Massachusetts Career Technical Education

Engineering Technology Framework

2014

DESE is in the process of updating all CTE Frameworks. This framework was adopted in 2014. More information about the process to update frameworks will be provided in DESE’s CCTE Newsletter.

# [Strand 2: Technical Knowledge and Skills](#_bookmark0)

###### Engineering Safety Health and Skills

* + 1. Obtain OSHA 10 Hour General Certification.
       1. Implement safety knowledge obtained on a continuous basis.
       2. Identify safety hazards in the shop, remove hazards, and develop continuous improvement solutions.
       3. Implement a tag-out and lock-out shop procedure.
    2. Performance Example:
       - Student will satisfy the requirements for an OSHA 10-hour general industry certification, based on school policy.
    3. Read, explain and implement shop safety manual and procedures according to current industry and OSHA standards.
       1. Demonstrate safety procedure(s) for maintaining machinery and equipment.
       2. Demonstrate safety procedure(s) for operating machinery and equipment.

###### Engineering – Introductory Knowledge and Skills

* + 1. Demonstrate and apply the design process.
       1. Identify a problem to be solved based on identifying customer needs.
       2. Brainstorm ideas; develop and evaluate solutions; create documentation; build and test prototype; and present design.
       3. Create new designs by working in teams using brainstorming techniques.
       4. Maintain an engineering journal to document design solutions.
       5. Conduct market surveys, research patents, search internet sources, contact companies, and develop justification for at least three solutions of given engineering problems/customer needs..
       6. Develop best solution, sketch and model idea, survey market and customers, produce a timeline, develop industry support, report results periodically, re-evaluate solution, develop criteria and limitations and produce initial drawings.
       7. Describe the role of drawings and CAD models as vital documentation components in the engineering process.
       8. Fabricate a prototype using hand tools, manual machine tools, CNC devices, joining processes, measuring and cutting techniques.
       9. Develop testing protocol, test and evaluate prototype, assess performance and function, and modify design based upon results.

2.B.01.10 Produce final drawing documentation, develop presentation, present results; patent, market, and sell idea.

* + 1. Performance Examples:
       - 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 that has been 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).
       - Student identifies a problem with the seats in a vehicle. Following the engineering process, they create, test and present a solution to the problem.
       - Student sees a need for a new product. Following the engineering process, the student creates, tests and presents the product, identifying the strengths and usefulness of the product.
       - 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. Demonstrate skills in problem solving, diagnostics, and troubleshooting.
       1. Identify the components and process of the system (equipment).
       2. Identify the problem or source of the problem.
       3. Develop solutions using a structured problem solving process.
       4. Use appropriate testing equipment and tools for diagnosing the problem.
       5. Implement the appropriate strategies to remedy the problem.

2.B.02 Performance Example:

* 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.
  + 1. Define and describe types of engineering.
       1. Describe different pathways towards a variety of engineering careers.
       2. Explain how engineers impact society, the environment, economy, and daily life through their work.
       3. Identify the unique components and considerations of the different engineering fields (e.g., civil/structural, transportation, electrical, computer, software, manufacturing, mechanical, and biological/environmental/chemical).
       4. List the attributes of design in a variety of technical fields (e.g., biotechnology, manufacturing, environmental, power and energy, transportation, etc.).
       5. Describe one major engineering category or sub-discipline and describe core tasks, working conditions, salary, education and training, skills and abilities required.

2.B.03 Performance Example:

* Select a product or process (communication for example) and develop a historical time line noting the key inventions, adaptations, and impact that occurred over a centennial time period.
  + 1. Document and communicate engineering concepts.
       1. Write a technical design report.
       2. Maintain engineering logs/notebooks/journals and portfolios for projects.
       3. Utilize a variety of media formats to convey designs and processes (animation, presentation software, web page, etc.).
    2. Develop project or product objectives and criteria.
       1. Define requirements for a project or product.
       2. Create specifications (or follow if given) for a project or product.
       3. Establish milestones for a project or product.
       4. Develop a time line for a project or product.
       5. Identify critical path components.
       6. Implement a schedule for a project or product.
    3. Develop methods and plan of production.
       1. Determine method to be used to create a product (molding, machining, etc.).
       2. Define efficient order of fabrication operation.
       3. Identify parts and materials for product.
       4. Make custom parts (those not readily available that meet specifications).
       5. Assemble a product.
    4. Explain, demonstrate and apply manufacturing process management techniques according to current industry and OSHA standards.
       1. Identify internal and external customer needs.
       2. Identify resources needed (supplies, personnel, equipment).
       3. Identify/create/provide needed standard operational procedures (SOPs).
       4. Monitor process using process control data.
       5. Explain inventory control and the implications to production and performance.
       6. Test product to verify that it meets customer specifications, regulations, etc.
       7. Demonstrate process used to document and ensure compliance.
       8. Insure timely delivery of product to customer.

2.B.07 Performance Example:

* Identify and develop a process for project development and apply it to the completion of a product/drawing/etc.
  + 1. Apply principles of 'world class' operations (i.e., industry quality standard operation).
       1. Explain quality control techniques as applied to manufacturing/engineering and technical processes.
       2. Identify and apply the concepts of total quality management (TQM) appropriate to the field.
       3. Assess a plan for continuous improvement.
    2. Apply industrial design and packaging.
       1. Explain the different elements of industrial design including branding, usability, ergonomics, sustainability, maintainability, aesthetics, etc.
       2. Design a packaging solution for a product (such as food, hair care, a tool, etc.). Explain the purposes, goals, and the risks and benefits of your design choices.
    3. Explain introductory engineering concepts.
       1. Define and use engineering notations and prefixes: tera, giga, mega, kilo, milli, micro, nano, pico.
       2. Explain Prior Technologies in several common engineering areas.
       3. Complete a reverse engineering process for a design or device.
       4. Use both metric and English systems of measurements.

2.B.10 Performance Example:

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

###### Electrical Engineering Demonstration, Design, and Implementation

* + 1. Demonstrate introductory electrical engineering knowledge and skills.
       1. Identify appropriate test devices for specific tasks (e.g., oscilloscope or multimeter).
       2. Calibrate and use test devices accurately (e.g., oscilloscope or multimeter).
       3. Read and interpret schematics.
    2. Performance Example:
       - Students measure a sine wave and provide the following information to their instructor: the peak to peak voltage, the peak voltage, the RMS voltage, the average voltage, the wave’s time (period) and the wave’s frequency.
    3. Explain and apply electrical engineering principles, and techniques and use design tools and materials according to current industry and OSHA standards..
       1. Label and describe the parts of an atom.
       2. Explain what classifies a material as an insulator, conductor, or semiconductor.
       3. Describe resistance and what its function is in circuit design.
       4. Identify resistors using color code.
       5. Measure resistance using multimeters.
       6. Identify basic circuit components (source, load, control, and conductors).
       7. Describe different types and functions of switches.
       8. Calculate voltage, current and resistance in circuits using Ohm’s law.
       9. Calculate current and voltage using Kirchhoff’s law.
       10. Measure voltage, current, and resistance in both series and parallel circuits.
       11. Describe the differences among series, parallel, and series-parallel circuits.
       12. Measure the value of capacitors using instrumentation.
       13. Identify different types of capacitors, their values, and their voltage polarity requirements.
       14. Differentiate between direct and alternating currents.
       15. Draw and label waveforms (e.g., square, sawtooth, and sine).
       16. Determine rise time, fall time, frequency, and amplitude using an oscilloscope.
       17. Demonstrate the operation of diodes and describe their function.
       18. Demonstrate the operation of transistors and describe their function.
       19. Describe the differences among display devices: LED (light emitting diodes), seven segment display and LCD (liquid crystal display).
       20. Locate logic families in a reference catalog.
       21. Read specification sheets on an individual IC to determine suitability for use in a given circuit.
       22. Perform conversions between binary and decimal, hexadecimal and binary, and hexadecimal and decimal.
       23. Use schematics and symbolic algebra to represent digital gates as part of a solution to a design problem (logic symbols: AND, OR, NOT, NAND, NOR, X- OR and X-NOR gates).
       24. Create Boolean expressions and truth tables.
       25. Select min-term and max-term expressions (sum of product: SOP, product of sum: POS).
       26. Use DeMorgan’s theorem to convert a SOP to a POS in order to save resources in the production of circuits.
       27. Formulate and use a Karnaugh Map and/or Boolean algebra to reduce logic equation.
       28. Describe duality of logic functions.
       29. Simplify, solve, construct, and demonstrate a circuit from a digital word problem.
       30. Design circuits using reprogrammable logic devices.

