*Career Technical Education Framework*

***Stationary Engineering***

CIP Code 479999 | June 2014

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

###### Stationary Engineering Safety and Health Knowledge and Skills

* + 1. Demonstrate essential safety knowledge and skills for stationary engineering.
       1. Successfully complete and obtain a 10 hour OSHA certificate in general industries.
       2. Determine the fundamentals behind the implementation of a lock and tag out system, secure an energy source, and install a lock and tag out.
       3. Explain the dangers of confined space entry, air testing, and monitoring emergency retrieval.
       4. State SDS purpose and location in plant.
       5. Explain the importance of personal protective equipment and fall protection.
       6. Demonstrate safe use of all hand and power tools used in stationary engineering, in accordance with current OSHA standards.
    2. Performance Examples:
       - Identify, isolate, and then lock and tag out a boiler power supply. Write work permit and store key in lock box when preparing a boiler for inspection.
       - List situations where P.P.E. must be used to safeguard against injury.
       - Don a five point body harness, secure to safety tie off, and safely access unguarded elevated area.

###### Fundamentals of Stationary Engineering

* + 1. Explain concepts fundamental to differentiating between boiler classifications.
       1. Differentiate between high and low pressure boilers.
       2. Describe how a water tube boiler is different from a fire tube boiler.
       3. Compare conditions that call for a water tube boiler over a fire tube boiler and vice versa.
       4. Contrast the difference between a field-erected and packaged boiler.
    2. Performance Example:
       - Enter into both water and fire tube boilers and identify components that are common and uncommon to both.
    3. Explain concepts fundamental to safety and relief valves.
       1. Explain the purpose of a safety valve.
       2. Describe American Society of Mechanical Engineers (A.S.M.E.) code requirements for safety valves on boilers.
       3. Differentiate between safety and relief valves.
       4. Explain when to hand test a safety valve under boiler pressure and describe the procedures used for the test.
       5. Explain the purpose of blowback and how to calculate the percentage of safety valve blowback.
       6. Disassemble, label and reassemble a spring loaded pop safety valve.

2.B.02 Performance Examples:

* Disassemble, label, and reassemble a spring loaded pop safety valve cut away.
* Bring boiler up to seventy five percent of safety valve popping pressure and perform tri lever test
  + 1. Explain concepts fundamental to soot blowers.
       1. Explain the purpose of a soot blower.
       2. Describe the dangers inherent to the operation of a soot blower.
       3. Give the sequence of blowing tubes on a boiler with auxiliary equipment (e.g., economizers).

2.B.03 Performance Example:

* Perform a soot blowing sequence on a boiler while under operation.
  + 1. Explain concepts fundamental to draft fans and dampers.
       1. Examine and describe the difference between mechanical and natural draft.
       2. Define forced, induced, and combination draft as they pertain to boiler systems.
       3. Report how dampers are used to control the flow of air entering and leaving boiler systems.

2.B.04 Performance Examples:

* Trace the draft system of a boiler starting at air intake and culminating at the stack.
* Take draft reading at boiler stack in low, medium, and high fire operating conditions.
  + 1. Illustrate and explain concepts fundamental to economizers and air pre-heaters.
       1. Explain the cost savings associated with the operation of both air pre- heaters and economizers.
       2. Assess and describe, with association to steam pressure, when economizers become a necessity.
       3. Identify to what medium thermal energy is transferred, in the example of both economizers and air pre-heaters.
       4. Diagram and label the piping of a condensing economizer.

2.B.05 Performance Examples:

* Identify the location and purpose of both an economizer and a pre-heater.
* Open and label both the internal and external components of a condensing economizer.
  + 1. Explain concepts fundamental to super heaters and de-super heaters.
       1. Describe the purpose of super heated steam and how it differs from saturated steam.
       2. Summarize the advantages to using superheated steam.
       3. Identify the proper procedure for starting boilers that employ super heaters.
       4. Describe how superheated steam temperature is controlled.
       5. Specify the inherent dangers to operating super heaters with no flow; super heater safety valve setting in relation to boiler drum safety valve setting; and venting and draining of super heater.

