Texas Mathematics

# Grade 9

Adopted 2012

**Subchapter C. High School**

**Algebra I**

(1) Mathematical process standards. The student uses mathematical processes to acquire and demonstrate mathematical understanding. The student is expected to: AI.9.1

(A) apply mathematics to problems arising in everyday life, society, and the workplace; AI.9.1.A

(B) use a problem-solving model that incorporates analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem-solving process and the reasonableness of the solution; AI.9.1.B

(C) select tools, including real objects, manipulatives, paper and pencil, and technology as appropriate, and techniques, including mental math, estimation, and number sense as appropriate, to solve problems; AI.9.1.C

(D) communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate; AI.9.1.D

(E) create and use representations to organize, record, and communicate mathematical ideas; AI.9.1.E

(F) analyze mathematical relationships to connect and communicate mathematical ideas; and AI.9.1.F

(G) display, explain, and justify mathematical ideas and arguments using precise mathematical language in written or oral communication. AI.9.1.G

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(2) Linear functions, equations, and inequalities. The student applies the mathematical process standards when using properties of linear functions to write and represent in multiple ways, with and without technology, linear equations, inequalities, and systems of equations. The student is expected to: AI.9.2

(A) determine the domain and range of a linear function in mathematical problems; determine reasonable domain and range values for real-world situations, both continuous and discrete; and represent domain and range using inequalities; AI.9.2.A

(B) write linear equations in two variables in various forms, including y = mx + b, Ax + By = C, and y - y1 = m(x - x1), given one point and the slope and given two points; AI.9.2.B

(C) write linear equations in two variables given a table of values, a graph, and a verbal description; AI.9.2.C

(D) write and solve equations involving direct variation; AI.9.2.D

(E) write the equation of a line that contains a given point and is parallel to a given line; AI.9.2.E

(F) write the equation of a line that contains a given point and is perpendicular to a given line; AI.9.2.F

(G) write an equation of a line that is parallel or perpendicular to the X or Y axis and determine whether the slope of the line is zero or undefined; AI.9.2.G

(H) write linear inequalities in two variables given a table of values, a graph, and a verbal description; and AI.9.2.H

(I) write systems of two linear equations given a table of values, a graph, and a verbal description. AI.9.2.I

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(3) Linear functions, equations, and inequalities. The student applies the mathematical process standards when using graphs of linear functions, key features, and related transformations to represent in multiple ways and solve, with and without technology, equations, inequalities, and systems of equations. The student is expected to: AI.9.3

(A) determine the slope of a line given a table of values, a graph, two points on the line, and an equation written in various forms, including y = mx + b, Ax + By = C, and y - y1 = m(x - x1); AI.9.3.A

(B) calculate the rate of change of a linear function represented tabularly, graphically, or algebraically in context of mathematical and real-world problems; AI.9.3.B

(C) graph linear functions on the coordinate plane and identify key features, including x-intercept, y-intercept, zeros, and slope, in mathematical and real-world problems; AI.9.3.C

(D) graph the solution set of linear inequalities in two variables on the coordinate plane; AI.9.3.D

(E) determine the effects on the graph of the parent function f(x) = x when f(x) is replaced by af(x), f(x) + d, f(x - c), f(bx) for specific values of a, b, c, and d; AI.9.3.E

(F) graph systems of two linear equations in two variables on the coordinate plane and determine the solutions if they exist; AI.9.3.F

(G) estimate graphically the solutions to systems of two linear equations with two variables in real-world problems; and AI.9.3.G

(H) graph the solution set of systems of two linear inequalities in two variables on the coordinate plane. AI.9.3.H

(4) Linear functions, equations, and inequalities. The student applies the mathematical process standards to formulate statistical relationships and evaluate their reasonableness based on real-world data. The student is expected to: AI.9.4

(A) calculate, using technology, the correlation coefficient between two quantitative variables and interpret this quantity as a measure of the strength of the linear association; AI.9.4.A

(B) compare and contrast association and causation in real-world problems; and AI.9.4.B

(C) write, with and without technology, linear functions that provide a reasonable fit to data to estimate solutions and make predictions for real-world problems. AI.9.4.C

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(5) Linear functions, equations, and inequalities. The student applies the mathematical process standards to solve, with and without technology, linear equations and evaluate the reasonableness of their solutions. The student is expected to: AI.9.5

(A) solve linear equations in one variable, including those for which the application of the distributive property is necessary and for which variables are included on both sides; AI.9.5.A

(B) solve linear inequalities in one variable, including those for which the application of the distributive property is necessary and for which variables are included on both sides; and AI.9.5.B

(C) solve systems of two linear equations with two variables for mathematical and real-world problems. AI.9.5.C

(6) Quadratic functions and equations. The student applies the mathematical process standards when using properties of quadratic functions to write and represent in multiple ways, with and without technology, quadratic equations. The student is expected to: AI.9.6

(A) determine the domain and range of quadratic functions and represent the domain and range using inequalities; AI.9.6.A

(B) write equations of quadratic functions given the vertex and another point on the graph, write the equation in vertex form ($f(x) = a(x - h)^2 + k$), and rewrite the equation from vertex form to standard form ($f(x) = ax^2 + bx + c$); and AI.9.6.B

(C) write quadratic functions when given real solutions and graphs of their related equations. AI.9.6.C

(7) Quadratic functions and equations. The student applies the mathematical process standards when using graphs of quadratic functions and their related transformations to represent in multiple ways and determine, with and without technology, the solutions to equations. The student is expected to: AI.9.7

(A) graph quadratic functions on the coordinate plane and use the graph to identify key attributes, if possible, including x-intercept, y-intercept, zeros, maximum value, minimum values, vertex, and the equation of the axis of symmetry; AI.9.7.A

(B) describe the relationship between the linear factors of quadratic expressions and the zeros of their associated quadratic functions; and AI.9.7.B

(C) determine the effects on the graph of the parent function $f(x) = x^2$ when $f(x)$ is replaced by $af(x)$, $f(x) + d$, $f(x - c)$, $f(bx)$ for specific values of a, b, c, and d. AI.9.7.C

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(8) Quadratic functions and equations. The student applies the mathematical process standards to solve, with and without technology, quadratic equations and evaluate the reasonableness of their solutions. The student formulates statistical relationships and evaluates their reasonableness based on real-world data. The student is expected to AI.9.8