2.C.02 Performance Example:

* Student will design and build an alarm circuit that utilizes two different alarm signals (light and sound, two different sounds, etc.)
  + 1. Build and implement electrical engineering circuits.
       1. Simulate a circuit.
       2. Construct a circuit.
       3. Troubleshoot problems with a circuit.
       4. Create PLD (Programmable Logic Devices) logic files.
       5. Construct and test simple latches and flip-flops from discrete gates.
       6. Interpret, design, draw, and evaluate circuits using logic symbols (triggers, latches, flip-flops).
       7. Create timing diagrams and truth tables for J-K flip-flop.
       8. Analyze timing diagrams.
       9. Explain timing requirements of ICs.

2.C.03 Performance Example:

* Student will create a circuit that will display a message (time, temp., etc.).

###### Mechanical Engineering Demonstration, Design, and Implementation

* + 1. Demonstrate introductory mechanical engineering knowledge and skills.
       1. Identify the various industry-wide prototyping methods in use.
       2. Describe common engineering plastics, processing, additives, fillers, colorants, modifiers, and their effects on properties.
       3. Select suitable materials for a given application.
       4. Use the measurement units of mass, length, angles and time and their extensions (e.g., velocity, density)
       5. Identify and use devices and gauges (i.e. rulers, scales, timers, calipers, radius gauges, protractors) to accurately measure units of mass, length, angles, and time and their extensions.
       6. Calibrate mechanical measurement devices and gauges.
       7. Interpret detail and assembly drawings, technical processes, procedures, and instructions.
       8. Extract and analyze properties of mass (i.e. volume, density, moment of inertia, etc.).
       9. Evaluate the function and operation of assembly (motion, interference, etc.) of a mechanical design.
       10. Demonstrate ethical challenges facing engineers in the design, redesign, repair and implementation of products.
       11. Demonstrate various classes and subclasses of common engineering materials (e.g., organics, metals, polymers, ceramics, and composites) and their properties (solid, liquid, and plasma gas) from macrostructure to microstructure.
       12. Demonstrate the use and application of the various classes and subclasses of materials.
       13. Demonstrate property changing treatments (i.e. heat, chemical, additives, etc) in a variety of materials.
       14. Describe and define the process of casting and molding as it relates to the engineering process and fabrication.
       15. Trace the production of engineering materials from raw material to finished product as well as disposal, recycling, and describe the environmental impact of each process.
       16. Demonstrate how the properties of materials and their use influences the reliability of a mechanical design (i.e. Mean Time Between Failure: MTBF, etc.)
       17. Describe how design choices will affect the likelihood of safety and liability issues arising within the end use of a designed product.
       18. Explain and demonstrate where material removal or addition would be the appropriate process to use in production (e.g., turning, milling, grinding, and plating).
       19. Describe the process of forming (e.g., bending, forging, cutting, etc).
       20. Explain how design choices will affect the ease and efficiency of manufacturing the designed product.
    2. Performance Examples:
       - Student will create a 3-D model of a part or assembly, analyze its mass properties, dynamic function, and perform finite element analysis.
       - Student will describe the process for creating metals, plastics, ceramics or composites, conventional processing techniques, machining, forming and joining methods and common applications by creating a poster-board display.
       - Student will create a case study and debate the liability, reliability, and safety issues for the design of a toy listed as a ‘dangerous toy’ by consumer groups.
    3. Explain and apply mechanical engineering principles and techniques, and use design tools and materials according to current industry and OSHA standards.
       1. Define geometric shapes, line types, tools, and describe constraints used in sketching.
       2. Prepare clear and accurate hand sketches using orthographic and perspective views.
       3. Prepare clear and accurate hand sketches using annotative labels including materials, processes, functions and dimensions.
       4. Apply scale, dimensioning, and tolerance standards to drawings.
       5. Define and implement Geometric Dimensioning and Tolerancing (GD&T) for production drawings.Create and edit a solid model using a 3-D modeling program, based upon design sketches. Utilize appropriate materials, measurements, fits, appearances, processes and functions.
       6. Combine model parts into working assembly, manipulate and animate assembly using a 3-D modeling program.
       7. Analyze parts and assemblies with respect to safety, handling, end user, production, cost, packaging, and environmental impact.
       8. Create detail and assembly drawings based upon 3-D models.
       9. Annotate detail drawings with dimensions, materials, processes and appropriate views.
       10. Create section, detail, broken-out, break, and auxiliary views.
       11. Create an assembly drawing with: balloons, a parts list containing items, quantities, descriptions and part numbers, appropriate assembly notes; and a titleblock based upon 3-D models.
       12. Create a numbering system for each drawing set.
       13. Identify, describe and prescribe ferrous and non-ferrous metals, plastics, ceramics and composites, based upon their micro and macro structures, relationship between micro structure and properties, common property changing procedures and treatments.
       14. Design items using common engineering plastics based upon their processing, additives, fillers, colorants, modifiers and the effects on properties.
       15. Analyze, describe, and test the concepts of simple machines: gears, pulleys, lever, wheel and axle, wedge and screw, and determine their mechanical advantages.
       16. Analyze, describe, and test fluid systems based upon flow, pressure, density, temperature, elevation, and friction.
       17. Analyze, describe, and test heat flow systems based upon conduction, convection, and radiation, and perform heat loss calculations.
       18. Analyze, describe and test basic beam deflection relationships; stress, strain, tension, compression, torsion, moments for common cross-sectional shapes and materials using such techniques as finite element analysis (FEA).
       19. Construct free body diagrams, resolve forces into vector components, solve static equations and calculate stress, strain, deflection, moment of inertia, linear and angular velocity and acceleration.
       20. Identify where material joining would be the appropriate process to use in production (gluing, welding, etc.)

2.D.02 Performance Example: Students will:

* For a complex assembly (guitar, bicycle, hair dryer, arbor press, gearbox, and hydraulic jack), create: 3D models of all parts; a 3-D assembly model; a 2-D assembly drawing with a parts list, balloons, and assembly notes and all detail drawings with dimensions, material notes, and a completed titleblock.
* Draw the atomic (cubic), micro (crystalline) and macro (grain) structures for steel. Describe how steel becomes hardened with the addition of carbon to the cubic structure, closing of interstitial spacing in crystalline structures and the formation of carbides at the grain boundaries. Describe tempering, annealing, stress-relieving, and quenching processes as they relate to the properties of steel. Create a poster board titled: “Steel, its Structures, Treatments, and Properties.”
* Design and build a device or number of devices that use all six simple machines (lever, wheel and axle, pulley, inclined plane, wedge and screw) to transfer energy from one device to another.
* Design and build a hydraulic system to lift a known weight a defined distance in a specified time. Calculate the required input and output force, work and power for the system.
* Perform a heat loss study for a device. Consider convective, conductive, and radiation heat loss. For convective heat loss q = hc \* A \* T. For conductive heat loss q = k \*A \* T/s. For radiation heat loss q = σ \* T4 \* A.
* Create a tensile test specimen and test to failure. Record the force and elongation of sample at multiple points during testing; calculate the stress and strain; and plot a graph of stress versus strain. Determine the elastic range, proportional limit, yield point, resilience, plastic deformation, and the modulus of elasticity from the data. Compare to known values for the material.
* Design a structure utilizing trusses to support a known weight such as a crane. Solve the static equations necessary to determine maximum stress, strain, and deflection for the structure.
* Design a device to transmit linear motion into rotational motion. Determine the input linear velocity and calculate the output angular velocity and acceleration. Examples are:

rack and pinion steering, a piston and crankshaft, a pulley and cord. Determine the output force based upon the input force or weight and the angular acceleration.

* + 1. Build and implement mechanical engineering designs.
       1. Use industry-wide prototyping methods including rapid-prototyping.
       2. Build a prototype model from a drawing database.
       3. Set up and operate a basic manufacturing assembly process, resulting in a finished product.
       4. Build mechanical parts utilizing techniques such as turning, milling, cutting, bending, etc.

2.D.03 Performance Example:

* Students create parts for a mechanical assembly utilizing techniques such as turning, milling, cutting, bending, forming and 3-D printing. Students assemble parts and test for proper functioning.