2.B.06 Performance Examples:

* Locate and identify a super heater drain and or vent.
* Analyze the difference between the super heater safety valve and drum safety valve popping pressures; summarize the reason for the differential.
  + 1. Demonstrate an understanding of the concepts fundamental to steam traps.
       1. Indicate the purpose of steam traps in a steam system.
       2. Discuss the operation of the most common steam traps: inverted bucket, impulse, float thermostatic and thermostatic.
       3. Disassemble, label, and reassemble most common steam traps.
       4. Isolate, bypass, remove, and rebuild a steam trap when tied into a live line during boiler plant operation.

2.B.07 Performance Examples:

* Disassemble: thermostatic, float thermostatic, impulse, and inverted bucket steam trap cut- always and label their components.
* Isolate, bypass, remove, and rebuild a steam trap tied into a live line during steam plant
  + 1. Distinguish and report concepts fundamental to combustion.
       1. Explain how the combustion of a fuel is required to generate the heat necessary to produce steam in a boiler.
       2. Identify the most common fuels used in boilers today.
       3. Tabulate, in detail, how fuel is metered: oil gallons in barrel, gas cubic foot through deca therm, and coal in pounds and tons.
       4. Explain how coal is ranked.
       5. Identify equipment required to burn different fuels.
       6. List the requirements for preparing fuels for firing.
       7. State the flash point, poor point and fire point of a fuel.
       8. State the role of time, temperature, and turbulence related to combustion.
       9. Define the terms perfect combustion, complete combustion, and incomplete combustion.

2.B.08.10 Differentiate between primary, secondary, and tertiary air and their role in the combustion process.

2.B.08 Performance Examples:

* Visually identify the difference between number two fuel oil and number six fuel oil.
* Manually adjust boiler burner to cause poor combustion and return to proper adjustment using flue gas analyzer tool.

###### Heat and Energy

* + 1. Describe concepts fundamental to heat transfer.
       1. Define specific heat and explain the difference between sensible and latent heat of evaporation.
       2. Define how energy is transferred, conduction, convection, and radiation and their relation to heat transfer in a boiler.
       3. Explain the first two laws of thermodynamics and how they apply to boiler system operations.
       4. Explain the importance of the enthalpy of steam.
       5. Discuss how the transfer of energy causes circulation in a boiler.
       6. Identify and describe the four systems that apply to any steam boiler.
    2. Performance Examples:
       - With the boiler open, identify the areas where the transfer of heat by radiation and convection occur.
       - Identify the areas on an open boiler that are classified as heating surface.

###### Chapter 146 Massachusetts General Laws and the A.S.M.E. Code

* + 1. Demonstrate an understanding of the Massachusetts General Laws and regulations related to Stationary Engineering.
       1. Explain the terms chief, commissioner, department, division and inspector as they pertain to Chapter 146.
       2. List and describe requirements for both boilers and air tank annual and bi- annual inspections pursuant to state law.
       3. Use the formula which the state uses to determine boiler horsepower.
       4. Describe how high pressure boilers are to be monitored based on aggregate horsepower (i.e., Continuous, non continuous and periodic).
       5. Indicate how and where a boiler operator’s license and boiler inspection certificate should be displayed.
       6. Describe the limitations and capabilities of the second class fireman’s license.
    2. Performance Examples:
       - Calculate the total horsepower of the teaching boiler room and cite under which monitoring classification it falls.
       - Locate and explain where a boiler inspection certificate and a boiler operator license are displayed in a high pressure boiler plant.
    3. Describe rules as they apply to the American Society of Mechanical Engineers.
       1. State the minimum handhold and manhole dimensions.
       2. Explain the minimum water column connection sizes and requirements.
       3. Demonstrate an understanding of main steam line valve configurations.
       4. Identify the minimum pressure gauge graduation, valve arrangement and purpose of flooding, siphon or pigtail protection when installing a gauge on a boiler.