(A) solve quadratic equations having real solutions by factoring, taking square roots, completing the square, and applying the quadratic formula; and AI.9.8.A

(B) write, using technology, quadratic functions that provide a reasonable fit to data to estimate solutions and make predictions for real-world problems. AI.9.8.B

(9) Exponential functions and equations. The student applies the mathematical process standards when using properties of exponential functions and their related transformations to write, graph, and represent in multiple ways exponential equations and evaluate, with and without technology, the reasonableness of their solutions. The student formulates statistical relationships and evaluates their reasonableness based on real-world data. The student is expected to: AI.9.9

(A) determine the domain and range of exponential functions of the form f(x) = ab<sup>x</sup> and represent the domain and range using inequalities; AI.9.9.A

(B) interpret the meaning of the values of a and b in exponential functions of the form f(x) = abx in real-world problems; AI.9.9.B

(C) write exponential functions in the form f(x) = abx (where b is a rational number) to describe problems arising from mathematical and real-world situations, including growth and decay; AI.9.9.C

(D) graph exponential functions that model growth and decay and identify key features, including y-intercept and asymptote, in mathematical and real-world problems; and AI.9.9.D

(E) write, using technology, exponential functions that provide a reasonable fit to data and make predictions for real-world problems. AI.9.9.E

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(10) Number and algebraic methods. The student applies the mathematical process standards and algebraic methods to rewrite in equivalent forms and perform operations on polynomial expressions. The student is expected to: AI.9.10

(A) add and subtract polynomials of degree one and degree two; AI.9.10.A

(B) multiply polynomials of degree one and degree two; AI.9.10.B

(C) determine the quotient of a polynomial of degree one and polynomial of degree two when divided by a polynomial of degree one and polynomial of degree two when the degree of the divisor does not exceed the degree of the dividend; AI.9.10.C

(D) rewrite polynomial expressions of degree one and degree two in equivalent forms using the distributive property; AI.9.10.D

(E) factor, if possible, trinomials with real factors in the form $ax^2 + bx + c$, including perfect square trinomials of degree two; and AI.9.10.E

(F) decide if a binomial can be written as the difference of two squares and, if possible, use the structure of a difference of two squares to rewrite the binomial. AI.9.10.F

(11) Number and algebraic methods. The student applies the mathematical process standards and algebraic methods to rewrite algebraic expressions into equivalent forms. The student is expected to: AI.9.11

(A) simplify numerical radical expressions involving square roots; and AI.9.11.A

(B) simplify numeric and algebraic expressions using the laws of exponents, including integral and rational exponents. AI.9.11.B

(12) Number and algebraic methods. The student applies the mathematical process standards and algebraic methods to write, solve, analyze, and evaluate equations, relations, and functions. The student is expected to: AI.9.12

(A) decide whether relations represented verbally, tabularly, graphically, and symbolically define a function; AI.9.12.A

(B) evaluate functions, expressed in function notation, given one or more elements in their domains; AI.9.12.B

(C) identify terms of arithmetic and geometric sequences when the sequences are given in function form using recursive processes; AI.9.12.C

(D) write a formula for the nth term of arithmetic and geometric sequences, given the value of several of their terms; and AI.9.12.D

(E) solve mathematic and scientific formulas, and other literal equations, for a specified variable. AI.9.12.E

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**Algebra II**

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(1) Mathematical process standards. The student uses mathematical processes to acquire and demonstrate mathematical understanding. The student is expected to: AII.9-12.1

(A) apply mathematics to problems arising in everyday life, society, and the workplace; AII.9-12.1.A

(B) use a problem-solving model that incorporates analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem-solving process and the reasonableness of the solution; AII.9-12.1.B

(C) select tools, including real objects, manipulatives, paper and pencil, and technology as appropriate, and techniques, including mental math, estimation, and number sense as appropriate, to solve problems; AII.9-12.1.C

(D) communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate; AII.9-12.1.D

(E) create and use representations to organize, record, and communicate mathematical ideas; AII.9-12.1.E

(F) analyze mathematical relationships to connect and communicate mathematical ideas; and AII.9-12.1.F

(G) display, explain, or justify mathematical ideas and arguments using precise mathematical language in written or oral communication. AII.9-12.1.G

(2) Attributes of functions and their inverses. The student applies mathematical processes to understand that functions have distinct key attributes and understand the relationship between a function and its inverse. The student is expected to: AII.9-12.2

(A) graph the functions f(x)=√x, f(x)=1/x, f(x)=$x^3$, f(x)= $\sqrt[3]{x}$, f(x)=b<sup>x</sup>, f(x)=|x|, and f(x)=logb (x) where b is 2, 10, and e, and, when applicable, analyze the key attributes such as domain, range, intercepts, symmetries, asymptotic behavior, and maximum and minimum given an interval; AII.9-12.2.A

(B) graph and write the inverse of a function using notation such as f<sup>-1</sup> (x); AII.9-12.2.B

(C) describe and analyze the relationship between a function and its inverse (quadratic and square root, logarithmic and exponential), including the restriction(s) on domain, which will restrict its range; and AII.9-12.2.C

(D) use the composition of two functions, including the necessary restrictions on the domain, to determine if the functions are inverses of each other. AII.9-12.2.D

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(3) Systems of equations and inequalities. The student applies mathematical processes to formulate systems of equations and inequalities, use a variety of methods to solve, and analyze reasonableness of solutions. The student is expected to: AII.9-12.3

(A) formulate systems of equations, including systems consisting of three linear equations in three variables and systems consisting of two equations, the first linear and the second quadratic; AII.9-12.3.A

(B) solve systems of three linear equations in three variables by using Gaussian elimination, technology with matrices, and substitution; AII.9-12.3.B

(C) solve, algebraically, systems of two equations in two variables consisting of a linear equation and a quadratic equation; AII.9-12.3.C

(D) determine the reasonableness of solutions to systems of a linear equation and a quadratic equation in two variables; AII.9-12.3.D

(E) formulate systems of at least two linear inequalities in two variables; AII.9-12.3.E

(F) solve systems of two or more linear inequalities in two variables; and AII.9-12.3.F

(G) determine possible solutions in the solution set of systems of two or more linear inequalities in two variables. AII.9-12.3.G

