Massachusetts Department of Elementary and Secondary Education

Prerequisite Content Standards: Secondary Grades (6-12)

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English Language Arts and Literature

Grades 9-10

Reading Literature [RL]

1. Cite strong and thorough textual evidence to support analysis of what a text states explicitly as well as inferences drawn from the text.
2. Determine a theme or central idea of a text and analyze in detail its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of a text.
4. Determine the figurative or connotative meaning(s) of words and phrases as they are used in a text; analyze the impact of words with multiple meanings, as well as symbols or metaphors that extend throughout a text and shape its meaning. (See grades 9–10 Language Standards 4–6 on applying knowledge of vocabulary to reading.)

Reading Informational Text [RI]

1. Cite strong and thorough textual evidence to support analysis of what a text states explicitly as well as inferences drawn from the text.
2. Determine a central idea of a text and analyze its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of a text.
8. Delineate and evaluate the argument and specific claims in a text, assessing whether the reasoning is valid and the evidence is relevant and sufficient; identify false statements or incomplete truths and fallacious reasoning.
10. Independently and proficiently read and comprehend **literary texts** and **literary nonfiction** representing a variety of genres, cultures, and perspectives and exhibiting complexity appropriate for the grade/course.

Writing [W]

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (Grade-specific expectations for writing types are defined in Standards 1–3 above.)

9. Draw evidence from literary or informational texts to support written analysis, interpretation, reflection, and research, applying one or more grades 9–10 Standards for Reading Literature or Reading Informational Text as needed.

Language [L]

1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking; retain and further develop language skills learned in previous grades. (See grades 9–10 Writing Standard 5 and Speaking and Listening Standard 6 on strengthening writing and presentations by applying knowledge of conventions.)

Sentence Structure, Variety, and Meaning

a. Manipulate and rearrange clauses and phrases in sentences, paying attention to agreements of pronouns and their antecedents, logical use of verb tenses, and variety in sentence patterns.

b. Use various types of phrases (noun, verb, adjectival, participial, prepositional) and clauses (independent, dependent, noun, relative, adverbial) to convey specific meanings and add variety and interest to writing or presentations.

c. Use parallel structure as a technique for creating coherence in sentences, paragraphs, and larger pieces of writing.[19]

2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.

a. Use a semicolon (and perhaps a conjunctive adverb) to link two or more closely related independent clauses.

b. Use a colon to introduce a list or quotation.

c. Spell correctly, recognizing that some words have commonly accepted variations (e.g., catalog/catalogue).

Grades 11-12

Reading Literature [RL]

1. Cite strong and thorough textual evidence to support analysis of what a text states explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain.

2. Determine two or more themes or central ideas of a text and analyze their development over the course of the text, including how they interact and build on one another to produce a complex account; provide an objective summary of a text.

4. Determine the figurative or connotative meaning(s) of words and phrases as they are

used in a text; analyze the impact of specific words or rhetorical patterns (e.g., how the language evokes a sense of time and place, how shifts in rhetorical patterns signal new perspectives). (See grades 11–12 Language Standards 4–6 on applying knowledge of vocabulary to reading.)

Reading Informational Text [RI]

1. Cite strong and thorough textual evidence to support analysis of what a text states explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain.

2. Determine two or more central ideas of a text and analyze their development over the course of the text, including how they interact and build on one another to provide a complex analysis; provide an objective summary of a text.

8. Delineate and evaluate the reasoning in seminal historical texts, including the application of constitutional principles and use of legal reasoning (e.g., in U.S. Supreme Court majority opinions and dissents) and the premises, purposes, and arguments in works of public advocacy (e.g., *The Federalist*, presidential addresses).

10. Independently and proficiently read and comprehend **literary texts** and **literary nonfiction** representing a variety of genres, cultures, and perspectives and exhibiting complexity appropriate for the grade/course.

Writing [W]

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3 above.)

9. Draw evidence from literary or informational texts to support written analysis, interpretation, reflection, and research, applying one or more grades 11–12 standards for Reading Literature or Reading Informational Text as needed.