2.D.02 Performance Examples:

* Properly pipe a boiler pressure gauge and explain hazards associated with improper installation.
* Indicate the difference between the inside and outside boiler stop valves.
* Visually distinguish between pipes sized from half inch through one inch I.D.

###### Fundamental Mathematics

* + 1. Calculate using whole numbers.
       1. Practice using whole numbers and their relation to word problems.
       2. Compute word problems using whole numbers in operations requiring multiplication and division.
    2. Calculate fractions.
       1. Demonstrate how to convert from fractions to decimals.
       2. Illustrate adding, subtracting, multiplying and dividing fractions.
    3. Calculate decimals.
       1. Practice rounding decimals, changing decimals to fractions, multiplying and dividing decimals.
    4. Practice calculating percentages.
       1. Demonstrate calculating percentage rate, calculate base rate amount and determining cost.
    5. Convert measurements.
       1. Define and use denominate numbers.
       2. Distinguish units of measure.
       3. Convert units.
    6. Calculate ratios and proportions.
       1. Locate the missing term.
       2. Solve direct and inverse proportions.
    7. Use planes and solid figures to perform calculations.
       1. Calculate the radius, diameter and circumference of a circle.
       2. Calculate the volume of various solid figures.
    8. Create and interpret graphs.
       1. Use line, bar and circle graphs.

###### Fundamentals of Boiler Operations

* + 1. Employ practices related to blowing down a boiler.
       1. State valve sequence and procedure for blowing down a boiler, according to manufacturers’ specifications and current industry standards.
       2. Describe the various valve arrangements and design used on common boiler blow-down systems.
       3. Explain the reasoning behind the proper opening sequence of the blow- down valves.
       4. Describe the relationship between boiler blow-down and boiler water conductivity.
       5. Compare blow-down separators and flash-tanks and describe their function and applications.
    2. Performance Examples:
       - Identify the major components of the boiler blow down system and describe their associated functions.
       - Demonstrate the proper valve opening and closing sequence to perform a boiler bottom blow down.
       - Identify the blow down separator and define its purpose in the blow down system.
       - Draw a diagram of the boiler blow down system.
    3. Employ practices related to maintaining proper boiler water level.
       1. Explain the importance of maintaining a normal operating water level (NOWL) in a boiler.
       2. State the dangers of carrying a too high or low water condition in your boiler and means of prevention.
       3. Show how to manually add water to the boiler.
       4. Demonstrate how to automatically add and adjust water to the boiler using a feed-water regulator.
       5. Explain the operation of the float, thermo-expansion, and thermo-hydraulic feed-water regulators.
       6. Differentiate and describe the use of single, double, and triple element feed- water regulators.
       7. Illustrate the high and low pressure feed-water systems showing all lines, valves and equipment that are pertinent to its operation.

2.F.02 Performance Examples:

* Demonstrate how to manually add water the boiler.
* Demonstrate how to automatically add water to the boiler.
* Draw a diagram of the low and high pressure feedwater systems.
  + 1. Demonstrate practices related to plant start-up and shut down with various boiler arrangements.
       1. Employ the steps for starting a cold boiler according to current industry standards.
       2. Identify and locate all safety interlocks on the boiler before start-up and their purpose.
       3. Demonstrate the appropriate testing and resetting of all safety interlocks before and during boiler start-up.
       4. Illustrate the high and low pressure steam systems showing all lines, valves and equipment that are pertinent to its operation.

