

Domain**Functions****F****Grade 8***Define, evaluate, and compare functions.*

- Standard 1 CC.8.F.1 Define, evaluate, and compare functions. Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output. (Function notation is not required in Grade 8.)

Grade 8*Define, evaluate, and compare functions.*

- Standard 2 CC.8.F.2 Define, evaluate, and compare functions. Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). For example, given a linear function represented by a table of values and a linear function represented by an algebraic expression, determine which function has the greater rate of change.

Grade 8*Define, evaluate, and compare functions.*

- Standard 3 CC.8.F.3 Define, evaluate, and compare functions. Interpret the equation $y = mx + b$ as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. For example, the function $A = s^2$ giving the area of a square as a function of its side length is not linear because its graph contains the points (1,1), (2,4) and (3,9), which are not on a straight line.

Grade 8*Use functions to model relationships between quantities.*

- Standard 4 CC.8.F.4 Use functions to model relationships between quantities. Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x, y) values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values.

Grade 8*Use functions to model relationships between quantities.*

- Standard 5 CC.8.F.5 Use functions to model relationships between quantities. Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally.

Grade 9-12*Building Functions*

- Standard BF.1 CC.9-12.F.BF.1 Build a function that models a relationship between two quantities. Write a function that describes a relationship between two quantities.*

Grade 9-12*Building Functions*

- Standard BF.1a CC.9-12.F.BF.1a Determine an explicit expression, a recursive process, or steps for calculation from a context.

Grade 9-12*Building Functions*

Standard
BF.1b CC.9-12.F.BF.1b Combine standard function types using arithmetic operations. For example, build a function that models the temperature of a cooling body by adding a constant function to a decaying exponential, and relate these functions to the model.

Grade 9-12*Building Functions*

Standard
BF.1c CC.9-12.F.BF.1c (+) 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.

Grade 9-12*Building Functions*

Standard
BF.2 CC.9-12.F.BF.2 Build a function that models a relationship between two quantities. Write arithmetic and geometric sequences both recursively and with an explicit formula, use them to model situations, and translate between the two forms.*

Grade 9-12*Building Functions*

Standard
BF.3 CC.9-12.F.BF.3 Build new functions from existing functions. 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.

Grade 9-12*Building Functions*

Standard
BF.4 CC.9-12.F.BF.4 Build new functions from existing functions. Find inverse functions.

Grade 9-12*Building Functions*

Standard
BF.4a CC.9-12.F.BF.4a 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, $f(x) = 2(x^3)$ or $f(x) = (x+1)/(x-1)$ for $x \neq 1$ (x not equal to 1).

Grade 9-12*Building Functions*

Standard
BF.4b CC.9-12.F.BF.4b (+) Verify by composition that one function is the inverse of another.

Grade 9-12*Building Functions*

Standard
BF.4c CC.9-12.F.BF.4c (+) Read values of an inverse function from a graph or a table, given that the function has an inverse.

Grade 9-12*Building Functions*

Standard
BF.4d CC.9-12.F.BF.4d (+) Produce an invertible function from a non-invertible function by restricting the domain.

Grade 9-12*Building Functions*

Standard
BF.5 CC.9-12.F.BF.5 (+) Build new functions from existing functions. Understand the inverse relationship between exponents and logarithms and use this relationship to solve problems involving logarithms and exponents.

Grade 9-12*Interpreting Functions*

Standard
IF.1 CC.9-12.F.IF.1 Understand the concept of a function and use function notation. 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 $y = f(x)$.

Grade 9-12*Interpreting Functions*

Standard
IF.2 CC.9-12.F.IF.2 Understand the concept of a function and use function notation. Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.

Grade 9-12*Interpreting Functions*

Standard
IF.3 CC.9-12.F.IF.3 Understand the concept of a function and use function notation. 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 $n \geq 1$ (n is greater than or equal to 1).

Grade 9-12*Interpreting Functions*

Standard
IF.4 CC.9-12.F.IF.4 Interpret functions that arise in applications in terms of the context. 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.*

Grade 9-12*Interpreting Functions*

Standard IF.5 CC.9-12.F.IF.5 Interpret functions that arise in applications in terms of the context. 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.*

Grade 9-12*Interpreting Functions*

Standard IF.6 CC.9-12.F.IF.6 Interpret functions that arise in applications in terms of the context. 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.*

Grade 9-12*Interpreting Functions*

Standard IF.7 CC.9-12.F.IF.7 Analyze functions using different representations. Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.*

Grade 9-12*Interpreting Functions*

Standard IF.7a CC.9-12.F.IF.7a Graph linear and quadratic functions and show intercepts, maxima, and minima.*

Grade 9-12*Interpreting Functions*

Standard IF.7b CC.9-12.F.IF.7b Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions.*

Grade 9-12*Interpreting Functions*

Standard IF.7c CC.9-12.F.IF.7c Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior.*

Grade 9-12*Interpreting Functions*

Standard IF.7d CC.9-12.F.IF.7d (+) Graph rational functions, identifying zeros and asymptotes when suitable factorizations are available, and showing end behavior.*

Grade 9-12*Interpreting Functions*

Standard IF.7e CC.9-12.F.IF.7e Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.*

Grade 9-12*Interpreting Functions*

Standard IF.8 CC.9-12.F.IF.8 Analyze functions using different representations. Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function.

