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| N-CN. | The Complex Number System | |
| | Perform arithmetic operations with complex numbers. | |
| N-CN.1. | Know there is a complex number i such that i^2 = -1, and every complex number has the form a + bi with a and b real. | Polar Form of Complex Numbers<br>Add and Subtract Complex Numbers<br>Multiply and Divide Complex Numbers |
| N-CN.2. | Use the relation i^2 = -1 and the commutative, associative, and distributive properties to add, subtract, and multiply complex numbers. | Add and Subtract Complex Numbers<br>Multiply and Divide Complex Numbers |
| N-CN.3. | (+) Find the conjugate of a complex number; use conjugates to find moduli and quotients of complex numbers. | Polar Form of Complex Numbers<br>Multiply and Divide Complex Numbers |
| | Represent complex numbers and their operations on the complex plane. | |
| N-CN.4. | (+) Represent complex numbers on the complex plane in rectangular and polar form (including real and imaginary numbers), and explain why the rectangular and polar forms of a given complex number represent the same number. | Polar Form of Complex Numbers<br>Add and Subtract Complex Numbers<br>Multiply and Divide Complex Numbers<br>Graphing Parametric Equations |
| N-CN.5. | (+) Represent addition, subtraction, multiplication, and conjugation of complex numbers geometrically on the complex plane; use properties of this representation for computation. For example, (1 - square root of 3i)^3 = 8 because (1 - square root of 3i) has modulus 2 and argument 120 degrees. | Add and Subtract Complex Numbers<br>Multiply and Divide Complex Numbers |
| N-CN.6. | (+) Calculate the distance between numbers in the complex plane as the modulus of the difference, and the midpoint of a segment as the average of the numbers at its endpoints. | Add and Subtract Complex Numbers<br>Multiply and Divide Complex Numbers |
| | Perform operations on vectors. | |
| N-VM.4. | (+) Add and subtract vectors. | |
| N-VM.4(a) | Add vectors end-to-end, component-wise, and by the parallelogram rule. Understand that the magnitude of a sum of two vectors is typically not the sum of the magnitudes. | Vector Addition and Subtraction<br>Applying Vectors in the Plane |
| N-VM.4(b) | Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum. | Vector Addition and Subtraction<br>Applying Vectors in the Plane |

 

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| N-VM.4(c) | Understand vector subtraction v - w as v + (-w), where -w is the additive inverse of w, with the same magnitude as w and pointing in the opposite direction. Represent vector subtraction graphically by connecting the tips in the appropriate order, and perform vector subtraction component-wise. | Vector Addition and Subtraction<br>Applying Vectors in the Plane |
| N-VM.5. | (+) Multiply a vector by a scalar. | |
| N-VM.5(a) | Represent scalar multiplication graphically by scaling vectors and possibly reversing their direction; perform scalar multiplication component-wise, e.g., as c(vx, vy) = (cvx, cvy). | Vectors and Their Components<br>Vector Addition and Subtraction<br>Applying Vectors in the Plane |
| N-VM.5(b) | Compute the magnitude of a scalar multiple cv using \|\|cv\|\| = \|c\|v. Compute the direction of cv knowing that when \|c\|v ≠ 0, the direction of cv is either along v (for c > 0) or against v (for c < 0). | Vectors and Their Components<br>Vector Addition and Subtraction<br>Applying Vectors in the Plane |
| | Perform operations on matrices and use matrices in applications. | |
| N-VM.11. | (+) Multiply a vector (regarded as a matrix with one column) by a matrix of suitable dimensions to produce another vector. Work with matrices as transformations of vectors. | Vector Addition and Subtraction<br>Applying Vectors in the Plane |
| WA.A. | Algebra | |
| A-APR. | Arithmetic with Polynomials and Rational Functions | |
| | Understand the relationship between zeros and factors of polynomials. | |
| A-APR.2. | Know and apply the Remainder Theorem: For a polynomial p(x) and a number a, the remainder on division by x - a is p(a), so p(a) = 0 if and only if (x - a) is a factor of p(x). | |
| A-APR.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. | Polynomial Inequalities |
| | Rewrite rational expressions. | |
| A-APR.6. | Rewrite simple rational expressions in different forms; write a(x)/b(x) in the form q(x) + r(x)/b(x), where a(x), b(x), q(x), and r(x) are polynomials with the degree of r(x) less than the degree of b(x), using inspection, long division, or, for the more complicated examples, a computer algebra system. | Rational Inequalities |