Language [L]

1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking; retain and further develop language skills learned in previous grades. (See grades 11–12 Writing Standard 5 and Speaking and Listening Standard 6 on strengthening writing and presentations by applying knowledge of conventions.)
   Word Usage

   a. Apply the understanding that usage is a matter of convention, can change over time, and is sometimes contested.
   b. Resolve issues of complex or contested usage, consulting references (e.g., *Merriam-Webster's Dictionary of English Usage*, *Garner's Modern American Usage*) as needed.

2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
   a. Observe hyphenation conventions.

b. Spell correctly, recognizing that some words have commonly accepted variations (e.g., catalog/catalogue).

Science and Technology/Engineering

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High School Biology

LS1. From Molecules to Organisms: Structures and Processes
HS-LS1-1. Construct a model of transcription and translation to explain the roles of DNA and RNA that code for proteins that regulate and carry out essential functions of life.
HS-LS1-2. Develop and use a model to illustrate the key functions of animal body systems, including (a) food digestion, nutrient uptake, and transport through the body; (b) exchange of oxygen and carbon dioxide; (c) removal of wastes; and (d) regulation of body processes.

LS2. Ecosystems: Interactions, Energy, and Dynamics
HS-LS2-5. Use a model that illustrates the roles of photosynthesis, cellular respiration, decomposition, and combustion to explain the cycling of carbon in its various forms among the biosphere, atmosphere, hydrosphere, and geosphere.
HS-LS2-7. Analyze direct and indirect effects of human activities on biodiversity and ecosystem health, specifically habitat fragmentation, introduction of non-native or invasive species, overharvesting, pollution, and climate change. Evaluate and refine a solution for reducing the impacts of human activities on biodiversity and ecosystem health.*

LS3. Heredity: Inheritance and Variation of Traits
HS-LS3-1. Develop and use a model to show how DNA in the form of chromosomes is passed from parents to offspring through the processes of meiosis and fertilization in sexual reproduction. **HS-LS3-**
3. Apply concepts of probability to represent possible genotype and phenotype combinations in offspring caused by different types of Mendelian inheritance patterns.

LS4. Biological Evolution: Unity and Diversity
HS-LS4-4. Research and communicate information about key features of viruses and bacteria to explain their ability to adapt and reproduce in a wide variety of environments.

HS-LS4-5. Evaluate models that demonstrate how changes in an environment may result in the evolution of a population of a given species, the emergence of new species over

generations, or the extinction of other species due to the processes of genetic drift, gene flow, mutation, and natural selection.

High School Chemistry

PS1. Matter and Its Interactions

HS-PS1-2. Use the periodic table model to predict and design simple reactions that result in two main classes of binary compounds, ionic and molecular. Develop an explanation based on given observational data and the electronegativity model about the relative strengths of ionic or covalent bonds.

HS-PS1-4. Develop a model to illustrate the energy transferred during an exothermic or endothermic chemical reaction based on the bond energy difference between bonds broken (absorption of energy) and bonds formed (release of energy).

HS-PS1-7. Use mathematical representations and provide experimental evidence to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. Use the mole concept and proportional relationships to evaluate the quantities (masses or moles) of specific reactants needed in order to obtain a specific amount of product.

HS-PS1-10(MA). Use an oxidation-reduction reaction model to predict products of reactions given the reactants, and to communicate the reaction models using a representation that shows electron transfer (redox). Use oxidation numbers to account for how electrons are redistributed in redox processes used in devices that generate electricity or systems that prevent corrosion.*

PS2. Motion and Stability: Forces and Interactions

HS-PS2-6. Communicate scientific and technical information about the molecular-level structures of polymers, ionic compounds, acids and bases, and metals to justify why these are useful in the functioning of designed materials.*

HS-PS2-8(MA). Use kinetic molecular theory to compare the strengths of electrostatic forces and the prevalence of interactions that occur between molecules in solids, liquids, and gases. Use the combined gas law to determine changes in pressure, volume, and temperature in gases.

PS3. Energy

HS-PS3-4b. Provide evidence from informational text or available data to illustrate that the transfer of energy during a chemical reaction in a closed system involves changes in energy dispersal (entropy change) and heat content (enthalpy change) while assuming the overall energy in the system is conserved.

