*Massachusetts Career Technical Education Framework*

***Electronics***

June 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.

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

###### Safety in the Electronics Laboratory

* + 1. Demonstrate safe practices within the electronics laboratory following OSHA regulations, industry standards and established shop safety procedures.
       1. Complete the requirements of OSHA 10-hour certification course and receive a course completion card.
       2. Follow safety and emergency procedures, as defined in the shop safety manual.
       3. Practice work habits that provide personal safety, safety for others, and protect the safety and security of the external environment.
       4. Select and use appropriate personal protective equipment at all times.
       5. Maintain a sanitary and clutter-free work environment.
       6. Monitor, use, store, and dispose of materials according to established OSHA procedures.
       7. Follow standard Electrostatic Discharge (ESD) procedures.
    2. Performance Example:
       - Student will complete the General Industry OSHA 10 hour training course.
       - The student will prepare a shop Health and Safety plan describing safety procedures and work habits.

###### Fundamentals of Electronic Circuit Assembly

* + 1. Identify electronic schematic symbols.
       1. Identify passive component symbols.
       2. Identify active component symbols.
       3. Identify and list variable component symbols.
    2. Performance Example:
       - Given a schematic of a variable output power supply; the student will identify resistors, capacitors, transformers, diodes, regulator ICs, potentiometers etc.
    3. Draw a schematic diagram.
       1. Sketch a basic circuit by hand.
       2. Create a basic circuit using schematic software.

2.B.02 Performance Example:

* Using an electronic symbol template; the student will draw the schematic of a variable output power supply.
  + 1. Produce a parts list.
       1. List parts from a schematic.
       2. Locate vendors for electronic parts.
       3. Calculate total parts list cost.
    2. Construct an electronic circuit prototype according to current industry and OSHA standards.

2.B.03 Performance Example:

* Given a schematic of a variable output power supply; the student will generate a parts list including vendor and cost analysis.
  + - 1. Describe the connections on a solder-less breadboard.
      2. Arrange components on a solder-less breadboard.

2.B.04 Performance Example:

* Given a solder-less breadboard; the student will draw a line diagram showing which points are connected to each other.
* Given a solder-less breadboard, schematic, and all required parts; the student will build a functional variable output power supply prototype.
  + 1. Assemble an electronic circuit on a printed circuit board.
       1. Use solder to connect leaded components on a printed circuit board.
       2. Use solder to connect surface mount components on a printed circuit board.
       3. Differentiate polarity markings on components.

2.B.05 Performance Example:

* Given an unpopulated printed circuit board and all required parts; the student will assemble a variable output power supply.

###### Theory and Application of DC

* + 1. Apply electronic circuit laws.
       1. Use Ohm's Law to calculate voltage.
       2. Use Ohm's Law to calculate current.
       3. Use Ohm's Law to calculate resistance.
       4. Use Watt’s law to calculate power.
       5. Use Kirchhoff’s law to verify total voltage and total current.
       6. Describe basic magnetism laws and principles.
    2. Performance Example:
       - Given a series-parallel resistive network schematic; the student will calculate total current, individual voltage drops, parallel current legs, and power values.
       - Given two separate coils of wire; the student will demonstrate how the coils are repelled or attracted to each other when power is applied and polarity is reversed.
    3. Apply electronic circuit theorems.
       1. Use Norton’s theorem to analyze DC circuits.
       2. Use Thevenin’s theorem to analyze DC circuits.
       3. Use Superposition to analyze DC circuits.

2.C.02 Performance Example:

* Given a series-parallel resistive network schematic; the student will calculate the Thevenin's voltage and resistance values.
  + 1. Construct and test DC circuits.
       1. Construct a circuit and verify Thevenin’s Theorem.
       2. Construct a circuit and verify Norton’s Theorem.

2.C.03 Performance Example:

* Given a series-parallel resistive network schematic; the student will measure total current, individual voltage drops and parallel current leg values.
* Given a series-parallel resistive network schematic; the student will measure the Thevenin's voltage and resistance values.

###### Theory and Application of AC

* + 1. Perform calculations in AC circuits.
       1. Calculate RMS, peak, peak-to-peak, and average values of a sine wave.
       2. Calculate frequency, time and duty cycle of a periodic waveform.
       3. Calculate phase shift.
       4. Calculate reactance.
       5. Calculate impedance.
       6. Calculate apparent, true, reactive, power factor.
       7. Calculate transformer characteristics.
       8. Calculate filter circuits parameters.
    2. Performance Example:
       - Given a resistor-capacitor network schematic; the student will calculate capacitive reactance, impedance, and phase angle at three different input frequency values.
    3. Perform measurements in AC circuits.
       1. Measure peak and peak-to-peak values of a sine wave.
       2. Measure frequency, time and duty cycle of a periodic waveform.
       3. Measure phase shift.
       4. Graphically plot reactance versus frequency.
       5. Graphically plot impedance versus frequency.