(4) Quadratic and square root functions, equations, and inequalities. The student applies mathematical processes to understand that quadratic and square root functions, equations, and quadratic inequalities can be used to model situations, solve problems, and make predictions. The student is expected to: AII.9-12.4

(A) write the quadratic function given three specified points in the plane; AII.9-12.4.A

(B) write the equation of a parabola using given attributes, including vertex, focus, directrix, axis of symmetry, and direction of opening; AII.9-12.4.B

(C) determine the effect on the graph of $f(x) = \sqrt{x}$ when $f(x)$ is replaced by $af(x)$, $f(x) + d$, $f(bx)$, and $f(x - c)$ for specific positive and negative values of a, b, c, and d; AII.9-12.4.C

(D) transform a quadratic function $f(x) = ax^2 + bx + c$ to the form $f(x) = a(x - h)^2 + k$ to identify the different attributes of $f(x)$; AII.9-12.4.D

(E) formulate quadratic and square root equations using technology given a table of data; AII.9-12.4.E

(F) solve quadratic and square root equations; AII.9-12.4.F

(G) identify extraneous solutions of square root equations; and AII.9-12.4.G

(H) solve quadratic inequalities. AII.9-12.4.H

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(5) Exponential and logarithmic functions and equations. The student applies mathematical processes to understand that exponential and logarithmic functions can be used to model situations and solve problems. The student is expected to: AII.9-12.5

(A) determine the effects on the key attributes on the graphs of f(x) = b<sup>x</sup> and f(x) = logb (x) where b is 2, 10, and e when f(x) is replaced by af(x), f(x) + d, and f(x - c) for specific positive and negative real values of a, c, and d; AII.9-12.5.A

(B) formulate exponential and logarithmic equations that model real-world situations, including exponential relationships written in recursive notation; AII.9-12.5.B

(C) rewrite exponential equations as their corresponding logarithmic equations and logarithmic equations as their corresponding exponential equations; AII.9-12.5.C

(D) solve exponential equations of the form y = abx where a is a nonzero real number and b is greater than zero and not equal to one and single logarithmic equations having real solutions; and AII.9-12.5.D

(E) determine the reasonableness of a solution to a logarithmic equation. AII.9-12.5.E

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(6) Cubic, cube root, absolute value and rational functions, equations, and inequalities. The student applies mathematical processes to understand that cubic, cube root, absolute value and rational functions, equations, and inequalities can be used to model situations, solve problems, and make predictions. The student is expected to: AII.9-12.6

(A) analyze the effect on the graphs of $f(x) = x^3$ and $f(x) = \sqrt[3]{x}$ when f(x) is replaced by af(x), f(bx), f(x - c), and f(x) + d for specific positive and negative real values of a, b, c, and d; AII.9-12.6.A

(B) solve cube root equations that have real roots; AII.9-12.6.B

(C) analyze the effect on the graphs of f(x) = |x| when f(x) is replaced by af(x), f(bx), f(x-c), and f(x) + d for specific positive and negative real values of a, b, c, and d; AII.9-12.6.C

(D) formulate absolute value linear equations; AII.9-12.6.D

(E) solve absolute value linear equations; AII.9-12.6.E

(F) solve absolute value linear inequalities; AII.9-12.6.F

(G) analyze the effect on the graphs of f(x) = 1/x when f(x) is replaced by af(x), f(bx), f(x-c), and f(x) + d for specific positive and negative real values of a, b, c, and d; AII.9-12.6.G

(H) formulate rational equations that model real-world situations; AII.9-12.6.H

(I) solve rational equations that have real solutions; AII.9-12.6.I

(J) determine the reasonableness of a solution to a rational equation; AII.9-12.6.J

(K) determine the asymptotic restrictions on the domain of a rational function and represent domain and range using interval notation, inequalities, and set notation; and AII.9-12.6.K

(L) formulate and solve equations involving inverse variation. AII.9-12.6.L

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(7) Number and algebraic methods. The student applies mathematical processes to simplify and perform operations on expressions and to solve equations. The student is expected to: AII.9-12.7

(A) add, subtract, and multiply complex numbers; AII.9-12.7.A

(B) add, subtract, and multiply polynomials; AII.9-12.7.B

(C) determine the quotient of a polynomial of degree three and of degree four when divided by a polynomial of degree one and of degree two; AII.9-12.7.C

(D) determine the linear factors of a polynomial function of degree three and of degree four using algebraic methods; AII.9-12.7.D

(E) determine linear and quadratic factors of a polynomial expression of degree three and of degree four, including factoring the sum and difference of two cubes and factoring by grouping; AII.9-12.7.E

(F) determine the sum, difference, product, and quotient of rational expressions with integral exponents of degree one and of degree two; AII.9-12.7.F

(G) rewrite radical expressions that contain variables to equivalent forms; AII.9-12.7.G

(H) solve equations involving rational exponents; and AII.9-12.7.H

(I) write the domain and range of a function in interval notation, inequalities, and set notation. AII.9-12.7.I

(8) Data. The student applies mathematical processes to analyze data, select appropriate models, write corresponding functions, and make predictions. The student is expected to: AII.9-12.8

(A) analyze data to select the appropriate model from among linear, quadratic, and exponential models; AII.9-12.8.A

(B) use regression methods available through technology to write a linear function, a quadratic function, and an exponential function from a given set of data; and AII.9-12.8.B

(C) predict and make decisions and critical judgments from a given set of data using linear, quadratic, and exponential models. AII.9-12.8.C

**Geometry**

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(1) Mathematical process standards. The student uses mathematical processes to acquire and demonstrate mathematical understanding. The student is expected to: G.9-12.1

(A) apply mathematics to problems arising in everyday life, society, and the workplace; G.9-12.1.A

(B) use a problem-solving model that incorporates analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem-solving process and the reasonableness of the solution; G.9-12.1.B

(C) select tools, including real objects, manipulatives, paper and pencil, and technology as appropriate, and techniques, including mental math, estimation, and number sense as appropriate, to solve problems; G.9-12.1.C

(D) communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate; G.9-12.1.D

(E) create and use representations to organize, record, and communicate mathematical ideas; G.9-12.1.E

(F) analyze mathematical relationships to connect and communicate mathematical ideas; and G.9-12.1.F