2.F.03 Performance Examples:

* Demonstrate the start up procedure for a high and low pressure boiler using standard operating procedures.
* Demonstrate the shut down procedure for a high a low pressure boiler using standard operating procedures.
* Draw a diagram of the high and low pressure steam systems with associated equipment.
  + 1. Utilize practices related to troubleshooting an on-line boiler.
       1. Explain and employ the sequence of the pre-purge cycle on the boiler.
       2. Implement the necessary steps to troubleshoot and diagnose no power at start-up.
       3. Perform the necessary steps to troubleshoot and diagnose no pilot at start- up.
       4. Execute the necessary steps to troubleshoot and diagnose no main flame at start-up.
       5. Employ the necessary steps to troubleshoot and diagnose flame failure during run period.
       6. Perform the necessary steps to troubleshoot and diagnose low water condition during run period.

2.F.04 Performance Examples:

* Diagnose and troubleshoot various causes of no power at boiler start up.
* Diagnose and troubleshoot various causes of no pilot or main flame at ignition point.
* Diagnose and troubleshoot causes of main flame failure during run period.
* Diagnose and troubleshoot causes for low or high water conditions during run period.
  + 1. Recognize and apply concepts fundamental to the first duties of taking over a shift and logging in the state logbook.
       1. Explain the importance of arriving to work early.
       2. Demonstrate the record keeping procedures of the Massachusetts operator’s state log book.
       3. Demonstrate the record keeping procedures of the Massachusetts engineer’s log book.
       4. Document and record all pertinent information required in the state operator’s log book.
       5. Determine and explain the importance of establishing a true water level in the boiler.

2.F.05 Performance Examples:

* Record and document plant readings in the Massachusetts Operators State log book.
* Determine a true water level in an operating boiler.
* Explain the importance of arriving to work early to relieve a fireman of a work shift.
  + 1. Perform practices related to water column and gauge glass, according to current industry standards.
       1. Demonstrate blow down procedure on the lab water column and gauge glass.
       2. Exhibit blow down procedure on the live boiler water column and gauge glass.
       3. Show how to remove, measure, and install a new gauge glass.
       4. State the purpose the water column serves on the boiler.
       5. Explain the theory of try cocks and demonstrate how they operate.
       6. Describe the different methods and frequency of testing a LWFCO.

2.F.06 Performance Examples:

* Identify and define the parts associated with a water column and gauge glass and the purpose they serve.
* Establish a true water level in a high and low pressure boiler.
* Remove and install a new boiler gauge glass using standard operating procedures.
* Draw a diagram of the water column and gauge glass and the associated piping system.
  + 1. Exemplify practices related to preparing a boiler for inspection.
       1. Explain the purpose and frequency of boiler inspections.
       2. Demonstrate the steps used to prepare a boiler for an internal inspection.
       3. Demonstrate the steps used to prepare a boiler for an external inspection.
       4. Explain the purpose and function of manhole, and hand-hole plates.
       5. Describe and demonstrate the removal, preparation and reinstallation of common gaskets and seals used to secure hand-hole and manhole plates.

2.F.07 Performance Example:

* Student will prepare a boiler for an annual internal inspection using standard operating procedures including boiler isolation, opening, cleaning, hydrostatic testing, and closing of
  + 1. Complete practices related to performing the functions of an auxiliary operator.
       1. Describe and demonstrate the operation of starting and stopping an electrical driven feed-water pump.
       2. Demonstrate and explain the operation of starting and stopping of a steam driven feed-water pump.
       3. Compare and contrast the operation and purpose of the open and closed feed-water heaters and the equipment associated with them.
       4. Identify all auxiliary equipment associated with the steam plant.

2.F.08 Performance Examples:

* Perform start up and shut down procedures of various auxiliary equipment including electrical driven pumps and steam driven pumps.
* Record, evaluate, and troubleshoot temperatures and pressures of the equipment associated with the auxiliary system.
* Draw a diagram of the assortment of auxiliary systems.
  + 1. Employ practices related to the operation of burners and boiler flame safety controls.
       1. Explain the purpose of automatic combustion controls and identify the four basic types of combustion controls (on/off, modulating, positioning and metering).
       2. Identify controls for air for combustion and combustion gases.
       3. Demonstrate a flame failure in the boiler by manipulation of the flame scanner.
       4. Describe and demonstrate the operation of the low oil pressure switch.
       5. Explain the importance of the pre-purge and post-purge cycling of the boiler.
       6. Describe and demonstrate the operation of different types of fuel oil burners.
       7. List and describe components and accessories associated with the fuel oil system.