2.D.02 Performance Example:

* Using an oscilloscope; the student will analyze a resistor-capacitor network including measuring AC input values (frequency, peak voltage etc) as well as component voltage drops, and phase shifts at three different input frequency values.
* Using a function generator and oscilloscope; the student will display a sine wave with a period of 13 microseconds.

###### Theory and Application of Analog Electronics

* + 1. Analyze semiconductors.
       1. Explain manufacturers’ specifications of semiconductor devices.
       2. Explain characteristics of discrete semiconductors.
       3. Explain biasing of discrete semiconductor devices.
       4. Describe thermal management of discrete semiconductor devices.
       5. Identify transistor configurations.
       6. Identify and list types of transistor biasing configurations.
       7. Identify rectifier diode circuits.
       8. Identify regulator diode circuits.
       9. Analyze power supply circuits.

2.E.01.10 Analyze a thyristor circuit.

* + 1. Performance Example:
       - Given selected diode and transistor circuit schematics; the student will calculate diode currents, BJT and FET transistor current and voltage values, and plot results on graph paper.
       - Given a schematic of a power supply with a crowbar protection circuit; the student will specify the function and purpose of all semi-conductor devices.
       - Given the required components; the student will demonstrate use of a BJT as a switch in saturation and cutoff.
    2. Test semiconductors.
       1. Test diodes with multimeters.
       2. Test transistors.
       3. Test thyristors.

2.E.02 Performance Example:

* Using a multi-meter; the student will measure and record forward and reverse bias resistance values of various diodes, BJT and FET transistors, and an SCR.
  + 1. Construct and test semiconductor circuits.
       1. Measure and explain current and voltage characteristics of diode types.
       2. Measure and explain current and voltage characteristics of transistor types.
       3. Measure and explain current voltage characteristics of thyristor types.
       4. Analyze transistor amplifiers circuits.
       5. Analyze oscillator circuits.

2.E.03 Performance Example:

* Given selected diode and transistor DC circuit schematics, solder-less breadboard, and required components; the student will measure diode currents, BJT and FET transistor current and voltage values, and prepare laboratory reports on the collected data.
* Given selected transistor amplifier circuit schematics, solder-less breadboard, and required components; the student will measure BJT and FET transistor voltage gain values, phase relationships, and prepare laboratory reports on the collected data.
* Given the required parts; the student will build a 30 kHz oscillator using a 555 timer.
  + 1. Evaluate operational amplifier circuits.
       1. Describe operational amplifier IC characteristics.
       2. Design operational amplifier circuits.

2.E.04 Performance Example:

* Given various operational amplifier circuit schematics; the student will calculate input-output current and voltage values, and prepare laboratory reports on the collected data.
* Given various operational amplifier circuit schematics, solder-less breadboard, and required components; the student will measure input-output current and voltage values, and prepare laboratory reports on the collected data.

###### Theory and Application of Digital Electronics

* + 1. Perform calculations in digital circuits.
       1. Use the two’s complement number system for math operations.
       2. Convert between binary, decimal and hexadecimal numbers.
       3. Identify and use alternate digital codes.
       4. Draw logic diagrams from Boolean expressions.
       5. Write truth table from a Boolean expression or logic circuit.
       6. Use reduction theorems to simplify digital electronic circuits.
       7. Analyze waveforms for latches/flip-flops.
       8. Analyze counter circuits waveforms.
    2. Performance Example:
       - Given appropriate worksheets; the student will convert between binary, octal, decimal, and hexadecimal numbering systems.
       - Using K-Mapping and Boolean algebra; the student will simplify SOP expressions.
       - Given appropriate worksheets; the student will convert between Boolean expressions, truth tables and logic diagrams.
    3. Identify and apply digital principles.
       1. Differentiate between high, low and tri-state characteristics of a digital signal.
       2. Identify basic TTL gates of the 7400 series and describe IO characteristics.
       3. Specify pin numbers and manufacturer markings on digital ICs.
       4. Compare and contrast the differences between TTL and CMOS logic families.
       5. Identify and calculate parity bits for error control.
       6. Describe the universal properties of NAND and NOR gates.
       7. Illustrate alternate schematic forms of basic logic gates.
       8. Identify various combinational and sequential logic circuits.
       9. List reduction theorems used to simplify digital Electronic circuits.
       10. Identify the basic architecture of a microprocessor or microcontroller.
       11. Describe a digital oscillator circuit.
       12. Describe circuits that perform A/D and D/A conversions.

