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What is the inverse of an cubic function

Number of rows and columns in the reconstructed image, specified as a positive integer. If output_size is not specified, the size is determined from the length of the projections according to: output_size = 2*floor(size(R,1)/(2*sqrt(2))) If you specify output_size, then iradon reconstructs a smaller or larger portion of the image but does not change the scaling of the data. If the projections were calculated with the radon function, then the reconstructed image might not be the same size as the original image. 1 Write your function, replacing f(x) with y if necessary. Your formula should have y on one side of the equals sign by itself with the x terms on the other side of the equals sign. If you have an equation that's already written in terms of y and x (for instance, 2 + y = 3x2), all you need to do is solve for y by isolating it on one side of the equals sign. Example: If we have a function f(x) = 5x - 2, we would rewrite it as y = 5x - 2 simply by replacing the "f(x)" with a y. Note: f(x) is the standard function notation, but if you're dealing with multiple functions, each one gets a different letter to make telling them apart easier. For example, g(x) and h(x) are each common identifiers for functions. 2 Solve for x. In other words, perform the necessary mathematical operations to isolate x by itself on one side of the equal sign. Basic algebraic principles will guide you here: if x has a numeric coefficient, divide both sides of the equation by this number; if a certain number is added to the x term(s) on one side of the equals sign, subtract this number from both sides, and so on. Remember, you can perform any operation on one side of the equation as long as you perform the operation on every term on both sides of the equal sign.[2] Example: To continue our example, first, we'd add 2 to both sides of the equation. This gives us y + 2 = 5x. We'd then divide both sides of the equation by 5, yielding (y + 2)/5 = x. Finally, to make it easier to read, we'll rewrite the equation with "x" on the left side: x = (y + 2)/5. Advertisement 3 Switch the variables. Replace x with y and vice versa. The resulting equation is the inverse of the original function. In other words, if we substitute a value for x into our original equation and get an answer, when we substitute that answer into the inverse equation (again for x), we'll get our original value back! Example: After switching x and y, we'd have y = (x + 2)/5 4 Replace y with "f-1(x)." Inverse functions are usually written as f-1(x) = (x terms) . Note that in this case, the -1 exponent doesn't mean we should perform an exponent operation on our function. It's just a way of indicating that this function is the inverse of our original. Since taking x to the -1st power gives the fraction 1/x, you can also think of f-1(x) as a way of writing "1/f(x)," which also signifies the inverse of f(x). 5 Check your work. Try substituting a constant into the original function for x. If you found the correct inverse, you should be able to plug the result into the inverse function and get your original x-value as the result. Example: Let's substitute 4 for x in our original equation. This gives us f(x) = 5(4) - 2, or f(x) = 18. Next, let's substitute our answer, 18, into our inverse function for x. If we do this, we get y = (18 + 2)/5, which simplifies to y = 20/5, which further simplifies to y = 4. 4 is our original x-value, so we know we've calculated the correct inverse function. Advertisement Add New Question Question Where do I use inverse functions? For one thing, any time you solve an equation. To solve x+4 = 7, you apply the inverse function of f(x) = x+4, that is g(x) = x-4, to both sides (x+4)-4 = 7-4 . To solve 2^x = 8, the inverse function of 2^x is log2(x), so you apply log base 2 to both sides and get log2(2^x)=log2(8) = 3. To solve x^2 = 16, you want to apply the inverse of f(x)=x^2 to both sides, but since f(x)=x^2 isn't invertible, you have to split it into two cases. If x is positive, g(x) = sqrt(x) is the inverse of f, but if x is negative, g(x) = -sqrt(x) is the inverse. So the solutions are x = +4 and -4. Question What inverse operations do I use to solve equations? The inverse of any number is that number divided into 1, as in 1/N. Ask a Question Advertisement Thanks! Thanks! Advertisement wikiHow is a “wiki,” similar to Wikipedia, which means that many of our articles are co-written by multiple authors. To create this article, 17 people, some anonymous, worked to edit and improve it over time. This article has been viewed 146,043 times. Co-authors: 17 Updated: November 7, 2019 Views: 146,043 Categories: Algebra Print Send fan mail to authors Thanks to all authors for creating a page that has been read 146,043 times. 