develop employability skills to secure and keep employment in chosen field.**
 - 4.A.01a Evaluate industries, organizations, and careers based on multiple sources of research and information.
 - 4.A.02a Assess interest areas to determine potential career pathways, including career ladders.
 - 4.A.03a Develop a career plan with alternatives.
 - 4.A.04a Complete job applications and related employment documents (e.g.

- W-4).
- 4.A.05a Create professional cover letters, resumes, and portfolios in a variety of formats (print and electronic).
 - 4.A.06a Apply job search skills to seek, evaluate, apply for, and accept employment.
 - 4.A.07a Demonstrate good interviewing skills.
 - 4.A.08a Demonstrate employability skills needed to get and keep a job.
 - 4.A.09a Assess alternative occupational choices (e.g. working conditions, benefits, and opportunities to change).

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

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

4.C Solve problems using critical thinking.

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

4.D Demonstrate positive work behaviors.

- 4.D.01a Identify time management and task prioritization skills.
- 4.D.02a Explain the importance of following workplace etiquette/protocol.
- 4.D.03a Demonstrate willingness to learn and further develop skills.
- 4.D.04a Demonstrate self-management skills.
- 4.D.05a List causes of stress and effective stress management techniques.
- 4.D.06a Describe the importance of having a positive attitude and techniques that boost morale.
- 4.D.07a Show initiative by coming up with unique solutions and taking on extra responsibilities.
- 4.D.08a Explain the importance of setting goals and demonstrate the ability to set, reach, and evaluate goals.
- 4.D.09a Explain the importance of taking pride in work accomplished and extrinsic and intrinsic motivators that can be used to increase pride.

- 4.D.10a Value the importance of professionalism, including reliability, honesty, responsibility, and ethics.
- 4.D.11a Demonstrate a respect for diversity and its benefit to the workplace.

Strand 5: Management and Entrepreneurship Knowledge and Skills

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

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

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

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

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

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

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

- 5.D.01a List federal and state mandated employee rights.
- 5.D.02a Describe proper working conditions for your industry.
- 5.D.03a Explain the role of labor organizations.
- 5.D.04a Discuss the importance of diversity and list methods of encouraging diversity in the workplace.
- 5.D.05a Describe standard forms of employment contracts applicable to your industry.
- 5.D.06a State the current minimum wage, as well as wages for common jobs found within the field.
- 5.D.07a List opportunities for continual professional development.

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

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

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

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

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

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

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

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

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

5.F.06c Express a sense of personal obligation to each individual customer and his or her vehicle.

5.F.07c Exercise care for the customer's property while in your possession.

5.F.08c Repair the vehicle with the highest regard for the environment.

5.F.09c Promote and foster goodwill between the repair industry and customers.

5.F.10c Recommend corrective and maintenance services, explaining to the customer which of these are required to correct existing problems and which are for preventative maintenance.

5.F.11c Create a price estimate for work to be performed.

5.F.12c Explain legal standards regarding estimates, as established by the Commonwealth of Massachusetts Attorney General's Office.

5.F.13c Create an itemized invoice which clearly identifies any used or remanufactured parts.

5.F.14c Explain the importance of using merchandise meeting or exceeding the original manufacturers' standards.

5.F.15c Discuss offering warranties covering parts or services.

5.F.16c Identify the importance of obtaining prior authorization for all work performed.

5.F.17c List ways to notify the customer if appointments or completion promises cannot be kept.

5.F.18c Explain and identify ways to follow the Certified Technician's Code of Ethics published by the ASE: Automotive Service Excellence.

5.F.19c Explain and identify ways to follow the Auto Sales and Repair Regulations of the Massachusetts Attorney General.

Strand 6: Technological Knowledge and Skills

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

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

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

- 6.A.03a Differentiate between different operating systems and demonstrate use of at least one to open and switch between programs and files.
 - 6.A.04a Identify and demonstrate resolutions to simple hardware and software problems as they occur (e.g., frozen screen, disk error, printing problems).
 - 6.A.05a Save, retrieve, load, format, and import data into, and export a variety of electronic documents (word processing, spreadsheet, database, AND desktop publishing).
 - 6.A.06a Demonstrate the proper use of a variety of external peripherals and how they connect to a computer.
 - 6.A.07a Illustrate methods of selecting and using search engines.
 - 6.A.08a Send, receive, and manage electronic correspondence and files, in accordance with school policy.
 - 6.A.09a Demonstrate proper use of electronic proofreading tools and explain reasons why these shouldn't be relied upon solely.
- 6.B Demonstrate responsible use of technology and an understanding of ethics and safety issues in using electronic media.**
- 6.B.01a Identify ways in which technology is used in the workplace and in society.
 - 6.B.02a Summarize the rights and responsibilities of the school's Acceptable Use Policy.
 - 6.B.03a Explain laws restricting use of copyrighted materials on the Internet.
 - 6.B.04a Discuss the concerns about electronic communications, privacy and security, including protection from spyware and viruses.
- 6.C Demonstrate ability to use technology for research, problem solving, and communication.**
- 6.C.01a Locate, evaluate, collect, and process information from a variety of electronic sources.
 - 6.C.02a Demonstrate the use of telecommunications and other media to interact or collaborate with peers, experts, and other audiences.
 - 6.C.03a Demonstrate the use of appropriate electronic sources to conduct research (e.g., Web sites, online periodical databases, and online catalogs).
 - 6.C.04a Demonstrate proper style (with correct citations) when integrating electronic research results into a research project.
 - 6.C.05a Collect, organize, analyze, and graphically present data using the most appropriate tools.
 - 6.C.06a Present information, ideas, and results of work using any of a variety of communications technologies (e.g., multimedia presentations, Web pages, videotapes, desktop-published documents).
 - 6.C.07a Identify capabilities of technology resources and describe how they can be used for lifelong learning.
 - 6.C.08a Demonstrate the proper use of electronic tools and office communications equipment (telephone, fax, copier, etc).