2.F.02 Performance Example:

* Given circuit schematic, solder-less breadboard, and required components; the student will use a counter IC to drive a 3 to 8 decoder.
* Given circuit schematic, solder-less breadboard, and required components; the student will build a 2 bit Adder circuit using NAND gates.
  + 1. Identify and describe characteristics of digital components.
       1. Define and describe PLDs (Programmable Logic Devices).
       2. Describe line driver characteristics and their applications.

2.F.03 Performance Example:

* Given circuit schematic, solder-less breadboard, and required components; the student will connect multiple tri-state line driver devices (such as 74244 or equivalent) to a common bus and use the tri-state controls to determine which device drives the bus.
  + 1. Construct and test digital circuits.
       1. Wire, test and explain combinational logic circuits.
       2. Wire and test various flip-flops to verify truth tables.
       3. Wire and test various latches to verify truth tables.
       4. Measure waveforms for counter circuits and analyze behaviors and characteristics.
       5. Construct, simulate and explain encode and decode circuits.
       6. Construct, simulate and explain shift registers.
       7. Construct, simulate and explain comparators.
       8. Construct, simulate and explain adder circuits.
       9. Construct, simulate and explain multiplexer ICs.

2.F.04 Performance Example:

* Given circuit schematic, solder-less breadboard, and required components; the student will use a flip-flop and combinatorial logic to turn on an LED when an 8 bit counter reaches a specified value.

###### Applied Engineering

* + 1. Utilize engineering concepts.
       1. List and apply the steps of the design process to designated electronics projects.
       2. Utilize the steps of the design process to solve given problems.
       3. Work in teams using brainstorming techniques to create new designs.
       4. Use engineering notations and prefixes.
       5. Describe and use the steps for troubleshooting a given problem.
    2. Performance Example:
       - The student will develop both analog and digital versions of a collision detection and drive control system. Compare the positive and negative features of the two approaches.
       - Given appropriate worksheets; the student will convert between kilo, mega, milli, micro, nano, and pico numeric representations..
    3. Develop engineering documents.
       1. Write a technical design report.
       2. Maintain engineering logs/journals for projects.
       3. Utilize a variety of media formats to convey designs and processes.

2.G.02 Performance Example:

* The student will save a schematic from a schematic capture system and convert the file so it can be imported to an MS-Word document.
  + 1. Examine motors.
       1. Identify the various types of electric motors and demonstrate their proper use/operation.
       2. Identify various types of stepper motors.
       3. Utilize stepper motor circuitry.
       4. Design, build and operate a simple electric motor.

2.G.03 Performance Example:

* Given circuit schematic, solder-less breadboard, and required components; the student will examine the relationships between voltage level and polarity and a DC motor speed and rotation direction.
* Use a stepper motor control system to steer a vehicle in a prescribed path.
* Build a simple DC motor using a coil of wire, a magnet, and a power source.
  + 1. Design an autonomous robotics system.
       1. Utilize sensors to interface in a robotic control system.
       2. Design, build, and operate an autonomous robot.

2.G.04 Performance Example:

* Given the required components; the student will program a robot to maneuver through an obstacle course.
* Design and build an autonomous vehicle that drives toward the brightest light in a room.
* Design a controller that turns 8 devices on and off in sequence for various prescribed time periods.

###### Software Applications

* + 1. Utilize programming.
       1. Write a simple control program using a programming language.
       2. Simulate a circuit using a software simulation program.
    2. Performance Example:
       - Write a software program to turn one of eight LEDs on in repeating sequential order.
    3. Design circuit layouts.
       1. Use PCB software to develop a basic circuit design.
       2. Describe or use a process for PCB fabrication.

2.H.02 Performance Example:

* Simulate the performance of a modulo 9 digital counter circuit in your schematic capture software system.
* Using printed circuit board software; the student will generate a milling file for an electronic circuit board.

###### Applied Electronic Devices in a Manufacturing Environment

* + 1. Utilize electronic equipment for measuring.
       1. Identify DC functions and ranges on measuring devices.
       2. Use a multimeter to measure DC circuit values.
       3. Identify AC functions and ranges on measuring devices.
       4. Use a multimeter to measure AC circuit values.
       5. Demonstrate the use of an oscilloscope.
       6. Demonstrate the use of a function generator.
       7. Identify various waveforms.
    2. Performance Example:
       - Given the required components; the student will demonstrate how to use a meter to measure DC and AC voltage.
       - Given the required components; the student will demonstrate how to use an oscilloscope to measure DC and AC voltage.
    3. Utilize tools to build electronic projects.
       1. Solder and crimp connectors and lugs.
       2. Solder and de-solder electronic components, including surface mount components.
       3. Select and use basic hand tools and equipment used for electronic circuits.
       4. Describe and use advanced hand tools and equipment designed for manufacturing of electronic devices.

