***Telecommunications and Fiber Optics***

CIP Code 150305 | June 2014

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

###### Health and Safety

* + 1. Identify first aid, OSHA and safety code requirements.
			1. List the tasks that may, or may not be performed by trained first aid workers.
			2. List the level of electricity (shock) considered lethal to humans.
			3. Describe OSHA body restraint rules and list the hazards associated with use of ladders and working at heights.
			4. Explain the purposes and reasons for technician adherence to the National Electrical Code (NEC) and the National Fire Protection Association (NFPA) codes.
			5. Explain the purpose and usage of the REMC (Residential Electrical Maintenance Code).
		2. Performance Example:
			- Demonstrate how to properly set up a 24 foot extension ladder using the 4:1 ratio to reach a height of 20 feet.

###### Industry Standards

* + 1. Develop working knowledge of Telecommunications Industry Association (TIA), Electronics Industries Alliance (EIA), and American National Standards Institute (ANSI) standards.
			1. Describe the situations where an installer needs to refer to and abide by TIA 570-A.
			2. Describe the cabling components and methods addressed by TIA/EIA-568- A, TIA/EIA-568-B and ANSI/TIA-568-C.
			3. Describe the Telcordia standards related to cabling.
			4. Explain how to find correct cable pair colors and list the applicable TIA/EIA standard.
		2. Performance Example:
			- Create a detailed sketch illustrating the proper way to terminate a CAT 5e Unshielded Twisted Pair (UTP) patch cable with an RJ-45 connector in accordance with TIA/EIA 568-A.

###### Low Voltage Wiring

* + 1. Describe low voltage wiring requirements.
			1. Demonstrate the use of blue prints and adherence to specifications.
			2. Define AWG and explain American Wire Gauge (AWG) wire size standards.
			3. List possible government permits required to install or service low voltage wiring.
			4. Describe low voltage lighting, its usage and precautions.
			5. Describe current audio signal and speaker cabling and wiring and the reasons for choice of wire.
			6. Describe CAT 5e and 6 UTP cables and preferred usages.
			7. Describe control and sensor wiring used for home automation and manual operation.
		2. Performance Example:
			- List the most important factors to consider when selecting the optimum audio speaker cable wire.

###### Cabling and Connectors

* + 1. Explain network cable installation.
			1. Compare copper coaxial cable and plastic fiber optic cable usage in residential applications.
			2. Explain how 66 and 110 block panels are used in distribution and interface center for telecom services.
			3. Define patch cable and list the maximum length allowed by standards.
			4. Define workstation cables and explain usage.
			5. Define backbone/distribution cabling and compare with link, workstation and patch cables.
			6. Explain the differences between composite and hybrid cables.
			7. Describe proper cable prepping tools; how ends of cable are prepared for connectors; and how connectors are properly installed.
			8. List the types of signal losses in cables, the purpose of impedance matching and converting dB levels to microvolt levels.
			9. Properly prep and install F coaxial cable fittings and explain impedance problems.
			10. Properly install UTP, Cat 5e and 6 connectors.
			11. Explain how and why ground loops occur in electrical circuits.
			12. Identify and describe various network topologies.
		2. Performance Examples:
			- Given a diagram: wire a network; demonstrate that the network meets specifications, and troubleshoot any faults.

###### Pre-wiring

* + 1. Define the design and rough-in layout process.
			1. Describe the task of roughing-in cabling in new structures, installing wall and distribution boxes, conduit, speaker-in-wall units, CCTV mounts etc.
			2. Explain the purpose and usage of biscuit jacks/surface mount boxes.
			3. Explain the use of wall plates and indicate proper locations.
			4. Describe purposes and locations for J-hooks and cable trays.
			5. Explain inductive signal interference, its effects and precautions and separation distances for cabling.
			6. List advantages of stranded vs. solid wiring and reasons for choosing either.
			7. Describe detriments in exceeding TIA/EIA tensile strength/bend radius.
			8. Outline the purposes of wire labeling and how it applies.
			9. Explain the methods used to closely estimate cable requirements for individual applications.
			10. Explain UTP untwist precautions and define NEXT/FEXT testing issues.
			11. List common problems encountered in coaxial cable installation or repair.
			12. Describe surface mount channeling and how it is used.
		2. Performance Examples:
			- Create a costed bill of materials necessary to pre-wire a new residence or building.