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| A-APR.7. | (+) Understand that rational expressions form a system analogous to the rational numbers, closed under addition, subtraction, multiplication, and division by a nonzero rational expression; add, subtract, multiply, and divide rational expressions. | |
| A-REI. | Reasoning with Equations and Inequalities | |
| | Understand solving equations as a process of reasoning and explain the reasoning. | |
| A-REI.2. | Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise. | Rational Inequalities |
| | Solve equations and inequalities in one variable. | |
| A-REI.3. | Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. | Rational Inequalities |
| A-REI.4. | Solve quadratic equations in one variable. | |
| A-REI.4(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. | The General Equation of Conic Sections<br>Conic Inequalities |
| A-REI.4(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 plus-minus bi for real numbers a and b. | The General Equation of Conic Sections<br>Conic Inequalities |
| | Represent and solve equations and inequalities graphically. | |
| A-REI.11. | Explain why the x-coordinates of the points where the graphs of the equations y = f(x) and y = g(x) intersect are the solutions of the equation f(x) = g(x); find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where f(x) and/or g(x) are linear, polynomial, rational, absolute value, exponential, and logarithmic functions. | |
| A-REI.12. | Graph the solutions to 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 to a system of linear inequalities in two variables as the intersection of the corresponding half-planes. | Systems of Inequalities |

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| A-SSE. | Seeing Structure in Expressions | |
| | Write expressions in equivalent forms to solve problems. | |
| A-SSE.3. | Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. | |
| A-SSE.3(a) | Factor a quadratic expression to reveal the zeros of the function it defines. | |
| A-SSE.3(b) | Complete the square in a quadratic expression to reveal the maximum or minimum value of the function it defines. | The General Equation of Conic Sections<br>Conic Inequalities |
| A-SSE.3(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 approximately equals 1.012^12t to reveal the approximate equivalent monthly interest rate if the annual rate is 15%. | Modeling with Exponential and Logarithmic Equations |
| WA.F. | Functions | |
| F-IF. | Interpreting Functions | |
| | Understand the concept of a function and use function notation. | |
| F-IF.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). | Composition of Functions and Modeling<br>Inverse of a Function |
| F-IF.2. | Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context. | Composition of Functions and Modeling<br>Inverse of a Function |
| F-IF.3. | Recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers. For example, the Fibonacci sequence is defined recursively by f(0) = f(1) = 1, f(n+1) = f(n) + f(n-1) for n greater than or equal to 1. | |

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| | Interpret functions that arise in applications in terms of the context. | |
| F-IF.4. | For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity. | Inverse of a Function<br>Polynomial Inequalities<br>Modeling with Exponential and Logarithmic Equations<br>Graphing Sine and Cosine Functions<br>General Form of Sine and Cosine<br>Inverse Trigonometric Functions<br>Conic Sections<br>Equations of Ellipses<br>Equations of Hyperbolas<br>Equations of Hyperbolas (contined)<br>The General Equation of Conic Sections |
| F-IF.5. | Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. For example, if the function h(n) gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain for the function. | Composition of Functions and Modeling<br>Inverse of a Function<br>Modeling with Exponential and Logarithmic Equations<br>Inverse Trigonometric Functions<br>Solving Trigonometric Equations<br>Graphing Parametric Equations |
| | Analyze functions using different representations. | |
| F-IF.7. | Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. | |
| F-IF.7(a) | Graph linear and quadratic functions and show intercepts, maxima, and minima. | Functions and Transformations<br>Conic Sections<br>Conic Inequalities<br>Systems of Inequalities |
| F-IF.7(b) | Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions. | Functions and Transformations |
| F-IF.7(c) | Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior. | |

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| F-IF.7(d) | (+) Graph rational functions, identifying zeros and asymptotes when suitable factorizations are available, and showing end behavior. | Functions and Transformations |
| F-IF.7(e) | Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude. | Functions and Transformations<br>Modeling with Exponential and Logarithmic Equations<br>Graphing Sine and Cosine Functions<br>General Form of Sine and Cosine<br>Inverse Trigonometric Functions |
| F-IF.8. | Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. | |
| F-IF.8(a) | Use the process of factoring and completing the square in a quadratic function to show zeros, extreme values, and symmetry of the graph, and interpret these in terms of a context. | The General Equation of Conic Sections<br>Conic Inequalities |
| F-IF.8(b) | Use the properties of exponents to interpret expressions for exponential functions. For example, identify percent rate of change in functions such as y = (1.02)^t, y = (0.97)^t, y = (1.01)^12t, y = (1.2)^t/10, and classify them as representing exponential growth or decay. | Modeling with Exponential and Logarithmic Equations |
| F-BF. | Building Functions | |
| | Build a function that models a relationship between two quantities. | |
| F-BF.1. | Write a function that describes a relationship between two quantities. | |
| F-BF.1(a) | Determine an explicit expression, a recursive process, or steps for calculation from a context. | Functions and Transformations<br>Composition of Functions and Modeling<br>Rational Inequalities<br>Modeling with Exponential and Logarithmic Equations<br>Applications of Conics |
| F-BF.1(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. | Composition of Functions and Modeling<br>Inverse of a Function<br>Graphing Parametric Equations |