High School Introductory Physics

PS2. Motion and Stability: Forces and Interactions

HS-PS2-1. Analyze data to support the claim that Newton's second law of motion is a mathematical model describing change in motion (the acceleration) of objects when acted on by a net force. **HS-PS2-3.** Apply scientific principles of motion and momentum to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*

HS-PS2-10(MA). Use free-body force diagrams, algebraic expressions, and Newton's laws of motion to predict changes to velocity and acceleration for an object moving in one dimension in

various situations.

PS3. Energy

HS-PS3-1. Use algebraic expressions and the principle of energy conservation to calculate the change in energy of one component of a system when the change in energy of the other component(s) of the system, as well as the total energy of the system including any energy entering or leaving the system, is known. Identify any transformations from one form of energy to another, including thermal, kinetic, gravitational, magnetic, or electrical energy, in the system.

HS-PS3-2. Develop and use a model to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles and objects or energy stored in fields.

PS4. Waves and Their Applications in Technologies for Information Transfer

HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.*

Grade 9-12

Content Standards

*Secondary HSS courses follow variable scope and sequences; teachers should attempt to **address the Content Standards they have not yet introduced** for their course. The last Topic of each grade is identified here with the assumption that earlier Topics were introduced earlier in the year; however, teachers are encouraged to prioritize Content Standards not yet introduced, and to apply them in connection with Practice Standards 2,3, and 7 to encourage inquiry-based investigations.*

US History I

Practice Standards

2. Develop focused questions or problem statements and conduct inquiries
6. Argue or explain conclusions, using valid reasoning and evidence.
7. Determine next steps and take informed action, as appropriate.

Content Topic 7: Progressivism and WWI [USI.T7]

1. Explain what Progressivism meant in the early 20th century and analyze a text or images by a Progressive leader (e.g., Jane Addams, William Jennings Bryan, John Dewey, Robert La Follette, Theodore Roosevelt, Margaret Sanger, Upton Sinclair, Lewis Hine, William H. Taft, Ida Tarbell, Woodrow Wilson).
2. Research and analyze one of the following governmental policies of the Progressive Period, determine the problem it was designed to solve, and assess its long and short-term effectiveness: bans against child labor, the development of Indian boarding schools, the Sherman Anti-Trust Act (1890), the Pure Food and Drug Act (1906), the Meat Packing Act (1906), the Federal Reserve Act (1913), the Clayton Anti-Trust Act (1914), the Indian Citizenship Act (1924).
3. Analyze the campaign for, and the opposition to, women's suffrage in the late 19th and early 20th centuries; describe the role of leaders and organizations in achieving the passage of the 19th Amendment (e.g., Carrie Chapman Catt, Alice Paul, Ida B. Wells-Barnett the National Woman Suffrage Association, National Women's Party, League of Women Voters).
4. Analyze the strategies of African Americans to achieve basic civil rights in the early 20th century, and determine the extent to which they met their goals by researching leaders and organizations (e.g., Ida B. Wells-Barnett, W. E. B. DuBois, Marcus Garvey, Booker T, Washington, and the National Association for the Advancement of Colored People).
5. Analyze the causes and course of growing role of the United States in world affairs from the Civil War to World War I, researching and reporting on one of the following ideas, policies, or events, and, where appropriate, including maps, timelines, and other visual resources to clarify connections among nations and events
6. Explain the rationale and events leading to the entry of the U.S. into World War I (e.g., unrestricted submarine warfare, the sinking of the Lusitania, the Zimmerman

telegram, the concept of "making the world safe for democracy."
7. Analyze the role played by the U.S. in support of the Allies and in the conduct of the war
8. Explain the course and significance of Woodrow Wilson's wartime diplomacy, including his Fourteen Points, the League of Nations, and the failure of the Versailles Treaty.

US History II

Practice Standards

2. Develop focused questions or problem statements and conduct inquiries
6. Argue or explain conclusions, using valid reasoning and evidence.
7. Determine next steps and take informed action, as appropriate.