###### Fundamentals of Electricity/ Electronics

* + 1. Explain the basics of electricity.
			1. Perform calculations using Ohm’s and Watt’s Laws formulas.
			2. Explain electric power generation and services provided to residences.
			3. Describe wire size choices and distribution for home electrical circuitry.
			4. Compare fuse and circuit breaker boxes and describe the components and metering.
			5. Compare AC and DC voltages and currents.
			6. Explain the purpose of electric circuit grounding and NEC rules for residences.
			7. Describe lightning hazards, lightning arrestors used in electronic applications, and how ground blocks are used.
			8. Compare AC power frequency, and voice, TV and radio and data frequencies.
			9. Describe causes and methods of reducing electrical interference.
		2. Performance Examples:
			- The student will create a breadboard prototype circuit and demonstrate how to properly use a Digital Multi-meter (DMM) to measure voltage, current and resistance in a basic DC resistive circuit.
		3. Develop a working knowledge of electronic circuits.
			1. Identify and explain the function of various passive components found in DC and AC circuits.
			2. Analyze and calculate DC and AC passive circuit parameters using applicable formulas.
			3. Construct and demonstrate the testing of proper DC and AC passive circuit functionality.
			4. Identify and explain the function of discrete and integrated semiconductor devices and circuits.
			5. Analyze and calculate DC and AC circuit parameters of discrete and integrated semiconductor circuits using applicable formulas.
			6. Construct and demonstrate the testing of discrete and integrated semiconductor circuits for proper functionality.
			7. Identify and explain the function of logic gates, combinational and sequential logic circuits.
			8. Analyze and calculate DC and AC circuit parameters of logic gates, combinational and sequential logic circuits using applicable formulas.
			9. Construct and demonstrate the testing of logic gates, combinational and sequential logic circuits for proper functionality.
			10. Troubleshoot and repair defective components in electronic circuits.
			11. Read and interpret flow, block, and schematic diagrams.
			12. Determine the factors that affect thermal management of various electronic components and devices.
			13. Set up and use a variety of electronic/test equipment to test electronic equipment and systems.

2.F.02 Performance Example:

* Student will produce a complete documentation package for an electronic assembly project which they will then present and demonstrate to the class.

###### Fundamentals of Telephony

* + 1. Define the fundamentals of telephone systems.
			1. Diagram a basic telephone circuit.
			2. Define Tip & Ring and show wiring conventions of the POTS and list expected voltages on telephone plugs.
			3. Name the conventional color of UTP wires used with 2/4/8 wire connections.
			4. Compare analog and digital phone systems.
			5. Explain where type 66/110 punchdown blocks are used and their purpose.
			6. Differentiate between internet-cable TV-wireless systems and B-VoIP.
			7. Describe the main blocks that make up a Private Branch Exchange (PBX) system.
			8. Describe the concept of a cellular system and the makeup of a cell.
			9. Explain how handoffs and roaming work.

2.G.01.10 Explain the meaning of the terms “drop out” and “dead zones”.

* + 1. Performance Example:
			- Summarize common troubles associated with telephone systems and suggest repair solutions.

###### Fiber Optics Theory and Applications

* + 1. Define theories and applications of fiber optic cabling.
			1. List fiber optic cable eye, skin, and inhalation safety precautions.
			2. Summarize basic light theory and list commonly used wavelengths.
			3. Demonstrate connector and splice methods and testing.
			4. Differentiate between plastic and glass fiber and list reasons for choices.
			5. Explain the phrase “total internal reflection” relative to fiber optic cable.
			6. Explain fiber optic system design, installation and testing.
			7. Discuss the basic steps in planning a fiber optic system installation.
			8. Explain the operation of an Optical Time-Domain Reflectometer (OTDR).
			9. Describe and perform an optical continuity test.

2.H.01.10 Perform fiber cable loss testing using a calibrated light source and a power meter.

* + 1. Performance Example:
			- Discuss what a loss budget is and its importance in fiber optic system design.

###### Principles of Electronic Communication

* + 1. Explain the principles of electronic communication.
			1. Define the properties of signals in both acoustic and electrical form.
			2. Describe the dimension signal frequency, wavelength and phase.
			3. Calculate the relationship of time vs. frequency, phase vs. distance and phase vs. time.
			4. Calculate power gain and loss in dB units and convert to power.
			5. Calculate reference power levels in dBm and convert to power.
			6. State the S/N ratio required for communication with telephone/audio systems.
			7. Define fundamental and harmonic frequencies of electrical signals.
			8. Identify and define the harmonic structure of common signal waveforms.
			9. Specify the common forms of waveform distortion applied to signals in electronic circuits.

2.I.01.10 Identify the acoustic and electrical properties of common input and output transducers.

* + 1. Performance Examples:
			- Given a diagram: wire and demonstrate the operation of a basic electronic communication system.

###### Fundamentals of Wireless Communication

* + 1. Describe the fundamentals of wireless communication.
			1. Identify and explain various modulation schemes.
			2. State the functions of a transmitter, receiver and a channel in a basic wireless communication system.
			3. State the purpose and define the properties of transmission lines.
			4. Calculate the length of a ½ wave dipole antenna for a given frequency.
			5. Discuss ground waves, space waves, and sky waves.
			6. List the frequency components of AM, FM, and TV signals.
			7. Describe the major components of a communication satellite and ground stations.
			8. List the basic system requirements for digital data communications.
			9. Describe the nature and effects of transmission imperfections.