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| F-BF.2. | Write arithmetic and geometric sequences both recursively and with an explicit formula, use them to model situations, and translate between the two forms. | |
| | Build new functions from existing functions. | |
| F-BF.3. | Identify the effect on the graph of replacing f(x) by f(x) + k, k f(x), f(kx), and f(x + k) for specific values of k (both positive and negative); find the value of k given the graphs. Experiment with cases and illustrate an explanation of the effects on the graph using technology. Include recognizing even and odd functions from their graphs and algebraic expressions for them. | Functions and Transformations<br>Angles and Trigonometric Functions<br>Graphing Sine and Cosine Functions<br>General Form of Sine and Cosine<br>Conic Sections<br>The General Equation of Conic Sections |
| F-BF.4. | Find inverse functions. | |
| F-BF.4(a) | Solve an equation of the form f(x) = c for a simple function f that has an inverse and write an expression for the inverse. For example, f(x) =2 x^3 for x > 0 or f(x) = (x+1)/(x-1) for x not equal to 1. | Inverse of a Function<br>Inverse Trigonometric Functions |
| F-BF.4(b) | (+) Verify by composition that one function is the inverse of another. | Inverse of a Function<br>Inverse Trigonometric Functions |
| F-BF.4(c) | (+) Read values of an inverse function from a graph or a table, given that the function has an inverse. | Inverse of a Function<br>Inverse Trigonometric Functions |
| F-BF.4(d) | (+) Produce an invertible function from a non-invertible function by restricting the domain. | Inverse of a Function<br>Inverse Trigonometric Functions |
| F-BF.5. | (+) Understand the inverse relationship between exponents and logarithms and use this relationship to solve problems involving logarithms and exponents. | Modeling with Exponential and Logarithmic Equations |
| F-TF. | Trigonometric Functions | |
| | Extend the domain of trigonometric functions using the unit circle. | |
| F-TF.1. | Understand radian measure of an angle as the length of the arc on the unit circle subtended by the angle. | Angles and Trigonometric Functions |

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| F-TF.2. | Explain how the unit circle in the coordinate plane enables the extension of trigonometric functions to all real numbers, interpreted as radian measures of angles traversed counterclockwise around the unit circle. | Angles and Trigonometric Functions<br>Graphing Sine and Cosine Functions<br>Trigonometric Difference Identities<br>Trigonometric Sum Identities<br>Trigonometric Double Angle Identities<br>Trigonometric Half Angle Identities |
| F-TF.3. | (+) Use special triangles to determine geometrically the values of sine, cosine, tangent for pi/3, pi/4 and pi/6, and use the unit circle to express the values of sine, cosines, and tangent for x, pi + x, and 2pi - x in terms of their values for x, where x is any real number. | Angles and Trigonometric Functions<br>Graphing Sine and Cosine Functions<br>General Form of Sine and Cosine<br>Inverse Trigonometric Functions<br>Trigonometric Difference Identities<br>Trigonometric Sum Identities<br>Trigonometric Double Angle Identities<br>Trigonometric Half Angle Identities<br>Solving Trigonometric Equations |
| F-TF.4. | (+) Use the unit circle to explain symmetry (odd and even) and periodicity of trigonometric functions. | Angles and Trigonometric Functions<br>Graphing Sine and Cosine Functions<br>Trigonometric Difference Identities<br>Trigonometric Sum Identities<br>Trigonometric Double Angle Identities<br>Trigonometric Half Angle Identities |
| | Model periodic phenomena with trigonometric functions. | |
| F-TF.5. | Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline. | Graphing Sine and Cosine Functions<br>General Form of Sine and Cosine<br>Inverse Trigonometric Functions |
| F-TF.6. | (+) Understand that restricting a trigonometric function to a domain on which it is always increasing or always decreasing allows its inverse to be constructed. | Inverse Trigonometric Functions<br>Solving Trigonometric Equations |
| F-TF.7. | (+) Use inverse functions to solve trigonometric equations that arise in modeling contexts; evaluate the solutions using technology, and interpret them in terms of the context. | Inverse Trigonometric Functions<br>Solving Trigonometric Equations |