(G) display, explain, and justify mathematical ideas and arguments using precise mathematical language in written or oral communication. G.9-12.1.G

(2) Coordinate and transformational geometry. The student uses the process skills to understand the connections between algebra and geometry and uses the one- and two-dimensional coordinate systems to verify geometric conjectures. The student is expected to: G.9-12.2

(A) determine the coordinates of a point that is a given fractional distance less than one from one end of a line segment to the other in one- and two-dimensional coordinate systems, including finding the midpoint; G.9-12.2.A

(B) derive and use the distance, slope, and midpoint formulas to verify geometric relationships, including congruence of segments and parallelism or perpendicularity of pairs of lines; and G.9-12.2.B

(C) determine an equation of a line parallel or perpendicular to a given line that passes through a given point. G.9-12.2.C

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(3) Coordinate and transformational geometry. The student uses the process skills to generate and describe rigid transformations (translation, reflection, and rotation) and non-rigid transformations (dilations that preserve similarity and reductions and enlargements that do not preserve similarity). The student is expected to: G.9-12.3

(A) describe and perform transformations of figures in a plane using coordinate notation; G.9-12.3.A

(B) determine the image or pre-image of a given two-dimensional figure under a composition of rigid transformations, a composition of non-rigid transformations, and a composition of both, including dilations where the center can be any point in the plane; G.9-12.3.B

(C) identify the sequence of transformations that will carry a given pre-image onto an image on and off the coordinate plane; and G.9-12.3.C

(D) identify and distinguish between reflectional and rotational symmetry in a plane figure. G.9-12.3.D

(4) Logical argument and constructions. The student uses the process skills with deductive reasoning to understand geometric relationships. The student is expected to: G.9-12.4

(A) distinguish between undefined terms, definitions, postulates, conjectures, and theorems; G.9-12.4.A

(B) identify and determine the validity of the converse, inverse, and contrapositive of a conditional statement and recognize the connection between a biconditional statement and a true conditional statement with a true converse; G.9-12.4.B

(C) verify that a conjecture is false using a counterexample; and G.9-12.4.C

(D) compare geometric relationships between Euclidean and spherical geometries, including parallel lines and the sum of the angles in a triangle. G.9-12.4.D

(5) Logical argument and constructions. The student uses constructions to validate conjectures about geometric figures. The student is expected to: G.9-12.5

(A) investigate patterns to make conjectures about geometric relationships, including angles formed by parallel lines cut by a transversal, criteria required for triangle congruence, special segments of triangles, diagonals of quadrilaterals, interior and exterior angles of polygons, and special segments and angles of circles choosing from a variety of tools; G.9-12.5.A

(B) construct congruent segments, congruent angles, a segment bisector, an angle bisector, perpendicular lines, the perpendicular bisector of a line segment, and a line parallel to a given line through a point not on a line using a compass and a straightedge; G.9-12.5.B

(C) use the constructions of congruent segments, congruent angles, angle bisectors, and perpendicular bisectors to make conjectures about geometric relationships; and G.9-12.5.C

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(D) verify the Triangle Inequality theorem using constructions and apply the theorem to solve problems. G.9-12.5.D

(6) Proof and congruence. The student uses the process skills with deductive reasoning to prove and apply theorems by using a variety of methods such as coordinate, transformational, and axiomatic and formats such as two-column, paragraph, and flow chart. The student is expected to: G.9-12.6

(A) verify theorems about angles formed by the intersection of lines and line segments, including vertical angles, and angles formed by parallel lines cut by a transversal and prove equidistance between the endpoints of a segment and points on its perpendicular bisector and apply these relationships to solve problems; G.9-12.6.A

(B) prove two triangles are congruent by applying the Side-Angle-Side, Angle-Side-Angle, Side-Side-Side, Angle-Angle-Side, and Hypotenuse-Leg congruence conditions; G.9-12.6.B

(C) apply the definition of congruence, in terms of rigid transformations, to identify congruent figures and their corresponding sides and angles; G.9-12.6.C

(D) verify theorems about the relationships in triangles, including proof of the Pythagorean Theorem, the sum of interior angles, base angles of isosceles triangles, midsegments, and medians, and apply these relationships to solve problems; and G.9-12.6.D

(E) prove a quadrilateral is a parallelogram, rectangle, square, or rhombus using opposite sides, opposite angles, or diagonals and apply these relationships to solve problems. G.9-12.6.E

(7) Similarity, proof, and trigonometry. The student uses the process skills in applying similarity to solve problems. The student is expected to: G.9-12.7

(A) apply the definition of similarity in terms of a dilation to identify similar figures and their proportional sides and the congruent corresponding angles; and G.9-12.7.A

(B) apply the Angle-Angle criterion to verify similar triangles and apply the proportionality of the corresponding sides to solve problems. G.9-12.7.B

(8) Similarity, proof, and trigonometry. The student uses the process skills with deductive reasoning to prove and apply theorems by using a variety of methods such as coordinate, transformational, and axiomatic and formats such as two-column, paragraph, and flow chart. The student is expected to: G.9-12.8

(A) prove theorems about similar triangles, including the Triangle Proportionality theorem, and apply these theorems to solve problems; and G.9-12.8.A

(B) identify and apply the relationships that exist when an altitude is drawn to the hypotenuse of a right triangle, including the geometric mean, to solve problems. G.9-12.8.B

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(9) Similarity, proof, and trigonometry. The student uses the process skills to understand and apply relationships in right triangles. The student is expected to: G.9-12.9

(A) determine the lengths of sides and measures of angles in a right triangle by applying the trigonometric ratios sine, cosine, and tangent to solve problems; and G.9-12.9.A

(B) apply the relationships in special right triangles 30°-60°-90° and 45°-45°-90° and the Pythagorean theorem, including Pythagorean triples, to solve problems. G.9-12.9.B

(10) Two-dimensional and three-dimensional figures. The student uses the process skills to recognize characteristics and dimensional changes of two- and three-dimensional figures. The student is expected to: G.9-12.10

(A) identify the shapes of two-dimensional cross-sections of prisms, pyramids, cylinders, cones, and spheres and identify three-dimensional objects generated by rotations of two-dimensional shapes; and G.9-12.10.A

(B) determine and describe how changes in the linear dimensions of a shape affect its perimeter, area, surface area, or volume, including proportional and non-proportional dimensional change. G.9-12.10.B