###### Automated Systems Engineering Demonstration, Design, and Implementation

* + 1. Demonstrate automated systems engineering introductory knowledge and skills.
       1. Define an automated system and a robot.
       2. Evaluate the impact robots have on manufacturing and society.
       3. Classify different types of robots.
       4. Identify specifications for the work envelope of a robot.
       5. Identify and sketch the components of a robot.
       6. Describe servo, stepper and DC motors and possible uses.
       7. Describe the components of robot controllers.
       8. Select, size, and implement interface device(s) to control a motor(s).
       9. Describe ways an end effector is specific to a process.
       10. Explain the need for end of arm tooling and how it affects the robot’s operation.
       11. Describe various applications of a programmable logic controller (PLC) as related to its use in a computer integrated manufacturing (CIM) system.
       12. Describe the difference between a PLC and a computer with interface.
       13. Identify individual components used in CIM systems.
       14. Explain the significance of teamwork and communication when combining the designs of the individual groups into a complete model of Flexible Manufacturing Systems (FMS).
       15. Differentiate between open and closed loop control.
       16. Design and create a program to evaluate data and make decisions using external digital and analog sensors.
       17. Formulate a flow chart to correctly apply basic programming concepts.
       18. Describe the function of sensors in electronic circuitry (temp., optical, etc.).
       19. Explain the principles of control techniques and computer simulations.
       20. Compare and contrast the benefits and drawbacks of the three categories of CIM manufacturing systems.
       21. Describe the working relationship between the CNC mill and the robot.
       22. Analyze and select CIM system components for a specific industrial application.
    2. Performance Example:
       - Students will compare and contrast a servo, a stepper motor, and a DC motor and describe how they are utilized in an automated system.
    3. Explain and apply automated systems engineering principles and techniques, and use design tools and materials according to current industry and OSHA standards.
       1. Design an end effector.
       2. Design a working model of a robot or automated system.
       3. Program a robot or automated system to perform several tasks.
       4. Program a robot or automated system to solve a materials handling problem.
       5. Design an automated feed system with sensors.
       6. Design an interface that inspects, evaluates, and manages program parameters during the operation of the program.

2.E.02 Performance Example:

* Students will design an automated control system (door opener, automatic window shade, lighting control, etc.)
  + 1. Build and implement automated systems engineering designs.
       1. Develop an end effector.
       2. Build a working model of a robot or automated system.
       3. Build drive systems used in robotics or automated system.
       4. Operate a CIM system utilizing appropriate safety precautions.
       5. Demonstrate how individual components work together to form a complete CIM system.
       6. Assemble and test individual component designs by integrating them into a complete model FMS.
       7. Run, test, evaluate, and redesign system operation.
       8. Build an automated feed system with sensors.

2.E.03 Performance Examples:

* Using industry standard devices and controls, students will build and program a fully functioning robotic device that will perform a multi stepped task (travel to a location; pick up an object; move to another position; and place the object in a specific receptacle, etc.)
* Students will build an automated control system (door opener, automatic window shade, lighting control, etc.)

###### Civil Engineering/Architecture Demonstration, Design, and Implementation

* + 1. Demonstrate civil engineering/architecture introductory knowledge.
       1. Describe the importance of architecture and civil engineering and their evolution over time.
       2. Compare and contrast various architectural styles.
       3. Describe the components of and coordination required of an entire construction document set including: mechanical, electrical, plumbing, civil, structural and architectural drawings.
       4. Use an architectural or engineering scale to measure drawings.
       5. Identify various structural systems (i.e. steel frame, concrete frame, etc.) including foundation types.
       6. Explain surveying strategies and equipment use.
       7. Describe the importance of sustainable design.
       8. Identify and differentiate among the responsibilities of various members of a project team including the design (architect, engineers, etc.) and construction team (general contractor, subcontractors, etc.) members.
       9. Solve statics problems using computerized packages (e.g., MD Solids).
       10. Calculate stress and strain in simple parts.
       11. Plot a stress/strain diagram.
       12. Describe the parts of a stress/strain diagram.
       13. Perform moment of inertia calculations.
       14. Solve for stress, strain, and deflection in common beam shapes.
       15. Analyze, describe, and test basic beam deflection relationships: stress, strain, tension, compression, torsion, moments for common cross-sectional shapes and materials, using such techniques as finite element analysis (FEA).
       16. Construct free body diagrams; resolve forces into vector components; solve static equations; and calculate stress, strain, deflection, moment of inertia, linear and angular velocity and acceleration.
    2. Performance Examples:
       - Students will research and present a chosen architectural style.
       - Students will conduct a tensile test using a structural analyzer and use the results to create a stress/strain diagram.
    3. Explain and apply civil engineering/architectural principles and techniques, and use design tools and materials according to current industry and OSHA standards.
       1. Create a site survey.
       2. Conduct soil testing and analyze the results.
       3. Analyze a site and determine the drainage requirements.
       4. Design site grading including cut and fill volume calculations.
       5. Create a commercial site design including parking, roads, and landscaping.
       6. Apply building codes, regulations, and standards to a construction project.
       7. Calculate dead, live, and environmental (snow, wind) loads on a structure.
       8. Trace gravity loads through a structure from their point of application to the building’s foundation.
       9. Determine the tributary area of a particular structural element.
       10. Design a simply supported beam including an analysis of shear, bending moment and deflection requirements.
       11. Create a cost estimate for a construction project.
       12. Perform heat loss calculations.
       13. Apply sustainable design to a project.

2.F.02 Performance Example:

* Students will design a simply supported beam, column, and foundation of a one-story commercial building.
  + 1. Build and implement civil engineering/architecture designs.
       1. Create a 3D computer model of both residential and commercial buildings.
       2. Build a scale model of a building with a particular architectural style.
       3. Build, test, and redesign a scale model of an engineering structure (e.g., building, bridge, etc.).
       4. Create an as-built drawing set including plans, sections, and details.

2.F.03 Performance Examples:

* Students will use computer modeling software to create rendered drawings and a walk-through of a building.
* Students will create a balsa wood bridge and perform destructive testing.

Third Year Engineering Integrated Areas and Engineering Maintenance

Below are listed additional Categories of Learning, Standards and Objectives beyond the scope of the two year DESE requirement. They are placed in the Appendices as reference and can be used in the third year of an Engineering Technology program.

###### 2.G\* Third Year Engineering Integrated Area Research Design, Implementation and Maintenance

2.G.01\* Demonstrate integrated area research introductory knowledge.

* + - 1. \* Identify and explain additional engineering areas such as, but not limited to: Manufacturing, Aerospace, Environmental, Nuclear, Mining, Green/Sustainable Technologies, Geological, Agricultural, Marine and Ocean.
      2. \* Identify an emerging or other engineering area for student research. 2.G.01.03\* Present an emerging or other engineering area’s design for a business plan.
    1. Performance Examples: Student will:
       - Research an engineering topic of interest. Use expanding knowledge to develop a project/presentation. Reflect on use of prior core knowledge and project possibilities/uses in the selected engineering focus.
       - Develop a work improvement plan for a current co-op job experience relating to how a company operates in manufacturing.

2.G.02\* Explain and apply integrated area research principles and techniques, and use design tools and materials according to current industry and OSHA standards.

* + - 1. \* Develop a working design of a system used in an emerging or other selected engineering area.
      2. \* Identify components of design for the selected emerging or other engineering area.
      3. \* Identify how a component or subsystem of a design relates to core engineering learning area(s).

2.G.02 Performance Example:

* Student will design and develop a system to process used cooking oil for use in low powered diesel engines.

2.G.03\* Build and implement integrated area research designs.

2.G.03.01\* Build a model of a system for a selected emerging or other engineering area based on a business plan and working design.

2.G.03 Performance Example:

* Student will build a system for converting solar energy into electrical energy for use in the home. Student will develop a business plan and marketing strategy aimed at potential investors.

###### 2.H\* Third Year Elective Engineering Area Design Template

2.H.01\* Demonstrate elective engineering area introductory knowledge and skills.

*Note: This section provides a framework to help an Engineering Technology student pursue a personally interesting, self-selected domain of engineering for study.*

*This choice is in addition to the required standard sections, namely, Electrical, Mechanical, Automated Systems and Civil Engineering. This option may serve as a third year study elective, perhaps the basis for a senior year project or an advanced practice opportunity in the engineering design process.*

*Choices are as limitless, as are the many areas of engineering. A small example of engineering areas of focus would be: Environmental, Medical Device, Aeronautical*, *Computer Firmware, High Power Electrical, Municipal Systems, Chemical Manufacturing, Automotive Embedded Systems, Ceramics, Optical Sensor, Nuclear Power, Agricultural, etc.*

2.H.01.01\* Identify an elective engineering area (EEA) of interest. 2.H.01.02\* Present initial research and rationale of the feasibility for further

engineering study and activities within the EEA of choice.