1 Make sure your function is one-to-one. Only one-to-one functions have inverses. A function is one-to-one if it passes the vertical line test and the horizontal line test. Draw a vertical line through the entire graph of the function and count the number of times that the line hits the function. Then draw a horizontal line through the entire graph of the function and count the number of times this line hits the function. If each line only hits the function once, the function is one-to-one. If a graph does not pass the vertical line test, it is not a function. To algebraically determine whether the function is one-to-one, plug in f(a) and f(b) into your function and see whether a = b. As an example, let's take f(x) = 3x+5. f(a) = 3a + 5; f(b) = 3b + 5 3a + 5 = 3b + 5 3a = 3b a = b Thus, f(x) is one-to-one. 2 Given a function, switch the x's and the y's. Remember that f(x) is a substitute for "y." In a function, "f(x)" or "y" represents the output and "x" represents the input. To find the inverse of a function, you switch the inputs and the outputs. Example: Let's take f(x) = (4x+3)/(2x+5) -- which is one-to-one. Switching the x's and y's, we get x = (4y + 3)/(2y + 5). Advertisement 3 Solve for the new "y." You'll need to manipulate the expressions to solve for y, or to find the new operations that must be performed on the input to obtain the inverse as an output. This can be tricky depending on your expression. You may need to use algebraic tricks like cross-multiplication or factoring to evaluate the expression and simplify it. In our example, we'll take the following steps to isolate y: We're starting with x = (4y + 3)/(2y + 5) x(2y + 5) = 4y + 3 -- Multiply both sides by (2y + 5) 2xy + 5x = 4y + 3 -- Distribute the x's 2xy - 4y = 3 - 5x -- Get all the y terms on one side y(2x - 4) = 3 - 5x -- Reverse distribute to consolidate the y terms y = (3 - 5x)/(2x - 4) -- Divide to get your answer 4 Replace the new "y" with f^-1(x). This is the equation for the inverse of your original function. Our final answer is f^-1(x) = (3 - 5x)/(2x - 4). This is the inverse of f(x) = (4x+3)/(2x+5). Advertisement Add New Question Question Where did the +5 in the determining whether the function is one-to-one go? The 5's cancel each other out during the process. Here is the extended working out. 3a + 5 = 3b + 5, 3a +5 -5 = 3b, 3a = 3b. Ask a Question Advertisement wikiHow is a “wiki,” similar to Wikipedia, which means that many of our articles are co-written by multiple authors. To create this article, volunteer authors worked to edit and improve it over time. This article has been viewed 93,552 times. Co-authors: 4 Updated: March 29, 2019 Views: 93,552 Categories: Algebra Print Send fan mail to authors Thanks to all authors for creating a page that has been read 93,552 times. Mathematical concept Not to be confused with Multiplicative inverse or additive inverse. A function f and its inverse f −1. Because f maps a to 3, the inverse f −1 maps 3 back to a. Functionx ↦ f (x) Examples of domains and codomains X {\displaystyle X} → B {\displaystyle \mathbb {B} } , B {\displaystyle \mathbb {B} } → X {\displaystyle X} , B n {\displaystyle \mathbb {B} ^{n}} → X {\displaystyle X} X {\displaystyle X} → Z {\displaystyle \mathbb {Z} } , Z {\displaystyle \mathbb {Z} } → X {\displaystyle X} X {\displaystyle X} → R {\displaystyle \mathbb {R} } , R {\displaystyle \mathbb {R} } → X {\displaystyle X} , R n {\displaystyle \mathbb {R} ^{n}} → X {\displaystyle X} X {\displaystyle X} → C {\displaystyle \mathbb {C} } , C {\displaystyle \mathbb {C} } → X {\displaystyle X} , C n {\displaystyle \mathbb {C} ^{n}} → X {\displaystyle X} Classes/properties Constant Identity Linear Polynomial Rational Algebraic Analytic Smooth Continuous Measurable Injective Surjective Bijective Constructions Restriction Composition λ Inverse Generalizations Partial Multivalued Implicit vte In mathematics, the inverse function of a function f (also called the inverse of f) is a function that undoes the operation of f. The inverse of f exists if and only if f is bijective, and if it exists, is denoted by f − 1 . {\displaystyle f^{-1}.