(11) Two-dimensional and three-dimensional figures. The student uses the process skills in the application of formulas to determine measures of two- and three-dimensional figures. The student is expected to: G.9-12.11

(A) apply the formula for the area of regular polygons to solve problems using appropriate units of measure; G.9-12.11.A

(B) determine the area of composite two-dimensional figures comprised of a combination of triangles, parallelograms, trapezoids, kites, regular polygons, or sectors of circles to solve problems using appropriate units of measure; G.9-12.11.B

(C) apply the formulas for the total and lateral surface area of three-dimensional figures, including prisms, pyramids, cones, cylinders, spheres, and composite figures, to solve problems using appropriate units of measure; and G.9-12.11.C

(D) apply the formulas for the volume of three-dimensional figures, including prisms, pyramids, cones, cylinders, spheres, and composite figures, to solve problems using appropriate units of measure. G.9-12.11.D

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(12) Circles. The student uses the process skills to understand geometric relationships and apply theorems and equations about circles. The student is expected to: G.9-12.12

(A) apply theorems about circles, including relationships among angles, radii, chords, tangents, and secants, to solve non-contextual problems; G.9-12.12.A

(B) apply the proportional relationship between the measure of an arc length of a circle and the circumference of the circle to solve problems; G.9-12.12.B

(C) apply the proportional relationship between the measure of the area of a sector of a circle and the area of the circle to solve problems; G.9-12.12.C

(D) describe radian measure of an angle as the ratio of the length of an arc intercepted by a central angle and the radius of the circle; and G.9-12.12.D

(E) show that the equation of a circle with center at the origin and radius r is $x^2 + y^2 = r^2$ and determine the equation for the graph of a circle with radius r and center (h, k), $(x - h)^2 + (y - k)^2 = r^2$. G.9-12.12.E

(13) Probability. The student uses the process skills to understand probability in real-world situations and how to apply independence and dependence of events. The student is expected to: G.9-12.13

(A) develop strategies to use permutations and combinations to solve contextual problems; G.9-12.13.A

(B) determine probabilities based on area to solve contextual problems; G.9-12.13.B

(C) identify whether two events are independent and compute the probability of the two events occurring together with or without replacement; G.9-12.13.C

(D) apply conditional probability in contextual problems; and G.9-12.13.D

(E) apply independence in contextual problems. G.9-12.13.E

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**Precalculus**

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(1) Mathematical process standards. The student uses mathematical processes to acquire and demonstrate mathematical understanding. The student is expected to: P.9-12.1

(A) apply mathematics to problems arising in everyday life, society, and the workplace; P.9-12.1.A

(B) use a problem-solving model that incorporates analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem-solving process and the reasonableness of the solution; P.9-12.1.B

(C) select tools, including real objects, manipulatives, paper and pencil, and technology as appropriate, and techniques, including mental math, estimation, and number sense as appropriate, to solve problems; P.9-12.1.C

(D) communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate; P.9-12.1.D

(E) create and use representations to organize, record, and communicate mathematical ideas; P.9-12.1.E

(F) analyze mathematical relationships to connect and communicate mathematical ideas; and P.9-12.1.F

(G) display, explain, and justify mathematical ideas and arguments using precise mathematical language in written or oral communication. P.9-12.1.G

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(2) Functions. The student uses process standards in mathematics to explore, describe, and analyze the attributes of functions. The student makes connections between multiple representations of functions and algebraically constructs new functions. The student analyzes and uses functions to model real-world problems. The student is expected to: P.9-12.2

(A) use the composition of two functions to model and solve real-world problems; P.9-12.2.A

(B) demonstrate that function composition is not always commutative; P.9-12.2.B

(C) represent a given function as a composite function of two or more functions; P.9-12.2.C

(D) describe symmetry of graphs of even and odd functions; P.9-12.2.D

(E) determine an inverse function, when it exists, for a given function over its domain or a subset of its domain and represent the inverse using multiple representations; P.9-12.2.E

(F) graph exponential, logarithmic, rational, polynomial, power, trigonometric, inverse trigonometric, and piecewise defined functions, including step functions; P.9-12.2.F

(G) graph functions, including exponential, logarithmic, sine, cosine, rational, polynomial, and power functions and their transformations, including af(x), f(x) + d, f(x - c), f(bx) for specific values of a, b, c, and d, in mathematical and real-world problems; P.9-12.2.G

(H) graph arcsin x and arccos x and describe the limitations on the domain; P.9-12.2.H

(I) determine and analyze the key features of exponential, logarithmic, rational, polynomial, power, trigonometric, inverse trigonometric, and piecewise defined functions, including step functions such as domain, range, symmetry, relative maximum, relative minimum, zeros, asymptotes, and intervals over which the function is increasing or decreasing; P.9-12.2.I

(J) analyze and describe end behavior of functions, including exponential, logarithmic, rational, polynomial, and power functions, using infinity notation to communicate this characteristic in mathematical and real-world problems; P.9-12.2.J

(K) analyze characteristics of rational functions and the behavior of the function around the asymptotes, including horizontal, vertical, and oblique asymptotes; P.9-12.2.K

(L) determine various types of discontinuities in the interval $(-\infty, \infty)$ as they relate to functions and explore the limitations of the graphing calculator as it relates to the behavior of the function around discontinuities; P.9-12.2.L

(M) describe the left-sided behavior and the right-sided behavior of the graph of a function around discontinuities; P.9-12.2.M

(N) analyze situations modeled by functions, including exponential, logarithmic, rational, polynomial, and power functions, to solve real-world problems; P.9-12.2.N

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(O) develop and use a sinusoidal function that models a situation in mathematical and real-world problems; and P.9-12.2.O

(P) determine the values of the trigonometric functions at the special angles and relate them in mathematical and real-world problems. P.9-12.2.P

(3) Relations and geometric reasoning. The student uses the process standards in mathematics to model and make connections between algebraic and geometric relations. The student is expected to: P.9-12.3

(A) graph a set of parametric equations; P.9-12.3.A

(B) convert parametric equations into rectangular relations and convert rectangular relations into parametric equations; P.9-12.3.B

(C) use parametric equations to model and solve mathematical and real-world problems; P.9-12.3.C