Content Topic 5: United States and globalization

1. Using primary sources such as campaign literature and debates, news articles/analyses, editorials, and television coverage, analyze the important policies and events that took place during the presidencies of John F. Kennedy (e.g., the confrontation with Cuba over missile bases, the space exploration program, Kennedy's assassination), Lyndon Johnson (the Great Society programs, the Civil Rights and Voting Rights Acts, the Vietnam War and anti-war movements, the 1965 Immigration and Nationality Act, the assassinations of Martin Luther King, Jr., and Robert F. Kennedy), and Richard Nixon (the creation of the Environmental

   Protection Agency, diplomacy with China, détente with the Soviet Union, the Watergate scandal, and Nixon's resignation).
2. Analyze and evaluate the impact of economic liberalism on mid-20th century society, including the legacy of the New Deal on post World War II America, the expansion of American manufacturing and unionism, social welfare programs, and the regulation of major industries such as transportation, energy, communications and finance.
3. Analyze the presidency of Ronald Reagan (1981-1989) and the rise of the conservative movement in American politics, (e.g., policies such as tax rate cuts, anti-communist foreign and defense policies, replacement of striking air traffic controllers with non-union personnel.
4. Analyze how the failure of communist economic policies and U.S.-sponsored resistance to Soviet military and diplomatic initiatives contributed to the fall of the Berlin Wall in 1989 the dissolution of the Soviet Union in 1991, and the end of the Cold War.
5. Analyze some of the major technological and social trends and issues of the late 20th and early 21st centuries (e.g., the computer and technological revolution beginning in the 1980s, scientific and medical discoveries such as DNA research, major immigration and demographic changes such as the rise in Asian and Hispanic immigration).
6. Evaluate the effectiveness of the federal government's response to international terrorism in the 21st century, including the 2001 terrorist attack on the World Trade Center in New York City and the Pentagon near Washington, D.C., the Homeland Security Act, the Foreign Intelligence Surveillance Act, and the Afghanistan and Iraq Wars.

World History I

Practice Standards

2. Develop focused questions or problem statements and conduct inquiries
6. Argue or explain conclusions, using valid reasoning and evidence.
7. Determine next steps and take informed action, as appropriate.

Content Topic 6: Philosophies of Government

1. Identify the origins and the ideals of the European Enlightenment, such as happiness, reason, progress, liberty, and natural rights, and how intellectuals of the movement (e.g., Denis Diderot, Emmanuel Kant, John Locke, Charles de Montesquieu, Jean-Jacques Rousseau, Mary Wollstonecraft, Cesare Beccaria, Voltaire, or social satirists such as Molière and William Hogarth) exemplified these ideals in their work and challenged existing political, economic, social, and religious structures.

2. Explain historical philosophies of government, giving examples from world history: a. the Chinese doctrine of the Mandate of Heaven, in which a ruler must be worthy of the right to rule
b. absolute monarchy, in which a monarch holds unlimited power with no checks and balances (e.g., in France of Louis XIV, Spain, Prussia, and Austria) c. enlightened absolutism (e.g., in Russia under Czars Peter the Great and Catherine the Great, in which ideas of the Enlightenment temper absolutism) d. constitutional monarchy, in which a ruler is limited by a written or unwritten constitution (e.g., English traditions beginning with Magna Carta).

3. Explain why England was the exception to the growth of absolutism in Europe. a. the causes, essential events, and effects of the English Civil War and the Glorious Revolution of 1688 b. the

English Bill of Rights and its limits on the power of the monarch to act without the consent of Parliament
4. Explain the development of constitutional democracy following the American Revolution, the United States Constitution (1787), and the Bill of Rights (1791)

World History II

Practice Standards

2. Develop focused questions or problem statements and conduct inquiries
6. Argue or explain conclusions, using valid reasoning and evidence.
7. Determine next steps and take informed action, as appropriate.

Content Topic 7: The Politics of difference: conflicts, genocide and terrorism

1. Distinguish between the concepts of genocide and mass atrocity and analyze the causes of genocide and mass atrocities in the modern world (e.g., conflicts over political power, historical grievances, manipulation of ideas about difference and fear by political forces).
2. Analyze the events, people and conditions that have given rise to international terrorism including the emergence of the global terror network Al-Qaeda, the Taliban in Afghanistan, and ISIS, and evaluate responses by governments and societies to international terrorist activity.

Mathematics

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High School Standards for Mathematical Content: By Conceptual Category

Conceptual Category: Number and Quantity [N]

The Real Number System   N-RN

A. Extend the properties of exponents to rational exponents.
1. Explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values, allowing for a notation for radicals in terms of rational exponents.
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   h
2. Rewrite expressions involving radicals and rational exponents using the

properties of exponents.