2.J.01.10 Define the terms aspect ratio, resolution, pixels, and triads as they relate to HDTV.

* + 1. Performance Example:
			- Create the block diagrams of a tuned RF transmitter and super heterodyne receiver.

###### Residential Management

* + 1. Discuss residential management techniques.
			1. Explain bar coding and modern inventory control methods for residences.
			2. Explain manual, automatic and programmable appliances control.
		2. Performance Example:
			- List the benefits of residential management.

###### Premise Restoration

* + 1. Discuss the necessity of premise restoration.
			1. Describe the need for drywall and other penetrations of walls and ceilings in retrofit applications.
			2. Demonstrate restoration techniques and list materials used.
		2. Performance Example:
			- Restore a drywall surface to its original condition after installing a wall box outlet.

###### Tools and Equipment

* + 1. Explain the proper use of tools and equipment.
			1. Explain usage of VOM meters in residential cabling and demonstrate use of each function.
			2. Demonstrate the ability to use wire strippers/crimps/punch-down tool and fish tapes.
			3. Explain the usage of gofer poles, drills/bits, scissors and face mask.
			4. Explain the use of a toner and light meter/source.
			5. Describe the proper installation of an F connector using compression tool and fittings.
			6. Explain why wire pull lubricant is needed.
			7. Describe the proper usage and safety concerns for hand and power tools.
			8. Identify cable using cable markers and discuss how to identify wires that have no markers.
		2. Performance Examples:
			- Create a list of hand and power tools needed for a typical telecom tech’s tool kit.

###### Customer Orientation and Documentation

* + 1. Explain the need for customer satisfaction.
			1. Compare excellent customer/owner relations, problem prevention and conflict resolution concepts.
		2. Performance Example:
			- Create a flow chart showing the relationship between and factors that determine both internal and external customer satisfaction.

###### Troubleshooting Skills

* + 1. Demonstrate the ability to troubleshoot electronic communication systems.
			1. Explain the divide and conquer troubleshooting method.
			2. List common problems and solutions in residential cabling.
			3. Identify sources of on-line and phone technical help from product manufacturers and suppliers.
		2. Performance Example:
			- Demonstrate the ability to successfully troubleshoot a communication system.

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# [Strand 3: Embedded Academics](#_bookmark0)

Strand 3: Embedded Academics, a critical piece of a Vocational Technical Education Framework, are presented as Crosswalks between the Massachusetts Vocational Technical Education Frameworks and the Massachusetts Curriculum Frameworks. These Crosswalks are located in the Appendix of this Framework.

##### Academic Crosswalks

[Appendix A: English Language Arts](#_bookmark20) [Appendix B: Mathematics](#_bookmark20)

[Appendix C: Science and Technology/Engineering](#_bookmark22) Earth and Space Science

Life Science (Biology)