(D) graph points in the polar coordinate system and convert between rectangular coordinates and polar coordinates; P.9-12.3.D

(E) graph polar equations by plotting points and using technology; P.9-12.3.E

(F) determine the conic section formed when a plane intersects a double-napped cone; P.9-12.3.F

(G) make connections between the locus definition of conic sections and their equations in rectangular coordinates; P.9-12.3.G

(H) use the characteristics of an ellipse to write the equation of an ellipse with center (h, k); and P.9-12.3.H

(I) use the characteristics of a hyperbola to write the equation of a hyperbola with center (h, k). P.9-12.3.I

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(4) Number and measure. The student uses process standards in mathematics to apply appropriate techniques, tools, and formulas to calculate measures in mathematical and real-world problems. The student is expected to: P.9-12.4

(A) determine the relationship between the unit circle and the definition of a periodic function to evaluate trigonometric functions in mathematical and real-world problems; P.9-12.4.A

(B) describe the relationship between degree and radian measure on the unit circle; P.9-12.4.B

(C) represent angles in radians or degrees based on the concept of rotation and find the measure of reference angles and angles in standard position; P.9-12.4.C

(D) represent angles in radians or degrees based on the concept of rotation in mathematical and real-world problems, including linear and angular velocity; P.9-12.4.D

(E) determine the value of trigonometric ratios of angles and solve problems involving trigonometric ratios in mathematical and real-world problems; P.9-12.4.E

(F) use trigonometry in mathematical and real-world problems, including directional bearing; P.9-12.4.F

(G) use the Law of Sines in mathematical and real-world problems; P.9-12.4.G

(H) use the Law of Cosines in mathematical and real-world problems; P.9-12.4.H

(I) use vectors to model situations involving magnitude and direction; P.9-12.4.I

(J) represent the addition of vectors and the multiplication of a vector by a scalar geometrically and symbolically; and P.9-12.4.J

(K) apply vector addition and multiplication of a vector by a scalar in mathematical and real-world problems. P.9-12.4.K

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(5) Algebraic reasoning. The student uses process standards in mathematics to evaluate expressions, describe patterns, formulate models, and solve equations and inequalities using properties, procedures, or algorithms. The student is expected to: P.9-12.5

(A) evaluate finite sums and geometric series, when possible, written in sigma notation; P.9-12.5.A

(B) represent arithmetic sequences and geometric sequences using recursive formulas; P.9-12.5.B

(C) calculate the n<sup>th</sup> term and the n<sup>th</sup> partial sum of an arithmetic series in mathematical and real-world problems; P.9-12.5.C

(D) represent arithmetic series and geometric series using sigma notation; P.9-12.5.D

(E) calculate the n<sup>th</sup> term of a geometric series, the n<sup>th</sup> partial sum of a geometric series, and sum of an infinite geometric series when it exists; P.9-12.5.E

(F) apply the Binomial Theorem for the expansion of (a + b)<sup>n</sup> in powers of a and b for a positive integer n, where a and b are any numbers; P.9-12.5.F

(G) use the properties of logarithms to evaluate or transform logarithmic expressions; P.9-12.5.G

(H) generate and solve logarithmic equations in mathematical and real-world problems; P.9-12.5.H

(I) generate and solve exponential equations in mathematical and real-world problems; P.9-12.5.I

(J) solve polynomial equations with real coefficients by applying a variety of techniques in mathematical and real-world problems; P.9-12.5.J

(K) solve polynomial inequalities with real coefficients by applying a variety of techniques and write the solution set of the polynomial inequality in interval notation in mathematical and real-world problems; P.9-12.5.K

(L) solve rational inequalities with real coefficients by applying a variety of techniques and write the solution set of the rational inequality in interval notation in mathematical and real-world problems; P.9-12.5.L

(M) use trigonometric identities such as reciprocal, quotient, Pythagorean, cofunctions, even/odd, and sum and difference identities for cosine and sine to simplify trigonometric expressions; and P.9-12.5.M

(N) generate and solve trigonometric equations in mathematical and real-world problems. P.9-12.5.N

**Mathematical Models with Applications**

Skip to main content

(1) Mathematical process standards. The student uses mathematical processes to acquire and demonstrate mathematical understanding. The student is expected to: MMA.9-12.1

(A) apply mathematics to problems arising in everyday life, society, and the workplace; MMA.9-12.1.A

(B) use a problem-solving model that incorporates analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem-solving process and the reasonableness of the solution; MMA.9-12.1.B

(C) select tools, including real objects, manipulatives, paper and pencil, and technology as appropriate, and techniques, including mental math, estimation, and number sense as appropriate, to solve problems; MMA.9-12.1.C

(D) communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate; MMA.9-12.1.D

(E) create and use representations to organize, record, and communicate mathematical ideas; MMA.9-12.1.E

(F) analyze mathematical relationships to connect and communicate mathematical ideas; and MMA.9-12.1.F

(G) display, explain, and justify mathematical ideas and arguments using precise mathematical language in written or oral communication. MMA.9-12.1.G

(2) Mathematical modeling in personal finance. The student uses mathematical processes with graphical and numerical techniques to study patterns and analyze data related to personal finance. The student is expected to: MMA.9-12.2

(A) use rates and linear functions to solve problems involving personal finance and budgeting, including compensations and deductions; MMA.9-12.2.A

(B) solve problems involving personal taxes; and MMA.9-12.2.B

(C) analyze data to make decisions about banking, including options for online banking, checking accounts, overdraft protection, processing fees, and debit card/ATM fees. MMA.9-12.2.C

(3) Mathematical modeling in personal finance. The student uses mathematical processes with algebraic formulas, graphs, and amortization modeling to solve problems involving credit. The student is expected to: MMA.9-12.3

(A) use formulas to generate tables to display series of payments for loan amortizations resulting from financed purchases; MMA.9-12.3.A

(B) analyze personal credit options in retail purchasing and compare relative advantages and disadvantages of each option; MMA.9-12.3.B

(C) use technology to create amortization models to investigate home financing and compare buying a home to renting a home; and MMA.9-12.3.C

(D) use technology to create amortization models to investigate automobile financing and compare buying a vehicle to leasing a vehicle. MMA.9-12.3.D

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(4) Mathematical modeling in personal finance. The student uses mathematical processes with algebraic formulas, numerical techniques, and graphs to solve problems related to financial planning. The student is expected to: MMA.9-12.4