Conceptual Category: Algebra [A]

Seeing Structure in Expressions   A-SSE

A.   Interpret the structure of linear, quadratic, exponential, polynomial, and rational expressions.

   1. Interpret expressions that represent a quantity in terms of its context.★
      a. Interpret parts of an expression, such as terms, factors, and coefficients.
      b. Interpret complicated expressions by viewing one or more of their parts as a single entity.

For example, interpret $P(1 + r)^n$ as the product of P and a factor not depending on P.

B. Write expressions in equivalent forms to solve problems.

   3. Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
      a. Factor a quadratic expression to reveal the zeros of the function it defines.
      b. Complete the square in a quadratic expression to reveal the maximum or minimum value of the function it defines.
      c.   Use the properties of exponents to transform expressions for exponential functions. For example, the expression 1.15^t can be rewritten as $(1.15^{1/12})^{12t} \approx 1.012^{12t}$ to reveal the approximate equivalent monthly interest rate if the annual rate is 15%.

Arithmetic with Polynomials and Rational Expressions   A-APR

A. Perform arithmetic operations on polynomials.

   1. Understand that polynomials form a system analogous to the integers, namely, they are closed under certain operations.
      a. Perform operations on polynomial expressions (addition, subtraction, multiplication, division) and compare the system of polynomials to the system of integers when performing operations.
      b. Factor and/or expand polynomial expressions, identify and combine like terms, and apply the Distributive property.

B. Understand the relationship between zeros and factors of polynomials.

   3. Identify zeros of polynomials when suitable factorizations are available, and use the zeros to construct a rough graph of the function defined by the polynomial.

Creating Equations   A-CED

A. Create equations that describe numbers or relationships.

   1. Create equations and inequalities in one variable and use them to solve problems. (Include equations arising from linear and quadratic functions, and simple root and rational functions and exponential functions.)★

   2. Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.★

   3. Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or non-viable options in a m
c

   4. ^{R}earrange 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.

Reasoning with Equations and Inequalities   A-REI

B. Solve equations and inequalities in one variable.

   3. Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

      a. Solve linear equations and inequalities in one variable involving absolute value.

   4. Solve quadratic equations in one variable.

      a. Use the method of completing the square to transform any quadratic equation in x into an equation of the form $(x - p)^2 = q$ that has the same solutions. Derive the quadratic formula from this form.

      b. Solve quadratic equations by inspection (e.g., for $x^2 = 49$), 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 $a \pm bi$ for real numbers a and b.

C. Solve systems of equations.

   6. Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.

D. Represent and solve equations and inequalities graphically.

   10. Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line). Show that any point on the graph of an equation in two variables is a solution to the equation.

   11. Explain why the x-coordinates of the points where the graphs of the equations $y = f(x)$ and $y = g(x)$ intersect are the solutions of the equation $f(x) = g(x)$; find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where $f(x)$ and/or $g(x)$ are linear, polynomial, rational, absolute value, exponential, and logarithmic functions.★

   12. Graph the solutions of a linear inequality in two variables as a half-plane (excluding the boundary in the case of a strict inequality), and graph the solution set of a system of linear inequalities in two variables as the intersection of the corresponding half-planes.

Conceptual Category: Functions [F]

Interpreting Functions   F-IF

A. Understand the concept of a function and use function notation.

1. Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then $f(x)$ denotes the output of f corresponding to the input x. The graph of f is the graph of the equation $y = f(x)$.

2. Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.

    For example, given a function representing a car loan, determine the balance of the loan at different points in time.

B.   Interpret functions that arise in applications in terms of the context (linear, quadratic, exponential, rational, polynomial, square root, cube root, trigonometric, logarithmic).

4. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.★

6. Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph.★

C. Analyze functions using different representations.

7. Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.★

    a. Graph linear and quadratic functions and show intercepts, maxima, and minima.★

    b. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions.★

    c. Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior.★

    d. (+) Graph rational functions, identifying zeros and asymptotes when suitable factorizations are available, and showing end behavior.★

    e. Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.★

8. Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function.

    a. Use the process of factoring and/or completing the square in quadratic and polynomial functions, where appropriate, to show zeros, extreme values, and symmetry of the graph, and interpret these in terms of a context.

    b. Use the properties of exponents to interpret $V_n = P(1+r)^n$ expressions for exponential functions. Apply to financial situations such as identifying appreciation and depreciation rate for the value of a house or car some time after its initial purchase.

    For example, identify percent rate of change in functions such as $y = (1.02)^t$, $y = (0.97)^t$, $y = (1.01)^{12t}$, and $y = (1.2)^{t/10}$, and classify them as representing exponential growth or decay.

9. Translate among different representations of functions (algebraically, graphically, numerically in tables, or by verbal descriptions). Compare properties of two functions

each represented in a different way.

For example, given a graph of one polynomial function (including quadratic functions) and an algebraic expression for another, say which has the larger/smaller relative maximum and/or minimum.

10. Given algebraic, numeric and/or graphical representations of functions, recognize the function as polynomial, rational, logarithmic, exponential, or trigonometric.

Building Functions
F-BF

A. Build a function that models a relationship between two quantities.

1. Write a function (linear, quadratic, exponential, simple rational, radical, logarithmic, and trigonometric) that describes a relationship between two quantities.★

   a. Determine an explicit expression, a recursive process, or steps for calculation from a context.★

   b. Combine standard function types using arithmetic operations.★

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   a
   the model.

   c. (+) Compose functions.★

   For example, if T(y) is the temperature in the atmosphere as a function of height, and h(t) is the height of a weather balloon as a function of time, then T(h(t)) is the temperature at the location of the weather balloon as a function of time.

2. Write arithmetic and geometric sequences both recursively and with an explicit formula, use them to model situations, and translate between the two forms.★

B. Build new functions from existing functions.

3. Identify the effect on the graph of replacing $f(x)$ by $f(x) + k$, $kf(x, f(kx)$, and $f(x + k)$ for specific values of k (both positive and negative); find the value of k given the graphs. (Include linear, quadratic, exponential, absolute value, simple rational and radical, logarithmic and trigonometric functions.) Utilize technology to experiment with cases and illustrate an explanation of the effects on the graph. (Include recognizing even and odd functions from their graphs and algebraic expressions for them.)

Linear, Quadratic, and Exponential Models   F-LE

A. Construct and compare linear, quadratic, and exponential models and solve problems.

1. Distinguish between situations that can be modeled with linear functions and with exponential functions.★

   a. Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals.★

   b. Recognize situations in which one quantity changes at a constant rate per unit interval relative to another.★

   c. Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another.★

2. Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (including reading these from a table).★

3. Observe, using graphs and tables, that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or (more generally) as a polynomial function.★

Trigonometric Functions   F-TF

B. Model periodic phenomena with trigonometric functions.

  5. Choose trigonometric functions to model periodic phenomena with specified
  amplitude, frequency, and midline.★

Conceptual Category: Geometry [G]

Congruenc

e G-CO

A. Experiment with transformations in the plane.

  1. Know precise definitions of angle, circle, perpendicular line, parallel line, and line
  segment, based on the undefined notions of point, line, distance along a line, and
  distance around a circular arc.

  2. Represent transformations in the plane using, e.g., transparencies and geometry
  software; describe transformations as functions that take points in the plane as inputs
  and give other points as outputs. Compare transformations that preserve distance and
  angle to those that do not (e.g., translation versus horizontal stretch).

  5. Given a geometric figure and a rotation, reflection, or translation, draw the transformed
  figure using, e.g., graph paper, tracing paper, or geometry software. Specify a sequence
  of transformations that will carry a given figure onto another.

Similarity, Right Triangles, and Trigonometry   G-SRT

A. Understand similarity in terms of similarity transformations.

  1. Verify experimentally the properties of dilations given by a center and a scale factor:
      a. A dilation takes a line not passing through the center of the dilation to a parallel
      line, and leaves a line passing through the center unchanged.
      b. The dilation of a line segment is longer or shorter in the ratio given by the scale factor.

B. Prove theorems involving similarity.

  4. Prove theorems about triangles. Theorems include: a line parallel to one side of a triangle
  divides the other two proportionally, and conversely; the Pythagorean Theorem proved
  using triangle similarity.