2.F.09 Performance Examples:

* Demonstrate flame failure during boiler run period.
* Explain the function and purpose of the automatic combustion control system.
* Demonstrate the procedure of starting a boiler on dual fuels (natural gas and fuel oil).
* Remove and clean a fuel oil burner.
* Draw a diagram of the gas and fuel oil system.

###### Joining and Assembling Piping and Associated Accessories

* + 1. Demonstrate practices related to steel piping (ferrous), and tubing (non-ferrous) according to current industry standards.
       1. Explain the methods of measuring, cutting, reaming, filing and joining of ferrous (steel) pipe.
       2. Explain the methods of measuring, cutting, reaming, filing and joining of non-ferrous (brass, copper and aluminum) pipe and tubing.
       3. Compare the different types of support and suspension systems used in the suspension of piping and tubing.
    2. Performance Example:
       - Describe practices related to installation and maintenance of different piping (ferrous), tubing (non-ferrous), and associated support systems.
    3. Integrate practices related to steel fittings (ferrous) and non-ferrous fittings as used in stationary engineering.
       1. Describe the purpose, use and installation of ferrous (steel) fittings, and non-ferrous fittings (brass, copper).
       2. Describe and demonstrate all methods of measuring and joining steel fittings.
       3. Describe and demonstrate measuring and joining all types of copper, brass, aluminum and non-ferrous fittings.

2.G.02 Performance Example:

* Identify and integrate practices utilized in the acceptable installation standards of steel fittings (ferrous) and (non-ferrous) fittings.
  + 1. Employ practices related to valves.
       1. Describe and demonstrate the different types, function, purpose and use of: gate valves, globe valves, check valves, non-return valves, bottom blow down valves, control valves, ball valves and butterfly valves.
       2. Describe and demonstrate the operation and maintenance of valves in relation to pressure, temperature and application.

2.G.03 Performance Example:

* Explain the function, performance and selection of different types of valves used in the stationary engineering field.
  + 1. Describe practices related to gauges.
       1. Compare and contrast the types of pressure gauges, vacuum gauges, compound gauges and draft gauges commonly used in industry.
       2. Explain the purpose, function, location and use of gauges.
       3. Describe and demonstrate installation practices applicable to gauges, siphons, flooding and vibration.

2.G.04 Performance Example:

* List and describe the functions and purposes of different types of gauges.

###### Mechanical Drive Systems

* + 1. Demonstrate practices related to couplings.
       1. List the different types of couplings.
       2. Describe all methods used to connect couplings to various arrangements of shafts.
       3. Describe and demonstrate the use of the bearing key-ways, and set screws to fasten coupling to shafts.
    2. Performance Example:
       - Describe coupling types, and the installation, service, and repair of each type.
    3. Employ practices related to bearings.
       1. Cite different bearing design and applications.
       2. List and explain methods used to install and remove bearings to and from various arrangements on shafts as well as bearing housings.
       3. Display an understanding of the use and purpose of bearing oil and water jackets.

2.H.02 Performance Example:

* Explain the importance of bearings, including the different types of bearings, and their application in various types of equipment.
  + 1. Utilize practices related to alignment.
       1. Utilize appropriate coupling and shaft alignment terminology.
       2. Describe and demonstrate the alignment of shafts and couplings using straight edge and thickness gauge, dial indicator and rim face methods.

2.H.03 Performance Example:

* Align shafts, and associated equipment.