(A) analyze and compare coverage options and rates in insurance; MMA.9-12.4.A

(B) investigate and compare investment options, including stocks, bonds, annuities, certificates of deposit, and retirement plans; and MMA.9-12.4.B

(C) analyze types of savings options involving simple and compound interest and compare relative advantages of these options. MMA.9-12.4.C

(5) Mathematical modeling in science and engineering. The student applies mathematical processes with algebraic techniques to study patterns and analyze data as it applies to science. The student is expected to: MMA.9-12.5

(A) use proportionality and inverse variation to describe physical laws such as Hook's Law, Newton's Second Law of Motion, and Boyle's Law; MMA.9-12.5.A

(B) use exponential models available through technology to model growth and decay in areas, including radioactive decay; and MMA.9-12.5.B

(C) use quadratic functions to model motion. MMA.9-12.5.C

(6) Mathematical modeling in science and engineering. The student applies mathematical processes with algebra and geometry to study patterns and analyze data as it applies to architecture and engineering. The student is expected to: MMA.9-12.6

(A) use similarity, geometric transformations, symmetry, and perspective drawings to describe mathematical patterns and structure in architecture; MMA.9-12.6.A

(B) use scale factors with two-dimensional and three-dimensional objects to demonstrate proportional and non-proportional changes in surface area and volume as applied to fields; MMA.9-12.6.B

(C) use the Pythagorean Theorem and special right-triangle relationships to calculate distances; and MMA.9-12.6.C

(D) use trigonometric ratios to calculate distances and angle measures as applied to fields. MMA.9-12.6.D

(7) Mathematical modeling in fine arts. The student uses mathematical processes with algebra and geometry to study patterns and analyze data as it applies to fine arts. The student is expected to: MMA.9-12.7

(A) use trigonometric ratios and functions available through technology to model periodic behavior in art and music; MMA.9-12.7.A

(B) use similarity, geometric transformations, symmetry, and perspective drawings to describe mathematical patterns and structure in art and photography; MMA.9-12.7.B

(C) use geometric transformations, proportions, and periodic motion to describe mathematical patterns and structure in music; and MMA.9-12.7.C

(D) use scale factors with two-dimensional and three-dimensional objects to demonstrate proportional and non-proportional changes in surface area and volume as applied to fields. MMA.9-12.7.D

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(8) Mathematical modeling in social sciences. The student applies mathematical processes to determine the number of elements in a finite sample space and compute the probability of an event. The student is expected to: MMA.9-12.8

(A) determine the number of ways an event may occur using combinations, permutations, and the Fundamental Counting Principle; MMA.9-12.8.A

(B) compare theoretical to empirical probability; and MMA.9-12.8.B

(C) use experiments to determine the reasonableness of a theoretical model such as binomial or geometric. MMA.9-12.8.C

(9) Mathematical modeling in social sciences. The student applies mathematical processes and mathematical models to analyze data as it applies to social sciences. The student is expected to: MMA.9-12.9

(A) interpret information from various graphs, including line graphs, bar graphs, circle graphs, histograms, scatterplots, dot plots, stem-and-leaf plots, and box and whisker plots, to draw conclusions from the data and determine the strengths and weaknesses of conclusions; MMA.9-12.9.A

(B) analyze numerical data using measures of central tendency (mean, median, and mode) and variability (range, interquartile range or IQR, and standard deviation) in order to make inferences with normal distributions; MMA.9-12.9.B

(C) distinguish the purposes and differences among types of research, including surveys, experiments, and observational studies; MMA.9-12.9.C

(D) use data from a sample to estimate population mean or population proportion; MMA.9-12.9.D

(E) analyze marketing claims based on graphs and statistics from electronic and print media and justify the validity of stated or implied conclusions; and MMA.9-12.9.E

(F) use regression methods available through technology to model linear and exponential functions, interpret correlations, and make predictions. MMA.9-12.9.F

(10) Mathematical modeling in social sciences. The student applies mathematical processes to design a study and use graphical, numerical, and analytical techniques to communicate the results of the study. The student is expected to: MMA.9-12.10

(A) formulate a meaningful question, determine the data needed to answer the question, gather the appropriate data, analyze the data, and draw reasonable conclusions; and MMA.9-12.10.A

(B) communicate methods used, analyses conducted, and conclusions drawn for a data-analysis project through the use of one or more of the following: a written report, a visual display, an oral report, or a multi-media presentation. MMA.9-12.10.B

**Advanced Quantitative Reasoning**

Skip to main content

(1) Mathematical process standards. The student uses mathematical processes to acquire and demonstrate mathematical understanding. The student is expected to: AQR.9-12.1

(A) apply mathematics to problems arising in everyday life, society, and the workplace; AQR.9-12.1.A

(B) use a problem-solving model that incorporates analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem-solving process and the reasonableness of the solution; AQR.9-12.1.B

(C) select tools, including real objects, manipulatives, paper and pencil, and technology as appropriate, and techniques, including mental math, estimation, and number sense as appropriate, to solve problems; AQR.9-12.1.C

(D) communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate; AQR.9-12.1.D

(E) create and use representations to organize, record, and communicate mathematical ideas; AQR.9-12.1.E

(F) analyze mathematical relationships to connect and communicate mathematical ideas; and AQR.9-12.1.F

(G) display, explain, and justify mathematical ideas and arguments using precise mathematical language in written or oral communication. AQR.9-12.1.G

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(2) Numeric reasoning. The student applies the process standards in mathematics to generate new understandings by extending existing knowledge. The student generates new mathematical understandings through problems involving numerical data that arise in everyday life, society, and the workplace. The student extends existing knowledge and skills to analyze real-world situations. The student is expected to: AQR.9-12.2

(A) use precision and accuracy in real-life situations related to measurement and significant figures; AQR.9-12.2.A

(B) apply and analyze published ratings, weighted averages, and indices to make informed decisions; AQR.9-12.2.B

(C) solve problems involving quantities that are not easily measured using proportionality; AQR.9-12.2.C

(D) solve geometric problems involving indirect measurement, including similar triangles, the Pythagorean Theorem, Law of Sines, Law of Cosines, and the use of dynamic geometry software; AQR.9-12.2.D