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| | Prove and apply trigonometric identities. | |
| F-TF.8. | Prove the Pythagorean identity sin^2(θ) + cos^2(θ) = 1 and use it to find sin(θ), cos(θ), or tan(θ) given sin(θ), cos(θ), or tan(θ) and the quadrant of the angle. | |
| F-TF.9. | (+) Prove the addition and subtraction formulas for sine, cosine, and tangent and use them to solve problems. | Trigonometric Difference Identities<br>Trigonometric Sum Identities |
| G-SRT. | Similarity, Right Triangles, and Trigonometry | |
| | Define trigonometric ratios and solve problems involving right triangles | |
| G-SRT.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. | |
| G-SRT.7. | Explain and use the relationship between the sine and cosine of complementary angles. | Angles and Trigonometric Functions<br>Graphing Sine and Cosine Functions<br>General Form of Sine and Cosine<br>Inverse Trigonometric Functions<br>Trigonometric Difference Identities<br>Trigonometric Sum Identities<br>Trigonometric Double Angle Identities<br>Trigonometric Half Angle Identities<br>Solving Trigonometric Equations |
| G-SRT.8. | Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems. | |
| G-GPE. | Expressing Geometric Properties with Equations | |
| | Translate between the geometric description and the equation for a conic section | |
| G-GPE.1. | Derive the equation of a circle of given center and radius using the Pythagorean Theorem; complete the square to find the center and radius of a circle given by an equation. | Conic Sections<br>The General Equation of Conic Sections<br>Applications of Conics<br>Conic Inequalities<br>Systems of Inequalities<br>Graphing Parametric Equations |

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| G-GPE.2. | Derive the equation of a parabola given a focus and directrix. | Conic Sections<br>The General Equation of Conic Sections<br>Applications of Conics<br>Conic Inequalities<br>Systems of Inequalities |
| G-GPE.3. | (+) Derive the equations of ellipses and hyperbolas given the foci, using the fact that the sum or difference of distances from the foci is constant. | Conic Sections<br>Equations of Ellipses<br>Equations of Hyperbolas<br>Equations of Hyperbolas (contined)<br>The General Equation of Conic Sections<br>Applications of Conics<br>Conic Inequalities<br>Systems of Inequalities |
| A-CED. | Creating Equations | |
| | Create equations that describe numbers or relationships. | |
| A-CED.1. | Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions. | Rational Inequalities<br>Modeling with Exponential and Logarithmic Equations<br>Applications of Conics |
| A-CED.2. | Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. | Functions and Transformations<br>Composition of Functions and Modeling<br>Conic Sections<br>Applications of Conics<br>Conic Inequalities<br>Systems of Inequalities |
| A-CED.3. | Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. For example, represent inequalities describing nutritional and cost constraints on combinations of different foods. | Functions and Transformations<br>Composition of Functions and Modeling<br>Rational Inequalities<br>Modeling with Exponential and Logarithmic Equations<br>Applications of Conics |

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| A-CED.4. | Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R. | Graphing Parametric Equations |
| F-LE. | Linear and Exponential Models | |
| | Construct and compare linear and exponential models and solve problems. | |
| F-LE.1. | Distinguish between situations that can be modeled with linear functions and with exponential functions. | |
| F-LE.1(a) | Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals. | Modeling with Exponential and Logarithmic Equations |
| F-LE.1(b) | Recognize situations in which one quantity changes at a constant rate per unit interval relative to another. | |
| F-LE.1(c) | Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another. | |
| F-LE.2. | Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table). | |
| F-LE.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. | |
| F-LE.4. | For exponential models, express as a logarithm the solution to ab^ct = d where a, c, and d are numbers and the base b is 2, 10, or e; evaluate the logarithm using technology. | Modeling with Exponential and Logarithmic Equations |

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| | Interpret expressions for functions in terms of the situation they model. | |
| F-LE.5. | Interpret the parameters in a linear or exponential function in terms of a context. | Modeling with Exponential and Logarithmic Equations<br>General Form of Sine and Cosine<br>Equations of Ellipses<br>Equations of Hyperbolas<br>Equations of Hyperbolas (contined)<br>The General Equation of Conic Sections |
| G-C. | Circles | |
| | Find arc lengths and areas of sectors of circles | |
| G-C.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. | Angles and Trigonometric Functions |
| G-GMD. | Geometric Measurement and Dimension | |
| | Explain volume formulas and use them to solve problems | |
| G-GMD.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. | Angles and Trigonometric Functions |
| G-GMD.2. | (+) Given an informal argument using Cavalieri's principle for the formulas for the volume of a sphere and other solid figures. | |
| G-GMD.3. | Use volume formulas for cylinders, pyramids, cones and spheres to solve problems. | |