2.I.02 Performance Example:

* Given an electronic circuit kit: the student will construct a working electronic device from a kit.

###### Advanced Standards (ETA Sourced)

2.J.01\* Demonstrate knowledge and skills relevant to computer electronics.

* + - 1. \* Describe the major sections of a computer.
      2. \* Demonstrate how the computer block diagram and flow charts are utilized.

2.J.01.03\* Describe different types of computer memory and how storage is accomplished.

2.J.01.04\* Explain the importance of an Arithmetic Logic Unit (ALU).

2.J.01.05\* Define ROM, RAM, PROM, EPROM, EEPROM and EAPROM.

2.J.01.06\* Explain the importance of data-buses and their associated bandwidth.

2.J.01.07\* Explain the reasons for different computer languages and their relationships.

2.J.01.08\* Define the words ‘peripheral device’ and list various types.

2.J.01.09\* Explain the reasons for using interface devices/chips/cards and name common types.

2.J.02\* Demonstrate knowledge and skills relevant to optical electronics.

* + - 1. \* List common electronics display devices.
      2. \* Explain how LCD displays operate, comparing their advantages and disadvantages.
      3. \* Describe how LED remote hand units work.
      4. \* Explain why and list some locations of circuits in which opto-isolators are used.
      5. \* List uses of light activated controls and explain how photo devices are incorporated.

2.J.03\* Demonstrate knowledge and skills relevant to audio and video Systems.

* + - 1. \* Explain the major components of the most common home entertainment products.
      2. \* Describe microphone technology and usage.
      3. Explain speaker construction and precautions.
      4. \* Compare the differences between good quality and distorted sound and describe the electronic/acoustical reasons for each.
      5. \* Explain how signals may conflict and the symptoms the conflict may produce.
      6. \* Explain how to isolate troubles between discrete equipment units.

2.J.04\* Demonstrate knowledge and skills relevant to communications electronics.

2.J.04.01\* Describe major types of two-way radio communications (e.g., avionics, land mobile and maritime).

# [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.B  2.B.01.01  2.B.01.02  2.B.03.01  2.B.04.01  2.F  2.F.02.04  2.F.02.09  2.F.02.01 | RST. 9-12.4 | 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 9–12 texts and topics*. |
| Performance Example: |  | Students will maintain a journal defining and connecting words and symbols of domain-specific vocabulary while reading electronic schematics. |
| 2.B.  2.B.03.01  2.G.  2.G.01.01  2.G.01-04  2.G.02.01 | WHST. 6-12.4 | Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| Performance Example: |  | Utilizing content specific formatting, students will produce a written 2+ page technical report using domain- specific vocabulary using engineering notations. |
| 2.F  2.F.03.01  2.F.03.02  2.F.03.03  2.F.04.05  2.F.04.06  2.F.04.07  2.F.04.08  2.F.04.09  2.E.  2.E.01.01  2.E.0102  2.E.01.03 | SL.8-10.4 | 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.  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. |
| Performance Example: |  | In a group or individually, students will orally cite to the teacher and/or the class, specifications, characteristics, and biasing of semiconductors and any other content specific knowledge. |
| 2.E  2.E.04.01  2.E.04.02  2.F  2.F.02.12  2.F.02.09 | WHST.6-12.2 | Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes |
| Performance Example: | * Given a schematic of semiconductors, studies will write a short (1-3 pages) analysis of circuits, using domain specific vocabulary with organization and style appropriate to the purpose. * Students will prepare lab reports on collected data using a standard format with accurate calculations and conclusions. | * Students will write a 10% summary of text material using domain-specific vocabulary with a clear, concise, organized focus. |
| 2.G  2.G.02.02  2.G.02.03 | WHST.6-12.10  WHST.9-10.6 | 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.  Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology’s capacity to link to other information and to display information flexibly and dynamically. |
| Performance Example: |  | Students will maintain an engineering log for all projects, utilizing updated technological resources to produce designs/processes. |
| 2.I  2.I.02.04 | SL.9-12.5 | Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest |
| Performance Example: |  | Individually or in groups, students will demonstrate understanding of advanced hand tools and equipment by producing a multimedia presentation utilizing domain-specific vocabulary. |