* + - 1. \* Determine and demonstrate knowledge of essential scientific discoveries for the EEA.
      2. \* Determine and demonstrate knowledge of the mathematics required for success in engineering within the EEA.
      3. \* Describe the engineering history within the EEA.
      4. \* Explain the evolution and the state of the art of the technology (both devices and processes) within the EEA.
      5. \* Identify and demonstrate *knowledge* of the design tools, design techniques and materials utilized in the EEA.
      6. \* Identify and demonstrate *knowledge* of implementing and building a design within the EEA.
      7. \* Identify and demonstrate *knowledge* of the tools, techniques, skills and materials utilized in the maintenance of the system for the EEA.

2.H.01.10\* Comprehensively review and document your introductory EEA findings.

Note: this is to strengthen your understanding of the feasibility of

continuing your EEA efforts to include engineering design, implementation and maintenance within this domain.

* + 1. Performance Example:
       - Student presents their introductory findings on their elective engineering area to an audience of instructor(s) and peers for review. They declare their plans for an actual design or redesign, implementation and maintenance of their EEA subsystem.

2.H.02\* Explain and apply elective engineering area principles, and techniques and use design tools and materials according to current industry and OSHA standards.

* + - 1. \* Analyze or reverse engineer a design of a system, subsystem or component, typical of your EEA.
      2. \* Demonstrate a working knowledge of the design techniques typical of your EEA industry.
      3. \* Create or recreate an *initial* EEA design (i.e. schematics, drawing, flowcharts, psuedocode, etc.) using elementary design tools typical to the chosen engineering domain.
      4. \* Specify materials and/or components for your EEA design. 2.H.02.05\* Determine a maintenance strategy for your EEA design.
      5. \* After review and update of the initial design, create or recreate a working design (if possible, using computer aided design (CAD) tools) typical of your EEA industry.
      6. \* Follow the engineering design process through all stages of your EEA design or emulated design.

2.H.02 Performance Example:

* Student profiles their reverse engineering project, in words and photos, for inclusion in their vocational portfolio.

2.H.03\* Build and implement elective engineering area designs.

*Note: Dependant on the domain of the chosen EEA, the implementation or building specified in this section, may be physical or in some other form such as software.*

* + - 1. \* Build a model or working prototype of your EEA design or redesign. Or, alternatively, fashion a model of an emulated commercial EEA design.
      2. \* Specify and document processes that will ensure efficiency in the commercial manufacturing of an EEA design (either yours or an existing one).

2.H.03 Performance Example:

* Student builds, and utilizes, a jig or fixture which demonstrates increased efficiency in some element of the manufacturing of a component within an EEA design.

2.H.04\* Maintain elective engineering area designs.

* + - 1. \* Identify skills required for personnel who will perform maintenance and repair of design(s) typical of your EEA.
      2. \* Identify the tools and processes for maintenance and repair of your design or of design(s) typical for your EEA.
      3. \* Practice providing maintenance and/or repair of design(s) typical of your EEA, while keeping a repair log.

2.H.04 Performance Example:

* Student performs a maintenance test on their EEA implementation based on its design. They inset a fault or bug into their prototype and then allow a fellow student to determine the fault, while tracking the time and ease of diagnosis.

###### 2.I\* Engineering Maintenance

2.I.01\* Maintain electrical engineering equipment.

* + - 1. \* Identify skills for appropriate person(s) for maintenance and repair of electrical equipment.
      2. \* Identify the tools and processes for appropriate person(s) for maintenance and repair of electrical equipment.
      3. \* Research and provide preventative maintenance on an electrical system (such as a 3D printer), keeping a log for documentation. Provide corrective maintenance on an electrical system.
      4. \* Monitor equipment operational indicators to insure that equipment is performing according to manufacturer’s specifications .
    1. Performance Example:
       - Student will create a preventative maintenance schedule on an electrical system (such as an oscilloscope), keeping a log for documentation.

2.I.02\* Maintain mechanical engineering equipment.

* + - 1. \* Identify required skills for maintenance and repair of mechanically designed equipment.
      2. \* Identify the tools and processes required for maintenance and repair of mechanically designed equipment.
      3. \* Research and provide preventative maintenance on a mechanical system (such as a bicycle, lathe, or automobile), keeping a log for documentation. Provide corrective maintenance on a mechanical system.
      4. \* Monitor equipment operational indicators to insure that equipment is performing according to current industry and OSHA standards,
      5. \* Maintain, inventory, and organize tools and equipment.
      6. \* Develop and maintain a written log for service and repair of tools and equipment.
      7. \* Maintain electronic and mechanical devices and gauges as specified by manufacturer, including cleaning, storage and calibration.
      8. \* Store, retrieve, copy, and output drawing files depending upon system setup.

2.I.03\* Maintain automated systems engineering equipment.

2.I.03.01\* Identify skills required for maintenance and repair of an automated system. 2.I.03.02\* Identify the tools and processes required for maintenance and repair of an

automated system.

2.I.03.03\* Research and provide preventative maintenance on an automated system (such as a robot), keeping a log for documentation. Provide corrective maintenance on an automated system.

2.I.03.04\* Monitor operational indicators to insure that the automated system is performing according to current industry and OSHA standards.

2.I.03 Performance Example:

* Student will prepare a schedule to monitor operational indicators to insure that the automated system is performing according to current industry and OSHA standards (such as small CIM system).

2.I.04\* Maintain civil engineering/architecture equipment.

2.I.04.01\* Identify skills required for maintenance and repair of a structure. 2.I.04.02\* Identify the tools and processes required for maintenance and repair of a

structure.

2.I.04.03\* Research and describe preventative maintenance on a system (such as a bridge), keeping a log for documentation. Provide corrective maintenance on a system.

2.I.04.04\* Monitor structural operational indicators to insure that the system is performing according to current industry and OSHA standards.

2.I.04 Performance Example:

* Student will use sensors to observe the performance of a built structure.

2.I.05\* Maintain integrated area research equipment.

* + - 1. \* Identify skills required for maintenance and repair of integrated areas equipment.
      2. \* Identify the tools and processes required for maintenance and repair of integrated areas equipment.
      3. \* Research and provide preventative maintenance on integrated areas system, keeping a log for documentation. Provide corrective maintenance on another engineering areas system.