Physical Science (Chemistry and Physics) Technology/Engineering

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

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| CTELearning Standard Number | Strand Coding Designation Grades ELAsLearning Standard Number | Text of English Language Arts Learning Standard |
| 2.F.01.022.F.01.032.F.01.06 | WHST. Grades 6-10.2 b & d | Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.b.Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience’s knowledge of the topicd.Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. |
| Performance Example: | * Students will produce a flip-book explaining the basics of electricity with clear, concise domain specific language appropriate to the grade level.
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| 2.F,02.112.G.01.012.B.01.032.B.01.02 | RST. Grades 6 – 12.4 | 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 6–12 texts andtopics. |
| Performance Example: | * Students will read and interpret in written form domain specific schematics using precise language explaining the processes clearly and demonstrating understanding in an organized, concise style.
 |  |
| 2.G. .01 | WHST. Grades 6-10.6 | 6-8Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.9-10Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage oftechnology’s capacity to link to other information and to display information flexibly and dynamically |
| Performance Example: | * In a multimedia presentation to the class, students will compare analog & digital phone systems/internet cable wireless systems & B-V0LP and/or other appropriate content specific topics using appropriate
 | vocabulary and adapting speech to audience and purpose. |
| 2.I.01 | WHST. Grades 6-12.4WHST. Grades 6-10.6 | 6-12.4Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience6-8.6Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently. 9-10.6Use 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 displayinformation flexibly and dynamically |
| Performance Example: | * Students will create a dictionary with domain specific vocabulary and definitions demonstrating clear, concise, coherent writing, and an understanding of the principles of electronic communication.
 |  |
| 2.J.01 | WHST. Grades 6-12.2 a & dRST. Grades 9-10.2 | 2.a&dWrite informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g.,, headings), graphics (e.g.,, figures, tables), and multimedia when useful to aiding comprehension.d. Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. 2.Determine the central ideas or conclusions of a text; trace the text’s explanation or depiction of a complex process, phenomenon, orconcept; provide an accurate summary of the text |
| Performance Example: | * Students will write a paper summarizing the fundamentals of wireless communication accurately demonstrating command of standard English grammar and usage citing appropriate text.
 |  |
| 2.K.012.L.01 | SL. Grades 6-12.4 | 6-10Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation10-12Present 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 areappropriate to purpose, audience, and a range of formal and informal tasks |
| Performance Example: | * Students will create a multimedia presentation demonstrating the restoration of a drywall surface after installing a wall box outlet. Students will articulate in a logical step-by-step procedure adapting the speech
 | to the purpose and audience. |
| 2.L.01 | WHST. Grades 9-10.6WHST. Grades 6-10.7 | 6Use 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 dynamically7Conduct 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; synthesizemultiple sources on the subject, demonstrating understanding of the subject under investigation. |
| Performance Example: | * Students will design an advertising pamphlet for customers explaining Premise Restoration. The product will accurately use domain specific vocabulary and phrases and demonstrate an understanding of the content. With the use of technology, the product will demonstrate command of conventions and standards
 | of English grammar and usage. |
| 2.M.012.N.01 | WHST. Grades 6-10.4WHST. Grades 6-12.2SL.9-12.3 | 4Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience 2Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.SL 9-10Evaluate a speaker’s point of view, reasoning, and use of evidence and rhetoric, identifying any fallacious reasoning or exaggerated or distorted evidence.11-12Evaluate a speaker’s point of view, reasoning, and use of evidence andrhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used. |
| Performance Example:* Students will generate a 3 column paper (tool-usage-concerns)describing the proper use and safety concerns for hand and power tools in appropriate terminology in clear, concise English citing appropriate text and codes.
 | * Students will write scripts and role-play scenarios of difficult customer situations. Students will adapt speech to appropriate purpose and audience.
 | * Students will compose a response to a customer billing complaint clearly articulating logical reasoning in a clear manner with supporting facts.
 |
| 2.O.01 | SL.9-12.6 WHST.6-12.9L.9-12.6 | 6Adapt speech to a variety of contexts and tasks, demonstrating a command of formal English when indicated or appropriate9Draw evidence from informational texts to support analysis, reflection, and research.Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrateindependence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression |
| Performance Examples:* Individually or in a team, students will design and present a flip chart/guide book describing trouble- shooting skills demonstrating understanding of the topic using evidence from informational text.
 | * Individually or in a team, students will write and produce a podcast on trouble-shooting skills. Students
 | will research instructional manuals, texts, journals, and web sites while paying attention to accuracy in laws and regulations. |
| 2.A – 2.0 | L. Grades 6-12.6 | Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when consideringa word or phrase important to comprehension or expression |
| Performance Example: | * Students will demonstrate to the teacher in writing and speaking a clear understanding of domain specific vocabulary and its appropriate usage in all assignments.
 |  |
| 2.A | 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 summarizing the precise details of safety and other technical procedures in 2 column notes.
 |  |
| 2.A, 2.B,2.C, 2.D,2.E, 2.F,2.G, 2.H,2.I, 2.J,2.K, 2.L,2.M, 2.N,2.0 | SL. Grade 8.4SL. Grades 9 – 12.4 | 8Present 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.9-10Present 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.11-12Present 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 areappropriate to purpose, audience, and a range of formal and informal tasks. |
| Performance Example: | * Students will present orally to the teacher/class demonstrations and/or role plays on content specific topics and/or techniques in a clear, organized, logical manner using appropriate command of the English
 | language. |
| 2.A, 2.B,2.C, 2.D,2.E, 2.F,2.G, 2.H,2.I, 2.J,2.K, 2.L,2.M, 2.N,2.0 | WHST. Grades 6-12.10RST. Grades 9 – 10.1 | 10Write 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.1Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions |
| Performance Example: | * Students will maintain daily/weekly logs describing and defining important fundamentals of telecommunications including domain specific vocabulary and phrases in clear, concise, coherent writing.
 | * Students will read technical texts and articles summarizing the precise details of technical procedures using 2 column notes.
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| 2.D.01.012.D.01.062.F.01.042.F.01.052.G.01.062.N.01.01 | RST. Grades 9-10.9 | 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: | * Students will compare and contrast professional tools, techniques, and behaviors as well as various
 | business plans using Venn diagrams and other graphic organizers to demonstrate understanding that different strategies produce different results. |
| 2.B2.B.01.03 | RST. Grades 6-12.4 WHST. Grades 6-8.2d WHST. 9-10.2d | 4Determine 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 topics2.Write informative/explanatory texts, including the narration of |
|  |  | historical events, scientific procedures/ experiments, or technical processes.2dUse precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. |
| Performance Example: | * Students will write a short paper providing specific textual evidence from the Telecordia standards to support its relations to cabling utilizing domain specific phrasing and demonstrating command of the standards of English grammar and usage.
 | * (2.B)Students will read technical texts and demonstrate understanding of the specific technical process by creating a top-down web or other graphic organizer reflecting key details.
 |
| 2.C.012.F.022.H.01.02 | WHST. Grades 6 – 12.4 | Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| Performance Example:* Students will write, for their customers, an information sheet on the selection factors of optimum audio speaker cable wires demonstrating understanding of the content and vocabulary using correct standard English grammar.
 | * Students will create a written documentation package for a content specific project demonstrating well- chosen, relevant facts in precise language and vocabulary indicating understanding of purpose and audience.
 | * Students will create a poster summarizing basic light theory with a list of commonly used wave lengths. Students will present it to the class demonstrating understanding of the topic.
 |
| 2.D012.E.01 | WHST. Grades 6-10.6SL. Grades 6 – 12.6 | 6-10.6Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently6-12.6Adapt speech to a variety of contexts and tasks, demonstrating a command of formal English when indicated or appropriate. |
| Performance Example: | * Students will produce a multimedia presentation to the class on network cable installation demonstrating accurate information in a concise, organized manner adapting speech to the task.
 | * Students will produce, with the use of technology, a manual on the lay-out process using domain specific vocabulary and phrasing in an organized concise style following the rules of standard English conventions.
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### [Embedded Mathematics](#_bookmark0)