###### Fundamentals of Electrical Systems

* + 1. Explain and apply fundamental electrical concepts related to stationary engineering.
       1. Explain concepts fundamental to alternating and direct currents.
       2. Differentiate between parallel and series circuit.
       3. Measure voltage using a digital multi-meter.
       4. Isolate a circuit, remove and identify a failed fuse using multi-meter.
    2. Performance Example:
       - Students identify concepts of direct, and alternating current used in series, parallel circuitry. Students demonstrate knowledge of isolation of circuitry, to diagnose and troubleshoot over- current protective devices in applicable electrical systems.

# [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.

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# [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 |
| 1.A.01  1.A.02  1.A.03  4.A.02.02  4.A.02.03  4.A.02.04 | RST1: 9-12 | Cite specific textual evidence to support analysis of science and  technical texts, attending to important distinctions the author makes  and to any gaps or inconsistencies in the account. |
| Performance Example: | * 1.A. Identify, describe, and define the fundamentals of safety through citing textual evidence and learned experiences. | * 4.A.02 Locate trade information in texts and use appropriately. |
| 2.B.01 | RST2: 9-12 | Determine the central ideas or conclusions of a text; summarize  complex concepts, process, or information presented in a text by paraphrasing them in simpler but still accurate terms. |
| Performance Example: | * 2.B.01 Understand and demonstrate the fundamentals of steam engineering by accurately summarizing: differences in boiler classifications, concepts essential to safety and relief valves, soot blowers, draft | fans/dampers, economizers/pre-heaters, super-heaters/ de-super heaters, steam traps and heat combustion. |
| 2B.01.01-  2B.01.08,  2C.01.01-  2C.01-06,  2F.01.01-  2F.01.09 | RST: 9-12 | Follow precisely a complex multistep procedure when carrying out  experiments, taking measurements, or performing technical tasks;  analyze the specific results based on explanations in the text. |
| Performance Example: | * Students must properly demonstrate knowledge gained from the texts and oral instruction by performing multi-step tasks. |  |
| 2.D.01  2.D.02 | RI4: 9-12 | Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings. |
| Performance Example: | * Determine meanings and demonstrate understanding of Chapter 146 Massachusetts General Laws and the | A.S.M.E. Code |
| 4.A.01 | RI 7: 9-12 | Integrate and evaluate multiple sources of information presented in  different media or formats (e.g.,, visually, quantitatively) as well as in words in order to address a question or solve a problem. |
| Performance Example: | * Use text books, graphs, charts, equations, technical vocabulary and hands-on learning to solve problems and answer questions. |  |
| 4.A.02.04 | W2: 9-12 | Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.  a. Introduce a topic; organization complex ideas, concepts, and information so that each new element builds on that which  precedes it to create a unified whole; include formatting (e.g.,, headings), graphics (e.g.,, figures, tables), and |
|  |  | multimedia when useful to aiding comprehension.   1. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience’s knowledge of the topic. 2. Use appropriate and varied transitions and syntax to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts. 3. Use precise language, domain-specific vocabulary, and techniques such as metaphor, simile, and analogy to manage the complexity of the topic. 4. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. 5. Provide a concluding statement or section that follows from   and supports the information or explanation presented (e.g.,, articulating implications or the significance of the topic). |
| Performance Example: | * Create several written documents using technical terminology. Use graphs, charts, diagrams to further illustrate understanding and clearly convey information. [Genres of writing may include: ship essays, | product research, compare and contrast essays, etc.] |
| 2.F.05  6.A.01 | W4: 9-12 | Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and  audience. |
| Performance Example:   * Demonstrate aptitude in proper record keeping through documentation entered in Massachusetts operator’s state log book and the Massachusetts engineer’s log book. | | |