# [Embedded Academic Crosswalks](#_bookmark0)

### [Embedded English Language Arts and Literacy](#_bookmark0)

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| **CTE**  **Learning Standard Number** | **Strand Coding Designation Grades ELAs**  **Learning Standard Number** | **Text of English Language Arts Learning Standard** |
| 2.A.01 –  2.A.02  2B.01 –  2.B.10  2.C.01-  2.C.20 | WHST. Grades 6-12.10 | Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences |
| Performance Example: | Students will create and maintain over a period of time, logs and/or journals that reflect understanding of a variety of professional skills and professional vocabulary. Students will use domain specific vocabulary and demonstrate standard English grammar and usage. |  |
| 2.A.02.01  2.A.02.02 | RST. grades 9-10.1 | Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions |
| Performance Example: | Students will read technical texts and supporting articles and summarize the precise details of shop safety procedures in 2 column notes. |  |
| 2.B.01.02  2.B.01.03 | SL. Grades 8-.1a-d SL. Grades 9 -10.1a-d SL. Grades 11-12.1a-d | 8.  Engage effectively in a range of collaborative discussions (one-on- one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others’ ideas and expressing their own clearly.   1. Come to discussions prepared, having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. 2. Follow rules for collegial discussions and decision-making, track progress toward specific goals and deadlines, and define individual roles as needed. 3. Pose questions that connect the ideas of several speakers and respond to others’ questions and comments with relevant evidence, observations, and ideas. 4. Acknowledge new information expressed by others, and, when warranted, qualify or justify their own views in light of the evidence presented   9-10  Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9–10 topics, texts, and issues, building on others’ ideas and expressing their own clearly and persuasively.   1. Come to discussions prepared, having read and researched   material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or |
|  |  | issue to stimulate a thoughtful, well-reasoned exchange of ideas.   1. Work with peers to set rules for collegial discussions and decision- making (e.g.,, informal consensus, taking votes on key issues, presentation of alternate views), clear goals and deadlines, and individual roles as needed. 2. Propel conversations by posing and responding to questions that relate the current discussion to broader themes or larger ideas; actively incorporate others into the discussion; and clarify, verify, or challenge ideas and conclusions. 3. Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented   11-12  Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 11–12 topics, texts, and issues, building on others’ ideas and expressing their own clearly and persuasively.   1. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. 2. Work with peers to promote civil, democratic discussions and decision-making, set clear goals and deadlines, and establish individual roles as needed. 3. Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives. 4. Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what   additional information or research is required to deepen the investigation or complete the task. |
| Performance Example: | Students will participate effectively in collaborative efforts to brainstorm ideas and develop and evaluate solutions. Students will practice listening and engaging in diplomatic responses using professional language and | sound reasoning. |
| 2.b.01-  2.B.10  2.C.01-  2.C.20 | RST. grades 9-10.3  RST. Grades 11-12.3 | 9-10  Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text  11-12  Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. |
| Performance Example:   1. Students will read technical texts, such as but not limited to, service manuals or manufacturers’ recommendations, then follow a variety of complex multistep procedures to successfully complete the task. | 1. Students will read technical texts, such as but limited to, manuals or manufacturers’’ recommendations, then record using two column notes or any appropriate graphic organizer domain specific words and phrases relevant to | the technical procedures performed.. |
| 2.B.01-  2.B.10 | L. grades 9 – 12.6 | Acquire and use accurately general academic and domain-specific |
| 2.C.01-  2.C.20 |  | words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression |
| Performance Example: | Students will use domain specific words and phrases when performing technical tasks/procedures in the career area and related settings when working with the instructor, classmates or clients. |  |
| 2.B.03.02  2.B.01.10  2.B.07.05  2.B.09.02  2.C.05.13  2.C.05.17  2.C.07.01  2.C.07.23  2.C.07.30  2.C07.34  2.C.07.36  2.C.11.08 | SL. Grades 8.4  SL. Grades 9 – 10.4  SL. Grades 11-12.4 | 8.  Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation  9-10  Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.  11-12  Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks. |
| Performance Example: | Students will orally present to the instructor/class demonstrations and/or role plays on content specific technical techniques using domain specific vocabulary. Students will accurately and concisely describe the technical processes, techniques and tools. |  |
| 2.C.02.14  2.C.02.19  2.C.05.18  2.C.06.01  2.C.11.04  2C.12.03  2.C.13.03 | RST. Grades 6-12.4  RST.6-10.9 | Determine the meaning of symbols, key terms, and other domain- specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–12 texts and topics  6-8  Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.  9-10  Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts |
| Performance Example: | Using graphic organizers such as top-down webs, Venn diagrams, T sheets and others, students will compare and contrast technical information such as, but not limited to, engineering designs, architecture and tools. |  |
| 2.B.01.05  2.B.01.06  2.B.10.01  2.B.03.02  2.B.03.05  2.C.04.03 | W. grades 9-12.7 | 7  Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize  multiple sources on the subject, demonstrating understanding of the subject under investigation. |
| 2.C.05.17  2C.05.22  2C.07.36  2C.08.03  2.C.08.03  2.C.09.02  2.C.12.03  2.C.13.02  2.C.16.03  2.C.17.01  2.C.17.02  2.C.19.01  2.C.20.03 | W. grades 9-10.8  RST. Grades 9-10.10  RST. Grades 11-12.10 | 8  Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation  Grades 9-10.10  By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.  Grades 11-12.10  By the end of grade 12, read and comprehend science/technical texts in the grades 11–CCR text complexity band independently and proficiently |
| Performance Example:  Using technology, texts, manuals and other resources, students will research and write a paper on a content specific topic demonstrating knowledge of subject. Students will document the research using works cited pages, bibliographies and/or in-text citations. Students will demonstrate command of the conventions of standard English grammar and usage. | Students will research a content specific topic and present a multimedia PowerPoint which will demonstrate understanding and organization of the topic while using the standards of the English language appropriately. | Students will credit the appropriate sources. |
| 2.B.01.03  2.B.03.03  2.B.04.01  2.C.01.03  2.C.02.15  2.C.02.20  2,C.02.21  2.C.02.23  2.C.03.06  2.C.05.06  2.C.06.02  2.C.06.03  2.C.06.05  2.C.05.16  2.C.06.10  2.C.13.15 | WHST. Grades 6-12.4  RST. Grades 6-12.4 | Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience  Determine the meaning of symbols, key terms, and other domain- specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–12 texts and topics. |
| Performance Example: | Students will read and interpret either orally or in writing technical schematics, drawings, and/or specification sheets and other content specific informative texts for appropriate topic assignments. |  |
| 2.B.01.05 | SL.6-12.6 | Adapt speech to a variety of contexts and tasks, demonstrating a command of formal English when indicated or appropriate. |
| Performance Example: | In a professional tone and manner, Students will conduct market surveys and contact companies displaying articulated speech appropriate to the task. |  |