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| CTELearning Standard Number | Math Content Conceptual Category and Domain Code Learning Standard Number | Text of Mathematics Learning Standard |
| 2.A.01.02 | 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 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, includingequations with coefficients represented by letters. (see note for A- CED-1 ) |
| Performance example: | * Have students demonstrate the use of I=E/R.
 |  |
| 2.A.01.03 | 8.G.7 | Understand and apply the Pythagorean Theorem.8.G.7. Apply the Pythagorean Theorem to determine unknown side lengthsin right triangles in real-world and mathematical problems in two and three dimensions. |
| Performance example: | * Given the height of the point where a ladder is leaning against a building and the length of a ladder determine how far the base of the ladder is from the building.
 |  |
| 2.B.01.01 | 2.MD.1,2.MD.3, 3.MD.4 | Measure and estimate lengths in standard units.2.MD.1. Measure the length of an object by selecting and using appropriatetools such as rulers, yardsticks, meter sticks, and measuring tapes.2.MD.3. Estimate lengths using units of inches, feet, centimeters, and meters.Represent and interpret data.3.MD.4. Generate measurement data by measuring lengths using rulers markedwith halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units—whole numbers, halves, or quarters. |
| Performance example: | * Estimate the measurement of a drop cable from a telephone pole to the interface box and then verify using a tape measure.
 |  |
| 2.C.01.02 | 8.F.3,7.G.4,6.EE.1, 6.EE.2.C | Define, evaluate, and compare functions..8.F.3. Interpret the equation y = mx + b as defining a linear function, whosegraph is a straight line; give examples of functions that are not linear. For example, the function A = s2 giving the area of a square as a functionof its side length is not linear because its graph contains the points (1,1),(2,4) and (3,9), which are not on a straight line.Solve real-life and mathematical problems involving angle measure, area, surface area, and volume.7.G.4. Know the formulas for the area and circumference of a circle and usethem to solve problems; give an informal derivation of the relationshipbetween the circumference and area of a circle.Apply and extend previous understandings of arithmetic to algebraic expressions.6.EE.1. Write and evaluate numerical expressions involving whole- numberexponents.6.EE.2.c. Evaluate expressions at specific values of their variables.Includeexpressions that arise from formulas used in real-world problems. Perform arithmetic operations, including those involving whole numberexponents, in the conventional order when there are no parentheses to specify a particular order (Order of Operations).For example, use the formulas V = s3 and A = 6 s2 to find the volume and surface area of a cube with sides of length s = 1/2. |
| Performance example: | Calculate the area of a number 14 gauge wire. |  |
| 2.C.01.05 | 7.NS.2,7.NS.3 | 1. NS.2. Apply and extend previous understandings of multiplication and

division and of fractions to multiply and divide rational numbers.* 1. Understand that multiplication is extended from fractions to rational numbers by requiring that operations continue to satisfy the properties of operations, particularly the distributive property, leading to products such as (–1)(–1) = 1 and the rules for multiplying signed numbers. Interpret products of rational numbers by describing real-world contexts.
	2. Understand that integers can be divided, provided that the divisor is not zero, and every quotient of integers (with non-zero divisor)

is a rational number. If p and q are integers, then –(p/q) = (–p)/q = p/(–q). Interpret quotients of rational numbers by describing real- world contexts.* 1. Apply properties of operations as strategies to multiply and divide rational numbers.
	2. Convert a rational number to a decimal using long division; know that the decimal form of a rational number terminates in 0s or eventually repeats.