C. Define trigonometric ratios and solve problems involving right triangles.

  6. Understand that by similarity, side ratios in right triangles are properties of the angles
  in the triangle, leading to definitions of trigonometric ratios for acute angles.

  7. Explain and use the relationship between the sine and cosine of complementary angles.

  8. Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in
  applied problems.★

Circles   G-C

B. Find arc lengths and areas of sectors of circles.

  5. Derive using similarity the fact that the length of the arc intercepted by an angle is
  proportional to the radius, and define the radian measure of the angle as the
  constant of proportionality; derive the formula for the area of a sector.

Expressing Geometric Properties with Equations   G-GPE

B. Use coordinates to prove simple geometric theorems algebraically.

  4. Use coordinates to prove simple geometric theorems algebraically including the distance formula and its $\sqrt{3}$ relationship to the Pythagorean

    T

    F

    circle centered at the origin and containing the point (0, 2).

  5. Prove the slope criteria for parallel and perpendicular lines and use them to solve geometric problems (e.g., find the equation of a line parallel or perpendicular to a given line that passes through a given point).

Geometric Measurement and Dimension   G-GMD

A. Explain volume formulas and use them to solve problems.

  1. Give an informal argument for the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone. *Use dissection arguments, Cavalieri's principle, and informal limit arguments.*

  5. Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.★

Modeling with Geometry   G-MG

A. Apply geometric concepts in modeling situations.

  1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).★

Conceptual Category: Statistics and Probability [S]

Interpreting Categorical and Quantitative Data   S-ID

A. Summarize, represent, and interpret data on a single count or measurement variable. Use calculators, spreadsheets, and other technology as appropriate.

  1. Represent data with plots on the real number line (dot plots, histograms, and box plots).★

  2. Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.★

  3. Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).★

  4. Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.★

B. Summarize, represent, and interpret data on two categorical and quantitative variables.

  5. Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.★

  6. Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.★

    a. Fit a linear function to the data and use the fitted function to solve problems in the context of the data. Use functions fitted to data or choose a function suggested by the context. Emphasize linear and exponential models.★

    b. Informally assess the fit of a function by plotting and analyzing residuals.★

      c. Fit a linear function for a scatter plot that suggests a linear association.★

C. Interpret linear models.

7. Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.★
8. Compute (using technology) and interpret the correlation coefficient of a linear fit.★
9. Distinguish between correlation and causation.★

Making Inferences and Justifying Conclusions   S-IC

A. Understand and evaluate random processes underlying statistical experiments. Use calculators, spreadsheets, and other technology as appropriate.

4. Understand statistics as a process for making inferences about population parameters based on a random sample from that population.★

The High School Standards for Mathematical Content: Standards by Model Course

The mathematical content standards presented above are organized by Conceptual Categories. The tables below show how these conceptual category content standards are distributed across the eight model courses:

- Algebra I (AI)
- Geometry (GEO)
- Algebra II (AII)
- Math I (MI)
- Math II (MII)
- Math III (MIII)
- Precalculus (PC)
- Advanced Quantitative Reasoning (AQR)

Number and Quantity [N]

	A I	GEO	A II	M I	M II	M III	PC	AQR
The Real Number System (N-RN)								
A. Extend the properties of exponents to rational exponents.								
1	✓				✓			
2	✓				✓			

STATISTICS AND PROBABILITY [S]

	A I	GEO	A II	M I	M II	M III	PC	AQR
Interpreting Categorical and Quantitative Data (S-ID)								
A. Summarize, represent, and interpret data on a single count or measurement variable. Use calculators, spreadsheets, and other technology as appropriate.								
1	✓			✓				
2	✓			✓				
3	✓			✓				
4	✓		✓			✓		
B. Summarize, represent, and interpret data on two categorical and quantitative variables.								
5	✓			✓				
6	✓			✓				
a	✓			✓				
b	✓			✓				
c	✓			✓				
C. Interpret linear models.								
7	✓			✓				
8	✓			✓				
9	✓			✓				✓
Making Inferences and Justifying Conclusions (S-IC)								
A. Understand and evaluate random processes underlying statistical experiments.								
1			✓			✓		

ALGEBRA [A]