### [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.03.03 | 7.RP | Analyze proportional relationships and use them to solve real- world  and mathematical problems.  7.RP.b. Identify the constant of proportionality (unit rate) in tables,  graphs, equations, diagrams, and verbal descriptions of proportional relationships.*.* |
| Performance Example |  | Calculate total parts list cost. |
| 2.C.01.01 | A-CED-1, A-CED.4, A-REI.3 | Create equations that describe numbers or relationships  A-CED-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.( Note: This standard is included because given current and resistance students can write and use OHM’s Law to solve for voltage).*  A-CED.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *For example, rearrange Ohm’s law V = IR to highlight resistance R.*  Solve equations and inequalities in one variable  A-REI.3. Solve linear equations and inequalities in one variable,  including  equations with coefficients represented by letters. (see note for A- CED-1 ) |
| Performance Example: | Using OHM’s Law I=V/R calculate voltage when given current and resistance. |  |
| 2.C.01.02 | A-CED-1, A-CED.4, A-REI.3 | 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.( Note: This standard is included because given voltage and resistance students can write and use OHM’s Law to solve for current).*  A-CED.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *For example, rearrange Ohm’s law V = IR to highlight resistance R.*  Solve equations and inequalities in one variable  A-REI.3. Solve linear equations and inequalities in one variable, including  equations with coefficients represented by letters. (see note for A- CED-1 ) |
| Performance Example: | Using OHM’s Law I=V/R calculate current when given voltage and resistance. |  |
| 2.C.01.03 | A-CED-1, A-CED.4, A-REI.3 | 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.( Note: This standard is included because given voltage and current students can write and use OHM’s Law to solve for resistance).*  A-CED.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *For example, rearrange Ohm’s law V = IR to highlight resistance R.*  Solve equations and inequalities in one variable  A-REI.3. Solve linear equations and inequalities in one variable, including  equations with coefficients represented by letters. (see note for A- CED-1 ) |
| Performance Example: | Using OHM’s Law I=V/R calculate resistance when given current and voltage. |  |
| 2.C.01.04 | A-CED-1, A-CED.4, A-REI.3 | 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.( Note: This standard is included because given voltage and current students can write and use Watt’s Law to solve for power).*  A-CED.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *For example, rearrange Ohm’s law V = IR to highlight resistance R.*  Solve equations and inequalities in one variable  A-REI.3. Solve linear equations and inequalities in one variable, |
|  |  | including  equations with coefficients represented by letters. (see note for A- CED-1 ) |
| Performance Example: | Using Watt’s Law P=V X I, calculate power when given voltage and current. |  |
| 2.C.01.05 | 7.NS | Apply and extend previous understandings of operations with fractions to add, subtract, multiply, and divide rational numbers.  7.NS.1. Apply and extend previous understandings of addition and subtraction  to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram.   1. Describe situations in which opposite quantities combine to make 0. *For example, a hydrogen atom has 0 charge because its two constituents are oppositely charged.* 2. Understand *p* + *q* as the number located a distance |*q*| from *p*, in the positive or negative direction depending on whether *q* is positive or negative. Show that a number and its opposite have a sum of 0 (are additive inverses). Interpret sums of rational numbers by describing real-world contexts. 3. Understand subtraction of rational numbers as adding the additive inverse, *p* – *q* = *p* + (–*q*). Show that the distance between two rational numbers on the number line is the absolute value of   their difference, and apply this principle in real-world contexts. |
| Performance Example: | Using Kirchhoff’s Law VT=V1+V2+V3, calculate total voltage when given individual voltage drops. |  |
| 2.D.01.01 | F-TF.2,F-TF.5, F.TF.7 | Extend the domain of trigonometric functions using the unit circle F-TF.2. Explain how the unit circle in the coordinate plane enables the extension of trigonometric functions to all real numbers,  interpreted as radian measures of angles traversed counterclockwise around the unit circle.  Model periodic phenomena with trigonometric functions F-TF.5. Choose trigonometric functions to model periodic  phenomena with specified amplitude, frequency, and midline.  F-TF.7. (+) Use inverse functions to solve trigonometric equations that arise in modeling contexts; evaluate the solutions using  technology, and interpret them in terms of the context. |
| Performance Example: | Calculate RMS, peak, peak-to-peak, and average values of sine wave. |  |
| 2.D.01.03 | F-TF.2,F-TF.5, F.TF.7 | Extend the domain of trigonometric functions using the unit circle F-TF.2. Explain how the unit circle in the coordinate plane enables the extension of trigonometric functions to all real numbers,  interpreted as radian measures of angles traversed counterclockwise around the unit circle.  Model periodic phenomena with trigonometric functions F-TF.5. Choose trigonometric functions to model periodic  phenomena with specified amplitude, frequency, and midline.  F-TF.7. (+) Use inverse functions to solve trigonometric equations  that arise in modeling contexts; evaluate the solutions using technology, and interpret them in terms of the context. |