### [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.E.01.01  2.E.01.02 | 4OA3 | Solve multi-step world problems posed with whole numbers and having whole-number answers using the four operations, including problems in which remainders must be interpreted. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental  computation and estimation strategies including rounding. |
| Performance Example: | * Students must master the fundamentals of the four operations; including borrowing, place value, carrying, and being able to write numbers as words and words as numbers. |  |
| 2.E.02.01 | 5NF3 | Interpret a fraction as division of the numerator by the denominator (a/b = a divided by b). Solve word problems involving division of whole numbers leading to answers in the form of fractions or mixed numbers, e.g.,, by using visual fraction models or equations to  represent the problem. |
| Performance Example: | * For example, interpret 3/4 as the result of dividing 3 by 4, noting that 3/4 multiplied by 4 equals 3, and that when 3 wholes are shared equally among four people each person has a share of size 3/4. If 9 people want to share a 50-pound sack of rice equally by weight, how many pounds should each person get? Between | what two whole numbers does your answer lie? |
| 2.E.02.02 | 5NF1  5NF4  5NF7  6NS1 | Add and subtract fractions with unlike denominators (including  mixed numbers) by replacing given fractions with equivalent fractions in such a way as to produce an equivalent sum or difference of fractions with like denominators.  Apply and extend previous understandings of multiplication to multiply a fraction or whole number by a fraction.  Apply and extend previous understandings of division to divide unit fractions by whole numbers and whole numbers by unit fractions.  Interpret and compute quotients of fractions, and solve word problems involving division of fractions by fractions, e.g.,, by using visual fraction models and equations to represent the problem. |
| Performance Example: | * For example, use a visual fraction model to show (2/3) x 4 = 8/3, and create a story context for this equation. Do the same with (2/3) x (4/5) = 8/15. | * For example, create a story context for (1/3) divided by 4, and use a visual fraction model to show the quotient. |
| 2.E.03.01 | 5NBT4  5NBT7 | Use place value understanding to round decimals to any place.  Add, subtract, multiply, divide decimals to hundredths, using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition  and subtraction; relate the strategy to a written method and explain the reasoning used. |
| Performance Example: | * Students must be able to read, write and compare decimal to thousandths using base-ten numerals, number names, and expanded form. |  |
| 2.E.04.01 | 6RP3  6RP3b  6RP3c | Use ratio and rate reasoning to solve real-world problems and mathematical problems, e.g.,, by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.  Solve unit rate problems, including those involving unit pricing and constant speed.  Find a percent of a quantity as a rate per 100; solve problems involving finding the whole, given a part and the percent. |
| Performance Example: | * Understand ratio concepts and use ratio reasoning to solve problems. |  |
| 2.E.05.01  2.E.05.02  2.E.05.03 | 5MD1  6RP3d | Convert among different-sized standard measurement units within a given measurement system (e.g.,, convert 5 cm to .05m), and use these conversions to solve multi-step, real-world problems.  Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities. |
| Performance Example: | * Use ratio and rate reasoning to solve real-world and mathematical problems. |  |
| 2.E.06.01  2.E.06.02 | 6RP3a | Make tables of equivalent ratios relating quantities with whole number measurements, find missing values in the tables, and plot the  pairs of values on the coordinate plane. Use tables to compare ratios. |
| Performance Example:   * Understand the concept of a ratio and use ratio language to describe a ratio relationship between two | quantities. | * For example, Boiler Operation. Steam piping expands when heated. If a 200 ft. section expands 5 in., how much does a 240 ft. section expand? |
| 2.E.07.01 | 6G(MA1a)  6G(MA1b) | Use the relationships among radius, diameter, and center of a circle to find its circumference and area.  Solve real-world and mathematical problems involving the measurements of circles. |
| Performance Example: | * Students should understand the relationship between radius and diameter as well as the relationship between radius and circumference, pi. | * Boiler Operation: The amount of steam flow through an orifice meter depends on the area of the circular hole in the meter. What is the area of a hole with a radius of 1.5 in.? |
| 2.E.07.02 | 8G9 | Know the formulas for the volume of cones, cylinders, and spheres, and use them to solve real-world and mathematical problems. |
| Performance Example: | * A geothermal system includes a cylindrical heat exchanger that is 18'' in diameter and 42'' tall. What is the volume of the heat exchanger? |  |
| 2.E.08.01 | 6SP4  6SP(MA4a) | Display numerical data in plots on a number line, including dot plots, histograms, and box plots.  Read and interpret circle graphs. |
| Performance Example: | * Boiler operators use a daily water treatment log to track the condition of the boiler water. Students should be able to create various graphs, models and data displays from the log book. |  |