### [Embedded Mathematics](#_bookmark0)

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| **CTE**  **Learning Standard Number** | **Math Content Conceptual Category and Domain Code Learning Standard Number** | **Text of Mathematics Learning Standard** |
| 2.B.01 | \* Modeling | See the asterisks in the Math Framework document for more detail  information on the used standards assigned as these will be project dependant. |
| Performance Example:  \* Modeling | The basic modeling cycle is summarized in the diagram below. It involves (1) identifying variables in the situation and selecting those that represent essential features, (2) formulating a model by creating and selecting geometric, graphical, tabular, algebraic, or statistical representations that describe relationships between the variables, (3) analyzing and performing operations on these relationships to draw conclusions, (4) interpreting the results of the mathematics in terms of the original situation, (5) validating the conclusions by comparing them with the situation, and then either improving the model or, if it is acceptable, (6) reporting on the conclusions and the reasoning behind them. Choices, assumptions, and approximations are present throughout this cycle. | In descriptive modeling, a model simply describes the phenomena or summarizes them in a compact form. Graphs of observations are a familiar descriptive model—for example, build, test and redesign a scale model of a balsa wood bridge. |
| 2.B,08.01  2.B.08.02 | S-ID, | Summarize, represent, and interpret data on a single count or measurement variable.   1. Represent data with plots on the real number line (dot plots, histograms, and box plots). 2. Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.   4. Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve. |
|  | S-MD | Make inferences and justify conclusions from sample surveys, experiments, and observational studies.  3. Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how  randomization relates to each. |
| Performance Example: | Describe a set of numbers and then make accurate inferences about your group of data based on incomplete information. (i.e. a bag of multiple colored candies - M&M or Skittles) |  |
| 2.B.09.02 | G-GMD,  G-GG | Explain volume formulas and use them to solve problems.  1. Give an informal argument for the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone.  3. Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems  Apply geometric concepts in modeling situations.   1. Use geometric shapes, their measures, and their properties to describe objects (e.g.,, modeling a tree trunk or a human torso as a cylinder). 2. Apply concepts of density based on area and volume in modeling situations (e.g.,, persons per square mile, BTUs per cubic foot) 3. Apply geometric methods to solve design problems (e.g.,, designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios). |
| Performance Example: | Design a package to house a rubik’s cube. A pattern layout or development will be created on graph paper and transferred to paperboard. Graphics will then be applied to paperboard panels and flaps. |  |
| 2.B.10.01  2.B.10.04 | 4.MD | Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.  1. Know relative sizes of measurement units within one system of units, including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a  single system of measurement, express measurements in a larger unit in terms of a smaller unit. |
| Performance Example: | The United States is the only country that uses the English system. It is because of this global marketplace that the sizes of engineered objects must often be communicated in both English and metric units. Converting linear | measurements to provide dual dimensioning saves the manufacturer time, which keeps product costs down. |
| 2.C.02.04  2.C.02.05  2.C.02.08  2.C.02.09  2.C.02.15  2.C.02.16  2.C.02.22  2.C.02.23  2.C.02.24  2.C.02.27 | A-CED  F-IF | Create equations that describe numbers or relationships.   1. Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions. 2. Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.   4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.  Analyze functions using different representations.  7. Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology  for more complicated cases. |
|  | F-LE  F-TF | e. Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.  Construct and compare linear, quadratic, and exponential models and solve problems.   1. For exponential models, express as a logarithm the solution to abct = d where a, c, and d are numbers and the base b is 2, 10, or e; evaluate the logarithm using technology.   Model periodic phenomena with trigonometric functions.   1. Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline. |
| Performance Example: | Apply the mathematical principles of Ohm’s law and Kirchhoff’s voltage and current laws to circuits in order to gain understanding of circuit requirements and relationships between voltage, current, and resistance. |  |
| 2.D.01.04  2.D.01.08  2.D.01.09  2.D.01.13  2.D.01.18 | G-MG  F-TF  F-LE | Apply geometric concepts in modeling situations.  1. Use geometric shapes, their measures, and their properties  to describe objects (e.g.,, modeling a tree trunk or a human torso as a  cylinder).  2. Apply concepts of density based on area and volume in  modeling situations (e.g.,, persons per square mile, BTUs per cubic  foot).  3. Apply geometric methods to solve design problems (e.g.,,  designing an object or structure to satisfy physical constraints or  minimize cost; working with typographic grid systems based on  ratios).  MA.4. Use dimensional analysis for unit conversions to confirm  that expressions and equations make sense.  Prove and apply trigonometric identities.  8. Prove the Pythagorean identity sin2(θ) + cos2(θ) = 1 and use it to find sin(θ), cos(θ), or tan(θ) given sin(θ), cos(θ), or tan(θ)  and the quadrant.  9. (+) Prove the addition and subtraction formulas for sine,  cosine, and tangent and use them to solve problems.  Construct and compare linear, quadratic, and exponential models  and solve problems.  1. Distinguish between situations that can be modeled with  linear functions and with exponential functions.  a. Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors  over equal intervals.  b. Recognize situations in which one quantity changes at a  constant rate per unit interval relative to another.  c. Recognize situations in which a quantity grows or decays by  a constant percent rate per unit interval relative to another.  2. Construct linear and exponential functions, including  arithmetic and geometric sequences, given a graph, a description of a  relationship, or two input-output pairs (include reading these from a table).  3. Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly,  quadratically, or (more generally) as a polynomial function. |
|  |  | Performance Example:  Experimentally determine the density of several blocks. Then, calculate various blocks’ density and compare the experimental results with published densities of the blocks. |
| 2.D.02.01  2.D.02.04  2.D.02.05  2.D.02.18  2.D.02.19  2.D.02.20 | A-CED  5.MD  7.EE | Create equations that describe numbers or relationships.  1. Create equations and inequalities in one variable and use  them to solve problems. Include equations arising from linear and  quadratic functions, and simple rational and exponential functions.  4. Rearrange formulas to highlight a quantity of interest, using  the same reasoning as in solving equations.  Geometric measurement: Understand concepts of volume and relate  volume to multiplication and to addition.  3. Recognize volume as an attribute of solid figures and  understand concepts of volume measurement.  a. A cube with side length 1 unit, called a “unit cube,” is said to  have “one cubic unit” of volume, and can be used to measure volume.  b. A solid figure which can be packed without gaps or overlaps  using n unit cubes is said to have a volume of n cubic units.  4. Measure volumes by counting unit cubes, using cubic cm,  cubic in, cubic ft, and improvised units.  5. Relate volume to the operations of multiplication and  addition and solve real-world and mathematical problems involving  volume.  a. Find the volume of a right rectangular prism with whole-  number side lengths by packing it with unit cubes, and show that the  volume is the same as would be found by multiplying the edge  lengths, equivalently by multiplying the height by the area of the  base. Represent threefold whole-number products as volumes, e.g.,,  to represent the associative property of multiplication.  b. Apply the formulas V = l  w  h and V = b  h for rectangular  prisms to find volumes of right rectangular prisms with whole-  number edge lengths in the context of solving real-world and  mathematical problems.  c. Recognize volume as additive. Find volumes of solid figures  composed of two non-overlapping right rectangular prisms by  adding the volumes of the non-overlapping parts, applying this  technique  to solve real-world problems.  Solve real-life and mathematical problems using numerical and  algebraic expressions and equations.  3. Solve multi-step real-life and mathematical problems posed  with positive and negative rational numbers in any form (whole  numbers, fractions, and decimals), using tools strategically. Apply  properties of operations to calculate with numbers in any form;  convert between forms as appropriate; and assess the  reasonableness of answers using mental computation and estimation  strategies.  4. Use variables to represent quantities in a real-world or  mathematical problem, and construct simple equations and  inequalities to solve problems by reasoning about the quantities. |
| Performance Example: | Investigate the effects of work, thermo energy, and energy on a system: a 1/4 in. thick acrylic testing box with dimensions of 20.0 in. x 20.0 in. is covered with an unknown 0.50 in. insulation material. Determine the thermal conductivity for the insulating material if a 50.0W bulb is used to heat the box. The bulb maintains the inside temperature at 15.0ºC higher than the outside temperature using: | k= PL A  ΔT |
| 2.F.01.04  2.F.01.09  2.F.01.10  2.F.01.11  2.F.01.12  2.F.01.13  2.F.01.14  2.F.01.15  2.F.01.16 | G-MG  F-TF  F-LE | Apply geometric concepts in modeling situations.  1. Use geometric shapes, their measures, and their properties  to describe objects (e.g.,, modeling a tree trunk or a human torso as a  cylinder).  2. Apply concepts of density based on area and volume in  modeling situations (e.g.,, persons per square mile, BTUs per cubic  foot).  3. Apply geometric methods to solve design problems (e.g.,,  designing an object or structure to satisfy physical constraints or  minimize cost; working with typographic grid systems based on  ratios).  MA.4. Use dimensional analysis for unit conversions to confirm  that expressions and equations make sense.  Prove and apply trigonometric identities.  8. Prove the Pythagorean identity sin2(θ) + cos2(θ) = 1 and  use it to find sin(θ), cos(θ), or tan(θ) given sin(θ), cos(θ), or tan(θ)  and the quadrant.  Construct and compare linear, quadratic, and exponential models  and solve problems.  1. Distinguish between situations that can be modeled with  linear functions and with exponential functions.  a. Prove that linear functions grow by equal differences over  equal intervals, and that exponential functions grow by equal factors  over equal intervals.  b. Recognize situations in which one quantity changes at a  constant rate per unit interval relative to another.  c. Recognize situations in which a quantity grows or decays by  a constant percent rate per unit interval relative to another.  2. Construct linear and exponential functions, including  arithmetic and geometric sequences, given a graph, a description of a  relationship, or two input-output pairs (include reading these from a  table).  3. Observe using graphs and tables that a quantity increasing  exponentially eventually exceeds a quantity increasing linearly,  quadratically, or (more generally) as a polynomial function. |
| Performance Example: | Calculate stress (σ) on a wooden right rectangular prism (column) using the formula: σ = F/A. Given a force of 100 | lb. and with the prism (column) dimensions (length = 0.75 in, width = 0.75 in and a height of 5.0 in. |
| 2.F.02.04  2.F.02.05  2.F.02.06  2.F.02.07  2.F.02.08  2.F.02.10  2.F.02.11  2.F.02.12 | G-MG  F-TF  F-LE | Apply geometric concepts in modeling situations.  1. Use geometric shapes, their measures, and their properties  to describe objects (e.g.,, modeling a tree trunk or a human torso as a  cylinder).  2. Apply concepts of density based on area and volume in  modeling situations (e.g.,, persons per square mile, BTUs per cubic  foot).  3. Apply geometric methods to solve design problems (e.g.,,  designing an object or structure to satisfy physical constraints or  minimize cost; working with typographic grid systems based on  ratios).  MA.4. Use dimensional analysis for unit conversions to confirm  that expressions and equations make sense.  Prove and apply trigonometric identities.  8. Prove the Pythagorean identity sin2(θ) + cos2(θ) = 1 and  use it to find sin(θ), cos(θ), or tan(θ) given sin(θ), cos(θ), or tan(θ)  and the quadrant.  Construct and compare linear, quadratic, and exponential models  and solve problems.  1. Distinguish between situations that can be modeled with linear functions and with exponential functions.  a. Prove that linear functions grow by equal differences over  equal intervals, and that exponential functions grow by equal factors  over equal intervals.  b. Recognize situations in which one quantity changes at a  constant rate per unit interval relative to another.  c. Recognize situations in which a quantity grows or decays by  a constant percent rate per unit interval relative to another.  2. Construct linear and exponential functions, including  arithmetic and geometric sequences, given a graph, a description of a  relationship, or two input-output pairs (include reading these from a  table).  3. Observe using graphs and tables that a quantity increasing  exponentially eventually exceeds a quantity increasing linearly,  quadratically, or (more generally) as a polynomial function. |
| Performance Example: | Calculate strain (ε) on a metal right rectangular prism (a thin slab) using the formula: ε = ΔL/L. Given an original | length of 12 in. with a final length of 12.125 in. |