| Performance Example: Calculate phase shift. |  |  |
| 2.D.01.04 | F-TF.2,F-TF.5, F.TF.7 | Extend the domain of trigonometric functions using the unit circle F-TF.2. Explain how the unit circle in the coordinate plane enables |
|  |  | the extension of trigonometric functions to all real numbers, interpreted as radian measures of angles traversed counterclockwise around the unit circle.  Model periodic phenomena with trigonometric functions F-TF.5. Choose trigonometric functions to model periodic  phenomena with specified amplitude, frequency, and midline.  F-TF.7. (+) Use inverse functions to solve trigonometric equations that arise in modeling contexts; evaluate the solutions using technology, and interpret them in terms of the context. |
| Performance Example: Calculate reactance. |  |  |
| 2.D.01.05 | F-TF.2,F-TF.5, F.TF.7 | Extend the domain of trigonometric functions using the unit circle F-TF.2. Explain how the unit circle in the coordinate plane enables the extension of trigonometric functions to all real numbers,  interpreted as radian measures of angles traversed counterclockwise around the unit circle.  Model periodic phenomena with trigonometric functions F-TF.5. Choose trigonometric functions to model periodic  phenomena with specified amplitude, frequency, and midline.  F-TF.7. (+) Use inverse functions to solve trigonometric equations that arise in modeling contexts; evaluate the solutions using  technology, and interpret them in terms of the context. |
| Performance Example: Calculate impedance. |  |  |
| 2.D.01.06 | F-TF.2,F-TF.5, F.TF.7 | Extend the domain of trigonometric functions using the unit circle F-TF.2. Explain how the unit circle in the coordinate plane enables the extension of trigonometric functions to all real numbers,  interpreted as radian measures of angles traversed counterclockwise around the unit circle.  Model periodic phenomena with trigonometric functions F-TF.5. Choose trigonometric functions to model periodic  phenomena with specified amplitude, frequency, and midline.  F-TF.7. (+) Use inverse functions to solve trigonometric equations that arise in modeling contexts; evaluate the solutions using  technology, and interpret them in terms of the context. |
| Performance Example: | Calculate apparent, true, reactive, power factor. |  |
| 2.E.03.01 | 5.G.1,5.G.2,.5.G.3,.5.G.4, 6.NS.8, N-Q.1, A-REI.10, A-REI.11 | Graph points on the coordinate plane to solve real-world and mathematical problems.  5.G.1. Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in  the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., *x*-axis and *x*-coordinate, *y*-axis and  *y*-coordinate).  5.G.2. Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.  Classify two-dimensional figures into categories based on their properties. |
|  |  | 5.G.3. Understand that attributes belonging to a category of two dimensional figures also belong to all subcategories of that category. For example, all rectangles have four right angles and squares are rectangles, so all squares have four right angles.  5.G.4. Classify two-dimensional figures in a hierarchy based on properties. Apply and extend previous understandings of numbers to the system of rational numbers.  6.NS.8. Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane. Include use of coordinates and absolute value to find distances between points with the same first coordinate or the same second coordinate.  Reason quantitatively and use units to solve problems.  N-Q.1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.  Represent and solve equations and inequalities graphically  A-REI.10. Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).  A-REI.11. Explain why the x-coordinates of the points where the graphs of the equations y = f(x) and y = g(x) intersect are the solutions of the equation f(x) = g(x); find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where f(x) and/or g(x) are linear, polynomial, rational, absolute value, exponential, and logarithmic functions.  Interpret functions that arise in applications in terms of the context F-IF.4. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end  behavior; and periodicity. |
| Performance Example: | Produce a graph relating voltage and current through a semi-conductor device. |  |
| 2.E.03.02 | 1. G.1,5.G.2,.5.G.3,.5.G.4, 2. NS.8, N-Q.1, A-REI.10, A- REI.11 | Graph points on the coordinate plane to solve real-world and mathematical problems.  5.G.1. Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in  the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., *x*-axis and *x*-coordinate, *y*-axis and  *y*-coordinate).  5.G.2. Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.  Classify two-dimensional figures into categories based on their properties.  5.G.3. Understand that attributes belonging to a category of two |
|  |  | dimensional figures also belong to all subcategories of that category. For example, all rectangles have four right angles and squares are rectangles, so all squares have four right angles.  5.G.4. Classify two-dimensional figures in a hierarchy based on properties. Apply and extend previous understandings of numbers to the system of rational numbers.  6.NS.8. Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane. Include use of coordinates and absolute value to find distances between points with the same first coordinate or the same second coordinate.  Reason quantitatively and use units to solve problems.  N-Q.1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.  Represent and solve equations and inequalities graphically  A-REI.10. Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).  A-REI.11. Explain why the x-coordinates of the points where the graphs of the equations y = f(x) and y = g(x) intersect are the solutions of the equation f(x) = g(x); find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where f(x) and/or g(x) are linear, polynomial, rational, absolute value, exponential, and logarithmic functions.  Interpret functions that arise in applications in terms of the context F-IF.4. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end  behavior; and periodicity. |