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

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

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| CTE  Learning Standard Number | Subject Area, Topic Heading and  Learning Standard Number | Text of Earth and Space Science Learning Standard |
| 2.C.01 | Earth and Space Science, Grades 6-8, 23 | Differentiate among radiation, conduction, and convection, the three Mechanisms by which heat is transferred through the earth’s system. |
| 1.A.01 | Earth and Space Science, High School 2.1 | Recognize, describe, and compare renewable energy resources (e.g.,, solar, wind, water, biomass) and nonrenewable energy resources (e.g.,, fossil fuels, nuclear energy). |
| 2.B.08 | Earth and Space Science, High  School 2.2 | Describe the effects on the environment and on the carbon cycle of  using both renewable and nonrenewable sources of energy. |

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

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| CTE  Learning Standard Number | Subject Area, Topic Heading and  Learning Standard Number | Text of Chemistry Learning Standard |
| 2.B.01 | Chemistry, High School 6.1 | Using the kinetic molecular theory, explain the behavior of gases and the relationship between pressure and volume (Boyle’s law), volume and temperature (Charles’s law), pressure and temperature (Gay- Lussac’s law), and the number of particles in a gas sample (Avogadro’s hypothesis). Use the combined gas law to determine  changes in pressure, volume, and temperature. |
| Performance Example: | * Use kinetic molecular theory and the properties of gases to explain the differences between the various types of boilers. |  |
| 2.B.05 | Chemistry, High School 6.5 | Recognize that there is a natural tendency for systems to move in a direction of disorder or randomness (entropy). |
| Performance Example: | * Use the concept of entropy to explain why economizers and air pre heaters make the steam cycle more economical. |  |
| 2.B.06 | Chemistry, High School 6.5 | Recognize that there is a natural tendency for systems to move in a  direction of disorder or randomness (entropy). |
| Performance Example: | * Use the concept of entropy and entropy to explain the advantages of using super-heated steam. |  |
| 2.B.08 | Chemistry, High School 6.4 | Describe the law of conservation of energy. Explain the difference  between an endothermic process and an exothermic process. |
| Performance Example: | * Use the law of conservation of energy to explain why the combustion of fuel is necessary to generate heat. |  |
| 2.C.01 | Chemistry, High School 6.1 | Using the kinetic molecular theory, explain the behavior of gases and the relationship between pressure and volume (Boyle’s law), volume and temperature (Charles’s law), pressure and temperature (Gay- Lussac’s law), and the number of particles in a gas sample (Avogadro’s hypothesis). Use the combined gas law to determine  changes in pressure, volume, and temperature. |
| Performance Example: | * User kinetic molecular theory to explain heat transfer via various means and an understanding of the concept of enthalpy. |  |

#### [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 | Introductory Physics, High School 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: | * Use Concepts of thermodynamics to explain the different types of boilers. |  |
| 2.B.05 | Introductory Physics, High School 3.3 | Describe the relationship between average molecular kinetic energy and temperature. Recognize that energy is absorbed when a substance changes from a solid to a liquid to a gas, and that energy is  released when a substance changes from a gas to a liquid to a solid. Explain the relationships among evaporation, condensation, cooling,  and warming. |
| Performance Example: | * Use the concepts of thermodynamics to explain why economizers and air pre heaters make the steam cycle more economical. |  |
| 2.B.06 | Introductory Physics, Highs School 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. |
| 2.B.08 | Introductory Physics, High School 2.1 | Interpret and provide examples that illustrate the law of  conservation of energy. |
| 2.C.01 | Introductory Physics, High School 3.1 | Explain how heat energy is transferred by convection, conduction,  and radiation. |

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