	A I	GEO	A II	M I	M II	M III	PC	AQR
Seeing Structure in Expressions (A-SSE)								
A. Interpret the structure of expressions.								
1	✓		✓	✓	✓	✓		
a	✓		✓	✓	✓	✓		
b	✓		✓	✓	✓	✓		
B. Write expressions in equivalent forms to solve problems.								
3	✓				✓			
a	✓				✓			
b	✓				✓			
c	✓				✓			
Arithmetic with Polynomials and Rational Expressions (A-APR)								
A. Perform arithmetic operations on polynomials.								
1	✓		✓		✓	✓		
a	✓		✓		✓	✓		
b	✓				✓			
B. Understand the relationship between zeros and factors of polynomials.								
3			✓			✓		
Creating Equations (A-CED)								
A. Create equations that describe numbers or relationships.								
1	✓		✓	✓	✓	✓		
2	✓		✓	✓	✓	✓		
3	✓		✓	✓		✓		
4	✓			✓	✓			
Reasoning with Equations and Inequalities (A-REI)								
	A I	GEO	A II	M I	M II	M III	PC	AQR
B. Solve equations and inequalities in one variable.								
3	✓			✓				
a	✓			✓				
4	✓				✓			
a	✓				✓			
b	✓				✓			
C. Solve systems of equations.								
6	✓			✓				
D. Represent and solve equations and inequalities graphically.								
10	✓			✓				
11	✓		✓	✓		✓		
12	✓			✓				

Functions [F]

	A I	GEO	A II	M I	M II	M III	PC	AQR
Interpreting Functions (F-IF)								
A. Understand the concept of a function and use function notation.								
1	✓			✓				
2	✓			✓				
B. Interpret functions that arise in applications in terms of the context (linear, quadratic, exponential, rational, polynomial, square root, cube root, trigonometric, logarithmic).								
4	✓		✓	✓	✓	✓		
6	✓		✓	✓	✓	✓		
C. Analyze functions using different representations.								
7	✓		✓	✓	✓	✓	✓	
a	✓			✓	✓			
b	✓				✓			
c			✓			✓		
d+			✓			✓	✓	
e	✓		✓	✓		✓		
8	✓		✓		✓	✓		
a	✓		✓		✓	✓		
b	✓				✓	✓		
9	✓		✓	✓	✓	✓		
10			✓			✓		
Building Functions (F-BF)								
A. Build a function that models a relationship between two quantities.								
1	✓		✓	✓	✓	✓	✓	
a	✓			✓	✓			
b	✓		✓	✓	✓	✓		
c+							✓	
2	✓			✓				
B. Build new functions from existing functions.								
3	✓		✓	✓	✓	✓		
Linear, Quadratic, and Exponential Models (F-LE)								
A. Construct and compare linear, quadratic, and exponential models and solve problems.								
1	✓			✓				
a	✓			✓				
b	✓			✓				
c	✓			✓				
2	✓			✓				
3	✓			✓	✓			
B. Interpret expressions for functions in terms of the situation they model.								
5	✓			✓				

Geometry [G]

	A I	GEO	A II	M I	M II	M III	PC	AQR
Congruence (G-CO)								
A. Experiment with transformations in the plane.								
1		✓		✓				
2		✓		✓				
5		✓		✓				
Similarity, Right Triangles, and Trigonometry (G-SRT)								
A. Understand similarity in terms of similarity transformations.								
1		✓			✓			
a		✓			✓			
b		✓			✓			
B. Prove theorems involving similarity.								
4		✓			✓			
C. Define trigonometric ratios and solve problems involving right triangles.								
6		✓			✓			
7		✓			✓			
8		✓			✓			
Circles (G-C)								
B. Find arc lengths and areas of sectors of circles.								
5		✓			✓			
Expressing Geometric Properties with Equations (G-GPE)								
B. Use coordinates to prove simple geometric theorems algebraically.								
4		✓			✓			
5		✓		✓				
Geometric Measurement and Dimension (G-GMD)								
A. Explain volume formulas and use them to solve problems.								
1		✓			✓			
3		✓			✓			
Modeling with Geometry (G-MG)								
A. Apply geometric concepts in modeling situations.								
1		✓				✓		