| Performance Example: | Produce a graph relating voltage and current through a semi-conductor device. |  |
| 2.E.03.03 | 1. G.1,5.G.2,.5.G.3,.5.G.4, 2. NS.8, N-Q.1, A-REI.10, A- REI.11 | Graph points on the coordinate plane to solve real-world and mathematical problems.  5.G.1. Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in  the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., *x*-axis and *x*-coordinate, *y*-axis and  *y*-coordinate).  5.G.2. Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.  Classify two-dimensional figures into categories based on their properties.  5.G.3. Understand that attributes belonging to a category of two dimensional figures also belong to all subcategories of that category. |
|  |  | For example, all rectangles have four right angles and squares are rectangles, so all squares have four right angles.  5.G.4. Classify two-dimensional figures in a hierarchy based on properties. Apply and extend previous understandings of numbers to the system of rational numbers.  6.NS.8. Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane. Include use of coordinates and absolute value to find distances between points with the same first coordinate or the same second coordinate. Reason quantitatively and use units to solve problems.  N-Q.1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. Represent and solve equations and inequalities graphically.  A-REI.10. Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).  A-REI.11. Explain why the x-coordinates of the points where the graphs of the equations y = f(x) and y = g(x) intersect are the solutions of the equation f(x) = g(x); find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where f(x) and/or g(x) are linear, polynomial, rational, absolute value, exponential, and logarithmic functions. Interpret functions that arise in applications in terms of the context.  F-IF.4. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or  negative; relative maximums and minimums; symmetries; end behavior; and periodicity. |
| Performance Example: | Produce a graph relating voltage and current through a semi-conductor device. |  |
| 2.G.01.04 | 8.EE.1, 8.EE.2, 8.EE.3, 8.EE.4 | Work with radicals and integer exponents.  8.EE.1. Know and apply the properties of integer exponents to generate equivalent numerical expressions. *For example, 32 × 3–5 = 3–3 = 1/33 = 1/27.*  8.EE.2. Use square root and cube root symbols to represent solutions to equations of the form *x*2 = *p* and *x*3 = *p*, where *p* is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that √2 is irrational.  8.EE.3. Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other. *For example, estimate the population of the United States as 3 × 108 and the population of the world as 7 × 109, and determine that the world population is more than 20 times larger.*  8.EE.4. Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of very large or very small quantities (e.g., use millimeters per year for seafloor spreading).  Interpret scientific notation that has been generated by technology. |
| Performance Example: Given whole unit values, convert to various metric prefixes and write in both scientific and engineering notation formats. |  |  |
| 2.I.01.05 | 7.RP.1, 7.RP.2.a, 7.RP.2.b | Analyze proportional relationships and use them to solve real-world and mathematical problems.   1. Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units. *For example, if a person walks 1/2 mile in each 1/4 hour, compute the unit rate as the complex fraction 1/2/1/4 miles per hour, equivalently 2 miles per hour.* 2. Recognize and represent proportional relationships between quantities.    1. Decide whether two quantities are in a proportional relationship, e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight   line through the origin.   * 1. Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of   proportional relationships. |
| Performance Example: Using an oscilloscope, determine the amplitude and frequency as a function of vertical and horizontal calibration settings for each box/gradicule. |  |  |
| 2.I.01.06 | 7.RP.1, 7.RP.2.a, 7.RP.2.b | Analyze proportional relationships and use them to solve real-world and mathematical problems.   1. Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units. *For example, if a person walks 1/2 mile in each 1/4 hour, compute the unit rate as the complex fraction 1/2/1/4 miles per hour, equivalently 2 miles per hour.* 2. Recognize and represent proportional relationships between quantities.    1. Decide whether two quantities are in a proportional relationship, e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight   line through the origin.   * 1. Identify the constant of proportionality (unit rate) in tables,   graphs, equations, diagrams, and verbal descriptions of proportional relationships. |
| Performance Example: Using a signal generator, set the controls and multiplier switches to produce specific frequencies and amplitudes. |  |  |