(E) solve problems involving large quantities using combinatorics; AQR.9-12.2.E

(F) use arrays to efficiently manage large collections of data and add, subtract, and multiply matrices to solve applied problems, including geometric transformations; AQR.9-12.2.F

(G) analyze various voting and selection processes to compare results in given situations; and AQR.9-12.2.G

(H) select and apply an algorithm of interest to solve real-life problems such as problems using recursion or iteration involving population growth or decline, fractals, and compound interest; the validity in recorded and transmitted data using checksums and hashing; sports rankings, weighted class rankings, and search engine rankings; and problems involving scheduling or routing situations using vertex-edge graphs, critical paths, Euler paths, and minimal spanning trees and communicate to peers the application of the algorithm in precise mathematical and nontechnical language. AQR.9-12.2.H

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(3) Algebraic reasoning (expressions, equations, and generalized relationships). The student applies the process standards in mathematics to create and analyze mathematical models of everyday situations to make informed decisions related to earning, investing, spending, and borrowing money by appropriate, proficient, and efficient use of tools, including technology. The student uses mathematical relationships to make connections and predictions. The student judges the validity of a prediction and uses mathematical models to represent, analyze, and solve dynamic real-world problems. The student is expected to: AQR.9-12.3

(A) collect numerical bivariate data to create a scatterplot, select a function to model the data, justify the model selection, and use the model to interpret results and make predictions; AQR.9-12.3.A

(B) describe the degree to which uncorrelated variables may or may not be related and analyze situations where correlated variables do or do not indicate a cause-and-effect relationship; AQR.9-12.3.B

(C) determine or analyze an appropriate growth or decay model for problem situations, including linear, exponential, and logistic functions; AQR.9-12.3.C

(D) determine or analyze an appropriate cyclical model for problem situations that can be modeled with periodic functions; AQR.9-12.3.D

(E) determine or analyze an appropriate piecewise model for problem situations; AQR.9-12.3.E

(F) create, represent, and analyze mathematical models for various types of income calculations to determine the best option for a given situation; AQR.9-12.3.F

(G) create, represent, and analyze mathematical models for expenditures, including those involving credit, to determine the best option for a given situation; and AQR.9-12.3.G

(H) create, represent, and analyze mathematical models and appropriate representations, including formulas and amortization tables, for various types of loans and investments to determine the best option for a given situation. AQR.9-12.3.H

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(4) Probabilistic and statistical reasoning. The student uses the process standards in mathematics to generate new understandings of probability and statistics. The student analyzes statistical information and evaluates risk and return to connect mathematical ideas and make informed decisions. The student applies a problem-solving model and statistical methods to design and conduct a study that addresses one or more particular question(s). The student uses multiple representations to communicate effectively the results of student-generated statistical studies and the critical analysis of published statistical studies. The student is expected to: AQR.9-12.4

(A) use a two-way frequency table as a sample space to identify whether two events are independent and to interpret the results; AQR.9-12.4.A

(B) use the Addition Rule, P(A or B) = P(A) + P(B) - P(A and B), in mathematical and real-world problems; AQR.9-12.4.B

(C) calculate conditional probabilities and probabilities of compound events using tree diagrams, Venn diagrams, area models, and formulas; AQR.9-12.4.C

(D) interpret conditional probabilities and probabilities of compound events by analyzing representations to make decisions in problem situations; AQR.9-12.4.D

(E) use probabilities to make and justify decisions about risks in everyday life; AQR.9-12.4.E

(F) calculate expected value to analyze mathematical fairness, payoff, and risk; AQR.9-12.4.F

(G) determine the validity of logical arguments that include compound conditional statements by constructing truth tables; AQR.9-12.4.G

(H) identify limitations and lack of relevant information in studies reporting statistical information, especially when studies are reported in condensed form; AQR.9-12.4.H

(I) interpret and compare statistical results using appropriate technology given a margin of error; AQR.9-12.4.I

(J) identify potential misuses of statistics to justify particular conclusions, including assertions of a cause-and-effect relationship rather than an association, and missteps or fallacies in logical reasoning; AQR.9-12.4.J

(K) describe strengths and weaknesses of sampling techniques, data and graphical displays, and interpretations of summary statistics and other results appearing in a study, including reports published in the media; AQR.9-12.4.K

(L) determine the need for and purpose of a statistical investigation and what type of statistical analysis can be used to answer a specific question or set of questions; AQR.9-12.4.L

(M) identify the population of interest for a statistical investigation, select an appropriate sampling technique, and collect data; AQR.9-12.4.M

(N) identify the variables to be used in a study; AQR.9-12.4.N

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(O) determine possible sources of statistical bias in a study and how bias may affect the validity of the results; AQR.9-12.4.O

(P) create data displays for given data sets to investigate, compare, and estimate center, shape, spread, and unusual features of the data; AQR.9-12.4.P

(Q) analyze possible sources of data variability, including those that can be controlled and those that cannot be controlled; AQR.9-12.4.Q

(R) report results of statistical studies to a particular audience, including selecting an appropriate presentation format, creating graphical data displays, and interpreting results in terms of the question studied; AQR.9-12.4.R

(S) justify the design and the conclusion(s) of statistical studies, including the methods used; and AQR.9-12.4.S

(T) communicate statistical results in oral and written formats using appropriate statistical and nontechnical language. AQR.9-12.4.T

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**Independent Study in Mathematics**

(c) Knowledge and skills: mathematical process standards. The student uses mathematical processes to acquire and demonstrate mathematical understanding. The student is expected to: ISM.9-12.1

(1) apply mathematics to problems arising in everyday life, society, and the workplace; ISM.9-12.1.1

(2) use a problem-solving model that incorporates analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem-solving process and the reasonableness of the solution; ISM.9-12.1.2

(3) select tools, including real objects, manipulatives, paper and pencil, and technology as appropriate, and techniques, including mental math, estimation, and number sense as appropriate, to solve problems; ISM.9-12.1.3

(4) communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate; ISM.9-12.1.4

(5) create and use representations to organize, record, and communicate mathematical ideas; ISM.9-12.1.5

(6) analyze mathematical relationships to connect and communicate mathematical ideas; and ISM.9-12.1.6

(7) display, explain, and justify mathematical ideas and arguments using precise mathematical language in written or oral communication. ISM.9-12.1.7