3. Solve real-world and mathematical problems involving the four operations with rational numbers. |
| Performance example: | Calculate the resistance of a 100 foot length of copper wire with a cross sectional area of 810 cm. |  |
| 2.D.01.08 | F-BF.5, F-LE.4 | Build new functions from existing functionsF-BF.5. (+) Understand the inverse relationship between exponents andlogarithms and use this relationship to solve problems involving logarithms and exponents.Construct and compare linear, quadratic, and exponential models and solve problemsF-LE.4. For exponential models, express as a logarithm the solution toabct = d where a, c, and d are numbers and the base b is 2, 10, or e; evaluate the logarithm using technology. |
| Performance example: | Determine the relative power in dBm of a 100mW signal. |  |
| 2.E.01.09 | 2.MD.1, 2.MD.3, 3.MD.4 | Measure and estimate lengths in standard units.2.MD.1. Measure the length of an object by selecting and using appropriate |
|  |  | tools such as rulers, yardsticks, meter sticks, and measuring tapes.1. MD.3. Estimate lengths using units of inches, feet, centimeters, and meters.

Represent and interpret data.1. MD.4. Generate measurement data by measuring lengths using rulers marked

with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units— whole numbers, halves, or quarters. |
| Performance example: | * Estimate cable requirements for a home computer network. Explain your reasoning.
 |  |
| 2.E.01.10 | F-BF.5, F-LE.4 | Build new functions from existing functionsF-BF.5. (+) Understand the inverse relationship between exponents andlogarithms and use this relationship to solve problems involving logarithms and exponents.Construct and compare linear, quadratic, and exponential models and solve problemsF-LE.4. 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 |
| Performance example: | * Calculate the interference where the interference power is 10mWand the signal power is 1W.
 |  |
| 2.F.01.01 | A-CED.1, A-CED.4, A-REI.3, 8.EE.4 | Create equations that describe numbers or relationshipsA-CED.1. Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadraticfunctions, and simple rational and exponential functions |
|  |  | 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. (Note: This standard is included because given voltage and current students can write and use Watt’s Law to solve for power). |
|  |  | Solve equations and inequalities in one variableA-REI.3. Solve linear equations and inequalities in one variable, includingequations with coefficients represented by letters. |
|  |  | 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 scientificnotation that has been generated by technology.(Note: Use of engineering notation.) |
| Performance example: |  |  |
| 2.F.01.05 | F-TF.2, F-TF.5, F-TF.7, F-TF.3, F-TF.4 | Extend the domain of trigonometric functions using the unit circleF-TF.2. Explain how the unit circle in the coordinate plane enables the |
|  |  | extension of trigonometric functions to all real numbers, interpreted |
|  |  | asradian measures of angles traversed counterclockwise around the unit circle.Model periodic phenomena with trigonometric functionsF-TF.5. Choose trigonometric functions to model periodic phenomena withSpecified amplitude, frequency, and midline.★F-TF.7. (+) Use inverse functions to solve trigonometric equations that arisein modeling contexts; evaluate the solutions using technology, and interpret them in terms of the context.★Extend the domain of trigonometric functions using the unit circleF-TF.3. (+) Use special triangles to determine geometrically the values of sine,cosine, tangent for / 3, / expressthe values of sine, cosine, and tangent for –x, –x+inx,taenrmd 2s of their values for x, where x is any real number.F-TF.4. (+) Use the unit circle to explain symmetry (odd and even) and periodicity of trigonometric functions. |
| Performance example: | * Calculate the current in an electric circuit which has a 9 volt battery connected to 12 ohm resistor.
 |  |
| 2.F.02.05 | A-REI.4, F-IF.7.a | Solve equations and inequalities in one variableA-REI.4. Solve quadratic equations in one variable.b. Solve quadratic equations by inspection (e.g.,, for x2 = 49), taking square roots, completing the square, the quadratic formula and factoring, as appropriate to the initial form of the equation.Recognize when the quadratic formula gives complex solutions and write them as a ± bi for real numbers a and b.Analyze functions using different representationsF-IF.7. Graph functions expressed symbolically and show key features ofthe graph, by hand in simple cases and using technology for more complicated cases.★a. Graph linear and quadratic functions and show intercepts, maxima, and minima. |
| Performance example: | * Determine the resonant frequency of a filter with values of L=1mH and C=10µF.
 |  |
| 2.H.01.10 | F-BF.5, F-LE.4 | Build new functions from existing functionsF-BF.5. (+) Understand the inverse relationship between exponents andlogarithms and use this relationship to solve problems involving logarithms and exponents.Construct and compare linear, quadratic, and exponential models and solve problemsF-LE.4. 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 |
| Performance Example: | * Calculate the loss of a fiber cable where the output power is 6mW and the input power is 12mW.
 |  |
| 2.I.01.01 | A-CED.1, A-CED.4, A-REI.3, 8.EE.4 | Create equations that describe numbers or relationshipsA-CED.1. Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and |
|  |  | quadraticfunctions, and simple rational and exponential functionsA-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. (Note: This standard is included because given voltage and current students can write and use Watt’s Law to solve for power).Solve equations and inequalities in one variableA-REI.3. Solve linear equations and inequalities in one variable, includingequations with coefficients represented by letters.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 scientificnotation that has been generated by technology.(Note: Use of engineering notation.) |
| Performance Example: | * Calculate the wavelength of an electric signal for a frequency of 100MHz.
 |  |
| 2.J.01.04 | A-CED.1, A-CED.4, A-REI.3, 8.EE.4 | Create equations that describe numbers or relationshipsA-CED.1. Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadraticfunctions, and simple rational and exponential functionsA-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. (Note: This standard is included because given voltage and current students can write and use Watt’s Law to solve for power).Solve equations and inequalities in one variableA-REI.3. Solve linear equations and inequalities in one variable, includingequations with coefficients represented by letters.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 scientificnotation that has been generated by technology.(Note: Use of engineering notation.) |
| Performance Example: | * Calculate the length of a ½ wave dipole antenna at a frequency of 850kHz.
 |  |
| 2.M.01.01 | 5.G.1,5.G.2,.5.G.3,.5.G.4, | Graph points on the coordinate plane to solve real-world and |
|  | 6.NS.8, N-Q.1, A-REI.10, A- REI.11 | mathematical problems.5.G.1. Use a pair of perpendicular number lines, called axes, to define acoordinate 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 andy-coordinate).* + 1. Represent real world and mathematical problems by graphing points