} For a function f : X → Y {\displaystyle f\colon X\to Y} , its inverse f − 1 : Y → X {\displaystyle f^{-1}\colon Y\to X} admits an explicit description: it sends each element y ∈ Y {\displaystyle y\in Y} to the unique element x ∈ X {\displaystyle x\in X} such that f(x) = y. As an example, consider the real-valued function of a real variable given by f(x) = 5x − 7. One can think of f as the function which multiplies its input by 5 then subtracts 7 from the result. To undo this, one adds 7 to the input, then divides the result by 5. Therefore, the inverse of f is the function f − 1 : R → R {\displaystyle f^{-1}\colon \mathbb {R} \to \mathbb {R} } defined by f − 1 (y) = (y + 7) / 5. {\displaystyle f^{-1}(y)=(y+7)/5.} Definitions If f maps X to Y, then f −1 maps Y back to X. Let f be a function whose domain is the set X, and whose codomain is the set Y. Then f is invertible if there exists a function g from Y to X such that g (f (x)) = x {\displaystyle g(f(x))=x} for all x ∈ X {\displaystyle x\in X} and f (g (y)) = y {\displaystyle f(g(y))=y} for all y ∈ Y {\displaystyle y\in Y} .[1] If f is invertible, then there is exactly one function g satisfying this property. The function g is called the inverse of f, and is usually denoted as f −1, a notation introduced by John Frederick William Herschel in 1813.[2][3][4][5][6][nb 1] The function f is invertible if and only if it is bijective. This is because the condition g (f (x)) = x {\displaystyle g(f(x))=x} for all x ∈ X {\displaystyle x\in X} implies that f is injective, and the condition f (g (y)) = y {\displaystyle f(g(y))=y} for all y ∈ Y {\displaystyle y\in Y} implies that f is surjective. The inverse function f −1 to f can be explicitly described as the function f − 1 (y) = (the unique element x ∈ X such that f (x) = y) {\displaystyle f^{-1}(y)=({\text{the unique element }}x\in X{\text{ such that }}f(x)=y)} . Inverses and composition See also: Inverse element Recall that if f is an invertible function with domain X and codomain Y, then f − 1 (f (x)) = x {\displaystyle f^{-1}\left(f(x)\right)=x} , for every x ∈ X {\displaystyle x\in X} and f (f − 1 (y)) = y {\displaystyle f\left(f^{-1}(y)\right)=y} for every y ∈ Y {\displaystyle y\in Y} . Using the composition of functions, this statement can be rewritten to the following equations between functions: f − 1 ∘ f = id X {\displaystyle f^{-1}\circ f=\operatorname {id} _{X}} and f ∘ f − 1 = id Y , {\displaystyle f\circ f^{-1}=\operatorname {id} _{Y},} where idX is the identity function on the set X; that is, the function that leaves its argument unchanged. In category theory, this statement is used as the definition of an inverse morphism. Considering function composition helps to understand the notation f −1. Repeatedly composing a function f: X→X with itself is called iteration. If f is applied n times, starting with the value x, then this is written as f n(x); so f 2(x) = f (f (x)), etc. Since f −1(f (x)) = x, composing f −1 and f n yields f n−1, "undoing" the effect of one application of f. Notation While the notation f −1(x) might be misunderstood,[1] (f(x))−1 certainly denotes the multiplicative inverse of f(x) and has nothing to do with the inverse function of f.[6] In keeping with the general notation, some English authors use expressions like sin−1(x) to denote the inverse of the sine function applied to x (actually a partial inverse; see below).[7][6] Other authors feel that this may be confused with the notation for the multiplicative inverse of sin (x), which can be denoted as (sin (x))−1.[6] To avoid any confusion, an inverse trigonometric function is often indicated by the prefix "arc" (for Latin arcus).[8][9] For instance, the inverse of the sine function is typically called the arcsine function, written as arcsin(x).[8][9] Similarly, the inverse of a hyperbolic function is indicated by the prefix "ar" (for Latin ārea).[9] For instance, the inverse of the hyperbolic sine function is typically written as arsinh(x). [9] Note that the expressions like sin−1(x) can still be useful to distinguish the multivalued inverse from the partial inverse: sin − 1 (x) = { (− 1) k arcsin (x) + π n : n ∈ Z } {\displaystyle \sin ^{-1}(x)=\{(-1)^{k}\arcsin(x)+\pi n:n\in \mathbb {Z} \}} . Other inverse special functions are sometimes prefixed with the prefix "inv", if the ambiguity of the f −1 notation should be avoided.[10][9] Examples Squaring and square root functions The function f: R → [0,∞) given by f(x) = x2 is not injective because (− x) 2 = x 2 {\displaystyle (-x)^{2}=x^{2}} for all x ∈ R {\displaystyle x\in \mathbb {R} } . Therefore, f is not invertible. If the domain of the function is restricted to the nonnegative reals, that is, we take the function f : [0 , ∞) → [0 , ∞) ; x ↦ x 2 {\displaystyle f\colon [0,\infty)\to [0,\infty);\ x\mapsto x^{2}} with the same rule as before, then the function is bijective and so, invertible.