Grade 9-12*Interpreting Functions*

Standard IF.8a CC.9-12.F.IF.8a 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.

Grade 9-12*Interpreting Functions*

Standard IF.8b CC.9-12.F.IF.8b 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 and decay.

Grade 9-12*Interpreting Functions*

Standard IF.9 CC.9-12.F.IF.9 Analyze functions using different representations. Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). For example, given a graph of one quadratic function and an algebraic expression for another, say which has the larger maximum.

Grade 9-12*Linear, Quadratic, & Exponential Models*

Standard LE.1 CC.9-12.F.LE.1 Construct and compare linear, quadratic, and exponential models and solve problems. Distinguish between situations that can be modeled with linear functions and with exponential functions.*

Grade 9-12*Linear, Quadratic, & Exponential Models*

Standard LE.1a CC.9-12.F.LE.1a Prove that linear functions grow by equal differences over equal intervals and that exponential functions grow by equal factors over equal intervals.*

Grade 9-12Linear, Quadratic, & Exponential Models

Standard
LE.1b CC.9-12.F.LE.1b. Recognize situations in which one quantity changes at a constant rate per unit interval relative to another.*

Grade 9-12Linear, Quadratic, & Exponential Models

Standard
LE.1c CC.9-12.F.LE.1c Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another.*

Grade 9-12Linear, Quadratic, & Exponential Models

Standard
LE.2 CC.9-12.F.LE.2 Construct and compare linear, quadratic, and exponential models and solve problems. 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).*

Grade 9-12Linear, Quadratic, & Exponential Models

Standard
LE.3 CC.9-12.F.LE.3 Construct and compare linear, quadratic, and exponential models and solve problems. Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or (more generally) as a polynomial function.*

Grade 9-12Linear, Quadratic, & Exponential Models

Standard
LE.4 CC.9-12.F.LE.4 Construct and compare linear, quadratic, and exponential models and solve problems. 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.*

Grade 9-12Linear, Quadratic, & Exponential Models

Standard
LE.5 CC.9-12.F.LE.5 Interpret expressions for functions in terms of the situation they model. Interpret the parameters in a linear or exponential function in terms of a context.*

Grade 9-12Trigonometric Functions

Standard
TF.1 CC.9-12.F.TF.1 Extend the domain of trigonometric functions using the unit circle. Understand radian measure of an angle as the length of the arc on the unit circle subtended by the angle.

Grade 9-12Trigonometric Functions

Standard
TF.2 CC.9-12.F.TF.2 Extend the domain of trigonometric functions using the unit circle. 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.

Grade 9-12Trigonometric Functions

Standard
TF.3 CC.9-12.F.TF.3 (+) Extend the domain of trigonometric functions using the unit circle. 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, cosine, and tangent for $\pi - x$, $\pi + x$, and $2\pi - x$ in terms of their values for x , where x is any real number.

Grade 9-12Trigonometric Functions

Standard
TF.4 CC.9-12.F.TF.4 (+) Extend the domain of trigonometric functions using the unit circle. Use the unit circle to explain symmetry (odd and even) and periodicity of trigonometric functions.

Grade 9-12Trigonometric Functions

Standard
TF.5 CC.9-12.F.TF.5 Model periodic phenomena with trigonometric functions. Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline.*

Grade 9-12Trigonometric Functions

Standard
TF.6 CC.9-12.F.TF.6 (+) Model periodic phenomena with trigonometric functions. Understand that restricting a trigonometric function to a domain on which it is always increasing or always decreasing allows its inverse to be constructed.

Grade 9-12Trigonometric Functions

Standard
TF.7 CC.9-12.F.TF.7 (+) Model periodic phenomena with trigonometric functions. 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.*

Grade 9-12Trigonometric Functions

Standard
TF.8 CC.9-12.F.TF.8 Prove and apply trigonometric identities. Prove the Pythagorean identity $(\sin A)^2 + (\cos A)^2 = 1$ and use it to find $\sin A$, $\cos A$, or $\tan A$, given $\sin A$, $\cos A$, or $\tan A$, and the quadrant of the angle.

Grade 9-12

Trigonometric Functions

Standard CC.9-12.F.TF.9 (+) Prove and apply trigonometric identities. Prove the addition and subtraction formulas for sine, cosine, and tangent and use them to solve problems.
TF.9