in the first quadrant of the coordinate plane, and interpret coordinatevalues of points in the context of the situation.Classify two-dimensional figures into categories based on their properties.* + 1. 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.* + 1. 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 allfour quadrants of the coordinate plane. Include use of coordinates andabsolute 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 solutionof 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 graphicallyA-REI.10. Understand that the graph of an equation in two variables is the set ofall 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 ofthe 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 findsuccessive 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 thefunction is increasing, decreasing, positive, or negative; relative maximumsand minimums; symmetries; end behavior; and periodicity.★ |
| Performance Example: | * Graph a sine wave every 15 degrees with a maximum of 10.
 |  |

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

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

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| CTELearning Standard Number | Subject Area, Topic Heading andLearning Standard Number | Text of Earth and Space Science Learning Standard |
| 2.F.02.12 | Heat Transfer in the Earth System | 3. Differentiate among radiation, conduction, and convection, thethree mechanisms by which heat is transferred through the earth’s system. |
| Performance Example: | * Students will indentify the similarities between the temperature management of electronic systems and the climate mechanisms that manage temperature on earth.
 |  |
| 2.J.01.06 | 1. Matter and Energy in the Earth System | 1.2 Describe the characteristics of electromagnetic radiation and give examples of its impact on life and Earth’s systems. |
| Performance Example: | * Students will recognize that the electromagnetic spectrum includes both visible light energy, as well as the frequencies used in telecommunications and cellular phones.
 |  |
| 2.F.02.12 | 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 identify the similarities between the temperature management of electronic systems and the climate mechanisms that manage temperature on earth. |

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

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| CTELearning Standard Number | Subject Area, Topic Heading andLearning Standard Number | Text of Physics Learning Standard |
| 2.C.01.042.F.01.01 | 5. Electromagnetism | 5.2 Develop qualitative and quantitative understandings of current, voltage, resistance, and the connections among them (Ohm’s law). |
| Performance Example: | * Students will understand and apply knowledge of ohms law to solve problems in low voltage applications.
 |  |
| 2.F.01.022.F.01.052.F.01.09 | 5. Electromagnetism | * 1. 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.
	2. 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 understand the relationship between moving electrical charges and magnetism and how these relate to the generation of electricity and electrical interference.
 |  |
| 2.F.02.012.F.02.022.F.02.03 | 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 create a simple light bulb circuit using a power supply. The student will operate the same light bulb with AC and DC current and be able to measure the properties of the circuit and give an explanation of
 | the difference in illumination. |
| 2.F.02.12 | 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.

3.4 Explain the relationships among temperature changes in a substance, the amount of heat transferred, the amount (mass) of the substance, and the specific heat of the substance. |
| 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.H.01.022.I.01.022.I.01.072.I.01.082.J.01.04 | 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 able to make basic calculations of wave characteristics and apply them to determine wavelengths for various frequencies used in telecommunications.
 |  |
| 2.I.01.012.J.01.05 | 4. Waves | 4.2 Distinguish between mechanical and electromagnetic waves. |
| Performance Example: | * Students will understand the difference between waves caused by mechanical motion of a material and waves which are transmitted along the electromagnetic spectrum.
 |  |
| 2.H.01.022.H.01.05 | 4. Waves | 4.4 Describe qualitatively the basic principles of reflection and refraction of waves. |
| Performance Example: | * Students will understand how wave reflection and total internal reflection changes with different materials
 | and how this effects the selection of fiber optic cabling. |
| 2.J.01.052.J.01.06 | 6. Electromagnetic Radiation | 6.2 Describe the electromagnetic spectrum in terms of frequency and wavelength, and identify the locations of radio waves, microwaves, infrared radiation, visible light (red, orange, yellow, green, blue, indigo, and violet), ultraviolet rays, x-rays, and gamma rays on the spectrum. |
| Performance Example:* Students will understand the electromagnetic spectrum and the small portion which is occupied by communications technologies.
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#### [Technology/Engineering](#_bookmark0)