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

#### [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.B.01 | 5. Electromagnetism | 5.3 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 able to understand a schematic representation of a circuit and be able to analyze the circuit based on the symbolic representations. |  |
| 2.C.01  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.   5.5 Explain how electric current is a flow of charge caused by a potential difference (voltage), and how power is equal to current multiplied by voltage. |
| Performance Example: | Students will be able to analyze DC circuits and calculate values for voltage, current, and resistance using Ohm’s law. Students will also be able to understand the way current and voltage combine to calculate power. |  |
| 2.D.01.01  2.D.01.02  2.D.02.01  2.D.02.02 | 4. Waves | 4.1 Describe the measurable properties of waves (velocity, frequency, wavelength, amplitude, period) and explain the relationships among them. Recognize examples of simple harmonic motion. |
| Performance Example: | Students will be tasked with determining the basic properties of a periodic waveform such as a pendulum or simple sound wave through both measurement and calculation. |  |
| 2.G.03 | 5. Electromagnetism | 5.6 Recognize that moving electric charges produce magnetic forces and moving magnets produce electric forces. Recognize that the interplay of electric and magnetic forces is the basis for electric motors, generators, and other technologies. |
| Performance Example: | Students will construct a simple motor and be able to explain the role that electric current has in producing the magnetic field and the hazards involved with motor heating. Students will operate a stepper motor and be able to compare the design of a simple electric motor with a stepper motor. |  |

#### [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.B.02.01 | 2. Engineering Design | 2.2 Demonstrate methods of representing solutions to a design problem, e.g., sketches, orthographic projections, multi-view drawings. |
| Performance Example: | Students will be tasked with creating a phone charger for the car which converts 12V DC to 5V DC,; the student will be able to represent their solution using a schematic diagram of the circuit. |  |
| 2.B.03 | 2. Engineering Design | 2.4 Identify appropriate materials, tools, and machines needed to construct a prototype of a given engineering design. |
| Performance Example: | When a student is given a schematic diagram of a circuit, the student will be able to determine the best materials | for the circuit considering factors such as cost, availability, component reliability, and ease of operation/manufacture. Students will create a list of parts necessary to create the circuit. |
| 2.G.01  2.G.02 | 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 |
| Performance Example: | Students will be able to use the engineering design process to analyze a problem, consider possible solutions, and create a design solution. Students will also maintain a journal documenting the steps of their process. |  |
| 2.B.05.02  2.I.02.03 | 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 the tools needed to create and test simple electronic circuits that occur in creating prototypes of devices, such as soldering electrical connections on LEDs. |  |
| 2.B.02  2.B.03 | 1. Engineering Design | 1.1 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.  1.5 Interpret plans, diagrams, and working drawings in the construction of prototypes or models. |
| Performance Example: | When a student is tasked with designing a power supply or amplifier circuit, the student will be able to create an optimal design after considering many possible solutions. The students will determine the best materials for the circuit considering factors such as cost, availability, component reliability, and ease of operation/manufacture. | Students will create a list of parts necessary to create the circuit and determine overall cost. |
| 2.C.01  2.I.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.  5.3 Explain the relationships among voltage, current, and resistance in a simple circuit, using Ohm’s law. |
| Performance Example: | When given a multimeter and a simple light bulb and battery circuit, students will be able to determine the power consumption of the light bulb by measuring the light bulb and battery’s characteristics. |  |
| 2.C  2.D | 5. Energy and Power Technologies—Electrical Systems | 5.5 Compare and contrast alternating current (AC) and direct current (DC), and give examples of each. |
| Performance Example: | Students will operate the same light bulb with AC and DC current and be able to describe and give an explanation of the difference in illumination. |  |
| 2.D.02 | 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 observe an AC wave on an oscilloscope and be able to perform measurements to describe the wave. |  |
| 2.G | 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 tasked with creating a phone charger for the car which converts 12V DC to 5V DC. Students will | use the engineering design process to consider possible solutions, create schematic drawings of the solutions, and select the optimal design. Students will thoroughly document their process using engineering logs/journals. |
| 2.I.02.03 | 2. Construction Technologies | 2.5 Identify and demonstrate the safe and proper use of  common hand tools, power tools, and measurement devices used in construction |
| Performance Example: | Students will be able to identify and safely operate the tools needed to create and test simple electronic circuits that occur in creating prototypes of devices, such as soldering electrical connections on LEDs. |  |

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

ETA (Electronic Technicians Association)

* Student Electronics Technician
* Associate Level Technician

ISCET (International Society of Certified Electronic Technicians)

* Associate Certified Electronics Technician