### [Embedded Science and Technology/Engineering](#_bookmark0)

#### [Earth and Space Science](#_bookmark0)

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| **CTE**  **Learning Standard Number** | **Subject Area, Topic Heading and**  **Learning Standard Number** | **Text of Earth and Space Science Learning Standard** |
| 2.C.06.18  2.C.14.12  2.C.14.13 | 1. Matter and Energy in the Earth System | 1.3 Explain how the transfer of energy through radiation,  conduction, and convection contributes to global atmospheric processes, such as storms, winds, and currents. |
|  |  |  |
| Performance Example: | Students will indentify the similarities between the temperature management of building systems and the climate mechanisms that manage temperature on earth. |  |
| 2.C.14 | 3. Earth Processes and Cycles | * 1. Explain how water flows into and through a watershed. Explain the roles of aquifers, wells, porosity, permeability, water table, and runoff.   2. Describe the processes of the hydrologic cycle, including evaporation, condensation, precipitation, surface runoff and groundwater percolation, infiltration, and transpiration. |
| Performance Example: | Student will understand how a site’s location within a watershed effects the infiltration, drainage, and runoff. | Students will be able to use USGS topographical maps to determine the overland flow routes and estimated groundwater depth and flow direction for a site. |
| 2.C.06.18  2.C.14.12  2.C.14.13 | 1. Matter and Energy in the Earth System | 1.3 Explain how the transfer of energy through radiation, conduction, and convection contributes to global atmospheric processes, such as storms, winds, and currents. |
| Performance Example: | Students will indentify the similarities between the temperature management of building systems and the climate mechanisms that manage temperature on earth. |  |
| 2.C.14.13  2.C.13.07 | 2. Energy Resources in the Earth System | * 1. Recognize, describe, and compare renewable energy resources (e.g.,, solar, wind, water, biomass) and nonrenewable energy resources (e.g.,, fossil fuels, nuclear energy).   2. Describe the effects on the environment and on the carbon cycle of using both renewable and nonrenewable sources of energy. |
| Performance Example: | Students will use an understanding of how site location can provide renewable energy as well as reduce the need for climate control for a building to minimize the ecological footprint of a new development. |  |

#### [Physical Science (Chemistry)](#_bookmark0)

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| **CTE**  **Learning Standard Number** | **Subject Area, Topic Heading and**  **Learning Standard Number** | **Text of Chemistry Learning Standard** |
| 2.C.02.01 | 2. Atomic Structure and Nuclear Chemistry | 2.1 Recognize discoveries from Dalton (atomic theory), Thomson (the electron), Rutherford (the nucleus), and Bohr (planetary model of atom), and understand how each discovery leads to modern theory. |
| Performance Example: | Students will be able to identify the parts of an atom through an understanding of the scientific process that has resulted in our modern theory of the atom. |  |

#### [Physical Science (Physics)](#_bookmark0)

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| **CTE**  **Learning Standard Number** | **Subject Area, Topic Heading and**  **Learning Standard Number** | **Text of Physics Learning Standard** |
| 2.C.05.05 | Properties of Matter | Differentiate between weight and mass, recognizing that weight is the amount of gravitational pull on an object.  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. |
| Performance Example: | Students will be able to select measurement devices with an appropriate level of accuracy for the task involved. Students can demonstrate the use of measurement devices by determining the density of a very small and very large piece of metal forcing students to use different measurement tools to obtain an accurate measurement at different size scales. |  |
| 2.C.14.12 | Heat Energy | 14. Recognize that heat is a form of energy and that temperature change results from adding or taking away heat from a system.  16. Give examples of how heat moves in predictable ways, moving from warmer objects to cooler ones until they reach equilibrium. |
| Performance Example: | Students will be able to calculate the rate of heating and cooling of a material and understand how specific heat capacity influences the rate at which a substance will gain or lose heat. |  |
| 2.C.13.16 | 1. Motion and Forces | * 1. Compare and contrast vector quantities (e.g.,, displacement, velocity, acceleration force, linear momentum) and scalar quantities (e.g.,, distance, speed, energy, mass, work).   2. Distinguish between displacement, distance, velocity, speed, and acceleration. Solve problems involving displacement, distance, velocity, speed, and constant acceleration.   1.5 Use a free-body force diagram to show forces acting on a system consisting of a pair of interacting objects. For a diagram with only co-linear forces, determine the net force acting on a system and between the objects. |
| Performance Example: | Students will be able to analyze situations with multiple forces acting on an object and determine the net force acting on the object to determine it’s acceleration and velocity vectors. |  |
| 2.C.02 | 5. Electromagnetism | * 1. Develop qualitative and quantitative understandings of current, voltage, resistance, and the connections among them (Ohm’s law).   2. Analyze simple arrangements of electrical components in both series and parallel circuits. Recognize symbols and understand the functions of common circuit elements (battery, connecting wire, switch, fuse, resistance) in a schematic diagram. |
| Performance Example: | Students will be given a simple 2 battery LED flashlight and will be able to identify the basic electronic components and predict the effects each component will have on the flow of electricity through the circuit. | Students will predict the effect connecting batteries in series and parallel has on the voltage of the flashlight. Students will also be expected test their predictions with measurement tools. |
| 2.C.06.18 | 3. Heat and Heat Transfer | * 1. Explain how heat energy is transferred by convection, conduction, and radiation.   2. Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached. |
| Performance Example: | Students will understand why electrical components generate heat and how to properly select and apply devices (i.e. heat sinks and fans) to transfer heat energy away from sensitive electronics. |  |
| 2.C.06.16  2.C.06.17 | 2. Conservation of Energy and Momentum | * 1. Interpret and provide examples of how energy can be converted from gravitational potential energy to kinetic energy and vice versa.   2. Describe both qualitatively and quantitatively how work can be expressed as a change in mechanical energy. |
| Performance Example: | Students will be able to understand the mechanics behind the force multiplication of simple machines and explain why simple machines can be used to allow the user to do more work with less input force. |  |
| 2.C.06.16  2.C.06.17 | 1. Motion and Forces | 1.6 Distinguish qualitatively between static and kinetic friction, and describe their effects on the motion of objects. |
| Performance Example: | Students will be able to understand that simple machines require the user to do more work in order to overcome the effects of friction which are present in all mechanical systems. |  |
| 2.C.02.02 | 5. Electromagnetism | 5.1 Recognize that an electric charge tends to be static on insulators and can move on and in conductors. Explain that energy can produce a separation of charges. |
| Performance Example: | Students will be able to identify the properties of insulators and conductors and identify examples of each. Students will be able to explain the behavior static electricity on insulators and conductors and apply that knowledge to the flow of electricity in electrical current. |  |