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| CTELearningStandard Number | Subject Area, Topic Heading andLearning Standard Number | Text of Technology/Engineering Learning Standard |
| 2.D.01.012.D.01.072.E.01.052.E.01.062.F.01.032.H.01.042.L.01.01 | 1. Materials, Tools, and Machines | 1.1 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). |
| Performance Example: | * Given a task, students will be able to identify the best materials and tools for the situation.
 |  |
| 2.H.012.J.01.022.J.01.072.J.01.08 | 3. Communication Technologies | 3.1 Identify and explain the components of a communicationsystem, i.e., source, encoder, transmitter, receiver, decoder, storage,retrieval, and destination.3.3 Identify and compare communication technologies andsystems, i.e., audio, visual, printed, and mass communication. |
| Performance Example: | * Students will be able to explain the components necessary for a basic fiber optic system and identify the benefits and drawbacks between fiber optics and coax technologies
 |  |
| 2.M.01.07 | 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 othermechanical fasteners) needed to construct a prototype of an engineering design. |
| Performance Example: | * Students will be able to identify and safely operate the tools commonly used in residential service and installation of telecom equipment.
 |  |
| 2.C.01.01 | 1. Engineering Design | * 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: | * When given a set of blueprints, students will be able to interpret the specifications of the drawings.
 |  |
| 2.C.01.03 | 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 be able to understand and recognize the need for building codes in safely installing or
 | servicing electrical wiring. |
| 2.C.01.042.F.01.012.F.01.09 | 5. Energy and Power Technologies—Electrical Systems | 5.3 Explain the relationships among voltage, current, and resistance in a simple circuit, using Ohm’s law. |
| Performance Example: | * Students will understand how current and voltage relate in applications involving low voltage lighting. Students will understand how resistance can affect electrical interference.
 |  |
| 2.F.01.092.E.01.11 | 5. Energy and Power Technologies—Electrical Systems | 5.4 Recognize that resistance is affected by external factors (e.g., temperature). |
| Performance Example: | * Students will understand the external factors that can be controlled through proper installation that affect clear signal transmission in copper cabling.
 |  |
| 2.F.01.5 | 5. Energy and Power Technologies—ElectricalSystems | 5.5 Compare and contrast alternating current (AC) and direct current (DC), and give examples of each. |
| Performance Example: | * Students will understand how AC rather than DC current is required for communications technologies and the importance of AC frequency to different applications.
 |  |
| 2.F.02.012.F.02.032.F.02.052.F.02.082.M.01.01 | 5. Energy and Power Technologies—Electrical Systems | * 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.
	2. 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.
	3. 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: | * Students will be able to identify and understand the function of common circuit components in AC and DC circuits, make voltage and current calculations, and test their predictions using appropriate measurement
 | tools. |
| 2.F.02.12 | 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. |
| Performance Example: | * Students will understand the type of heating caused by electrical components and be able to develop solutions for temperature control.
 |  |
| 2.H.01.02,05-07 | 6. Communication Technologies | * 1. Identify and explain the applications of laser and fiber optic technologies (e.g.,, telephone systems, cable television, photography).
	2. Explain the application of electromagnetic signals in fiber optic technologies, including critical angle and total internal reflection.
 |
| Performance Example: | * Students will be able to explain the basic technology behind fiber optic communications as well as the benefits and limitations to fiber optics in the home.
 |  |
| 2.G.01.042.I.01.012.J.01.08 | 6. Communication Technologies | 6.2 Differentiate between digital and analog signals. Describe how communication devices employ digital and analog technologies (e.g.,, computers, cell phones). |
|  |  |  |
| Performance Example: | * Students will understand the benefits and drawbacks to switching from analog to digital communications. Students will apply this to understanding the 2008 regulatory decision by the FCC to switch from analog to digital cellular signals in the US.
 |  |
| 2.M.01.07 | 2. Construction Technologies | 2.5 Identify and demonstrate the safe and proper use of commonhand tools, power tools, and measurement devices used in construction. |
| Performance Example: | * Students will be able to identify and safely operate the tools commonly used in residential service and installation of telecom equipment.
 |  |

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

ETA Residential Electronics System Integrator Basic Skills & Knowledge Certification Program