#### [Technology/Engineering](#_bookmark0)

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| **CTE**  **Learning Standard Number** | **Subject Area, Topic Heading and**  **Learning Standard Number** | **Text of Technology/Engineering Learning Standard** |
| 2.A.2 | 1. Materials, Tools, and Machines | 1.3 Identify and explain the safe and proper use of measuring tools, hand tools, and machines (e.g.,, band saw, drill press, sander, hammer, screwdriver, pliers, tape measure, screws, nails, and other mechanical fasteners) needed to construct a prototype of an  engineering design. |
| Performance Example: | Students will be able to safely operate machinery and equipment related to engineering construction. |  |
| 2.B.01 | 2. Engineering Design | 2.1 Identify and explain the steps of the engineering design  process, i.e., identify the need or 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.  2.2 Demonstrate methods of representing solutions to a design problem, e.g.,, sketches, orthographic projections, multiview drawings.   * 1. Identify appropriate materials, tools, and machines needed to construct a prototype of a given engineering design.   2. Explain how such design features as size, shape, weight, function, and cost limitations would affect the construction of a given prototype. |
| Performance Example: | Students will be able to use the engineering design process to analyze a problem, consider possible solutions, and create a design solution. The students will determine the best materials for the design considering factors such as cost, availability, reliability, and ease of operation/manufacture. Students will create a list of parts necessary to create the design and determine overall cost. Students will also maintain a journal documenting the steps of their | process. |
| 2.C.05 | 1. Materials, Tools, and Machines | * 1. Given a design task, identify appropriate materials (e.g.,, wood, paper, plastic, aggregates, ceramics, metals, solvents, adhesives) based on specific properties and characteristics (e.g.,, strength, hardness, and flexibility).   2. Identify and explain appropriate measuring tools, hand tools, and power tools used to hold, lift, carry, fasten, and separate, and explain their safe and proper use. |
| Performance Example: | Students will asked to select a material for an insulating cup holder. The student will be able to research and understand the properties of common engineering materials used today and select a safe and cost effective material. |  |
| 2.C.05  2.C.07 | 2. Engineering Design | 2.4 Identify appropriate materials, tools, and machines needed to construct a prototype of a given engineering design. |
| Performance Example: | Students will be given a design to create a prototype of. The student research different possible materials and current prototyping methods and analyze their associated costs and benefits. |  |
| 2.C.13 | 5. Construction Technologies | Describe and explain parts of a structure, e.g.,, foundation, flooring, decking, wall, roofing systems.   * 1. Explain how the forces of tension, compression, torsion, bending, and shear affect the performance of bridges.   2. Describe and explain the effects of loads and structural shapes on bridges. |
| Performance Example: | Student will be able to understand the various ways architectural styles incorporate the safe support of loads. | Students will demonstrate knowledge by designing and building (or using simulation) a bridge and determining the weight it can support and point of failure of the design. |
| 2.B.08 | 2. Engineering Design | 2.6 Identify the five elements of a universal systems model: goal, inputs, processes, outputs, and feedback. |
| Performance Example: | Students will survey users and industry in order to obtain feedback on a design solution or prototype in order to improve design. |  |
| 2.A.02 | 2. Construction Technologies | 2.5 Identify and demonstrate the safe and proper use of |
| 2.C.08  2.C.12 |  | common hand tools, power tools, and measurement devices used in construction. |
| Performance Example: | Students will be able to safely operate machinery and equipment related to engineering and construction. |  |
| 2.B.01  2.C.06 | 1. Engineering Design | * 1. Identify and explain the steps of the engineering design process: identify the problem, research the problem, develop possible solutions, select the best possible solution(s), construct prototypes and/or models, test and evaluate, communicate the solutions, and redesign.   2. Understand that the engineering design process is used in the solution of problems and the advancement of society. Identify examples of technologies, objects, and processes that have been modified to advance society, and explain why and how they were modified.   3. Produce and analyze multi-view drawings (orthographic projections) and pictorial drawings (isometric, oblique, perspective), using various techniques. |
| Performance Example: | Students will be able to apply the engineering design process to a problem selected by the instructor and be able to communicate a design solution through drawings. |  |
| 2.B.01  2.C.06  2.C.13 |  | * 1. Interpret and apply scale and proportion to orthographic projections and pictorial drawings (e.g.,, ¼" = 1'0", 1 cm = 1 m).   2. Interpret plans, diagrams, and working drawings in the construction of prototypes or models. |
| Performance Example: | Students will be able to apply the engineering design process to a problem and produce documentation and designs with enough detail to allow construction of a prototype and which demonstrate a thorough analysis of many possible solutions. |  |
| 2.B.06  2.C.05 | 7. Manufacturing Technologies | * 1. Describe the manufacturing processes of casting and molding, forming, separating, conditioning, assembling, and finishing.   2. Identify the criteria necessary to select safe tools and procedures for a manufacturing process (e.g.,, properties of materials, required tolerances, end-uses). |
| Performance Example: | When given a manufacturing problem students will be able to select appropriate manufacturing methods and materials to safely and efficiently create a product. |  |
| 2.C.01 | 5. Energy and Power Technologies—Electrical Systems | 5.1 Explain how to measure and calculate voltage, current, resistance, and power consumption in a series circuit and in a parallel circuit. Identify the instruments used to measure voltage, current, power consumption, and resistance. |
| Performance Example: | Students will be able to use a multimeter to test and troubleshoot electrical equipment. |  |
| 2.C.02  2.C.03 | 5. Energy and Power Technologies—Electrical Systems | 5.1 Explain how to measure and calculate voltage, current, resistance, and power consumption in a series circuit and in a parallel circuit. Identify the instruments used to measure voltage,  current, power consumption, and resistance. |
|  |  | * 1. Identify and explain the components of a circuit, including sources, conductors, circuit breakers, fuses, controllers, and loads. Examples of some controllers are switches, relays, diodes, and variable resistors.   2. Explain the relationships among voltage, current, and resistance in a simple circuit, using Ohm’s law.   5.5 Compare and contrast alternating current (AC) and direct current (DC), and give examples of each. |
| Performance Example: | When given a diagram of a simple 2 battery LED flashlight students will be able to identify the basic electronic components and predict the effects each component will have on the flow of electricity through a circuit. Students will predict the effect connecting batteries in series and parallel has on the voltage of the flashlight. Students will also predict the effect an alternating current would have on the LED. Students will also be expected to build and test their predictions with measurement tools. |  |
| 2.C.05 | 2. Construction Technologies | 2.1 Identify and explain the engineering properties of materials used in structures (e.g.,, elasticity, plasticity, R value, density, strength). |
| 2.C.05  2.C.14.06 | 2. Construction Technologies | 2.6 Recognize the purposes of zoning laws and building codes in the design and use of structures. |
| Performance Example: | Students will understand how the selection of building location and building materials effects the safety and reliability of a mechanical structure and recognize the science and engineering rational for building codes |  |
| 2.C.06 | 3. Energy and Power Technologies—Fluid Systems | * 1. Calculate and describe the ability of a hydraulic system to multiply distance, multiply force, and effect directional change.   2. Recognize that the velocity of a liquid moving in a pipe varies inversely with changes in the cross-sectional area of the pipe.   3. Identify and explain sources of resistance (e.g.,, 45º elbow, 90º elbow, changes in diameter) for water moving through a pipe. |
| Performance Example: | Students will be tasked with designing a hand lift for a small automobile considering hydraulic and pneumatic solutions. Students will be able to determine the amount of force multiplication necessary, determine the necessary parts and create a design solution. |  |
| 2.C.06  2.C.13  2.C.14 | 4. Energy and Power Technologies—Thermal Systems | * 1. Differentiate among conduction, convection, and radiation in a thermal system (e.g.,, heating and cooling a house, cooking).   2. Give examples of how conduction, convection, and radiation are considered in the selection of materials for buildings and in the design of a heating system.   3. Explain how environmental conditions such as wind, solar angle, and temperature influence the design of buildings. |
| Performance Example: | Students will be able to calculate the rate of heating and cooling of a material and understand how specific heat capacity influences the rate at which a substance will gain or lose heat. Students will be able to apply this knowledge to sustainable building design. |  |
| 2.C.06 | 2. Construction Technologies | 2.2 Distinguish among tension, compression, shear, and torsion, |
| 2.C.13 |  | and explain how they relate to the selection of materials in structures.  2.4 Calculate the resultant force(s) for a combination of live loads and dead loads. |
| Performance Example: | Student will be able to understand the various ways architectural styles incorporate the safe support of loads. | Students will demonstrate knowledge by designing and building (or using simulation) a bridge and determining the weight it can support and point of failure of the design. |
| 2.C.09 | 7. Manufacturing Technologies | 7.3 Describe the advantages of using robotics in the automation of manufacturing processes (e.g.,, increased production, improved quality, safety). |
| Performance Example: | Students will observe the use of assembly line automation in the various industries and explain the benefits and limitations when compared to manual assembly. |  |
| 2.C.09 | 6. Communication Technologies | 6.3 Explain how the various components (source, encoder, transmitter, receiver, decoder, destination, storage, and retrieval) and processes of a communication system function. |
| Performance Example: | Students will be able to operate and program a communication system to have a robot perform an assembly line task. |  |

[Industry Recognized Credentials](#_bookmark0) (Licenses and Certifications/Specialty Programs)

1. Lego "Mindstorm" Provider: Carnegie Mellon University
2. VEX (RobotC) Provider: Carnegie Mellon University
3. AutoDesk Inventor Provider: Authorized AutoDesk instruction facility
4. Solidworks Provider: Authorized Solidworks instructional facility
5. Project Lead the Way (PLTW) Provider: Associated college that accept course credit
6. American Radio Relay League (ARRL) Provider: FCC HAM license Preparation
7. Basic Electronics Test Provider: <http://www.expertrating.com/certifications/Electronics-test.asp>
8. LabView - Provider: National Instruments

(optional PLTW software package)

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