[11] The inverse function here is called the (positive) square root function and is denoted by x ↦ x {\displaystyle x\mapsto {\sqrt {x}}} . Standard inverse functions The following table shows several standard functions and their inverses: Function f(x) Inverse f −1(y) Notes x + a y − a a − x a − y mx y/m m ≠ 0 1/x (i.e. x−1) 1/y (i.e. y−1) x, y ≠ 0 x2 y {\displaystyle {\sqrt {y}}} (i.e. y1/2) x, y ≥ 0 only x3 y 3 {\displaystyle {\sqrt[{3}]{y}}} (i.e. y1/3) no restriction on x and y xp y p {\displaystyle {\sqrt[{p}]{y}}} (i.e. y1/p) x, y ≥ 0 if p is even; integer p > 0 2x lb y y > 0 ex ln y y > 0 10x log y y > 0 ax loga y y > 0 and a > 0 xex W(y) x ≥ −1 and y ≥ −1/e trigonometric functions inverse trigonometric functions various restrictions (see table below) hyperbolic functions inverse hyperbolic functions various restrictions Formula for the inverse Many functions given by algebraic formulas possess a formula for their inverse. This is because the inverse f − 1 {\displaystyle f^{-1}} of an invertible function f : R → R {\displaystyle f\colon \mathbb {R} \to \mathbb {R} } has an explicit description as f − 1 (y) = (the unique element x ∈ R such that f (x) = y) {\displaystyle f^{-1}(y)=({\text{the unique element }}x\in \mathbb {R} {\text{ such that }}f(x)=y)} . This allows one to easily determine inverses of many functions that are given by algebraic formulas. For example, if f is the function f (x) = (2 x + 8) 3 {\displaystyle f(x)=(2x+8)^{3}} then to determine f − 1 (y) {\displaystyle f^{-1}(y)} for a real number y, one must find the unique real number x such that (2x + 8)3 = y. This equation can be solved: y = (2 x + 8) 3 y 3 = 2 x + 8 y 3 − 8 = 2 x y 3 − 8 2 = x . {\displaystyle {\begin{aligned}y&=(2x+8)^{3}\\{\sqrt[{3}]{y}}&=2x+8\\{\sqrt[{3}]{y}}-8&=2x\\{\dfrac {{\sqrt[{3}]{y}}-8}{2}}&=x.\end{aligned}}} Thus the inverse function f −1 is given by the formula f − 1 (y) = y 3 − 8 2 . {\displaystyle f^{-1}(y)={\frac {{\sqrt[{3}]{y}}-8}{2}}.} Sometimes, the inverse of a function cannot be expressed by a closed-form formula. For example, if f is the function f (x) = x − sin x , {\displaystyle f(x)=x-\sin x,} then f is a bijection, and therefore possesses an inverse function f −1. The formula for this inverse has an expression as an infinite sum: f − 1 (y) = ∑ n = 1 ∞ y n / 3 n ! lim θ → 0 (d n − 1 d θ n − 1 (θ θ − sin (θ) 3) n) . {\displaystyle f^{-1}(y)=\sum _{n=1}^{\infty }{\frac {y^{n/3}}{n!}}\lim _{\theta \to 0}\left({\frac {\mathrm {d} ^{\,n-1}}{\mathrm {d} \theta ^{\,n-1}}}\left({\frac {\theta }{\sqrt[{3}]{\theta -\sin(\theta)}}}\right)^{n}\right).} Properties Since a function is a special type of binary relation, many of the properties of an inverse function correspond to properties of converse relations. Uniqueness If an inverse function exists for a given function f, then it is unique.[12] This follows since the inverse function must be the converse relation, which is completely determined by f. Symmetry There is a symmetry between a function and its inverse. Specifically, if f is an invertible function with domain X and codomain Y, then its inverse f −1 has domain Y and image X, and the inverse of f −1 is the original function f. In symbols, for functions f:X → Y and f−1:Y → X,[12] f − 1 ∘ f = id X {\displaystyle f^{-1}\circ f=\operatorname {id} _{X}} and f ∘ f − 1 = id Y . {\displaystyle f\circ f^{-1}=\operatorname {id} _{Y}.} This statement is a consequence of the implication that for f to be invertible it must be bijective. The involutory nature of the inverse can be concisely expressed by[13] (f − 1) − 1 = f . {\displaystyle \left(f^{-1}\right)^{-1}=f.} The inverse of g ∘ f is f −1 ∘ g −1. The inverse of a composition of functions is given by[14] (g ∘ f) − 1 = f − 1 ∘ g − 1 . {\displaystyle (g\circ f)^{-1}=f^{-1}\circ g^{-1}.} Notice that the order of g and f have been reversed; to undo f followed by g, we must first undo g, and then undo f. For example, let f(x) = 3x and let g(x) = x + 5. Then the composition g ∘ f is the function that first multiplies by three and then adds five, (g ∘ f) (x) = 3 x + 5. {\displaystyle (g\circ f)(x)=3x+5.} To reverse this process, we must first subtract five, and then divide by three, (g ∘ f) − 1 (x) = 1 3 (x − 5) . {\displaystyle (g\circ f)^{-1}(x)={\tfrac {1}{3}}(x-5).} This is the composition (f −1 ∘ g −1)(x). Self-inverses If X is a set, then the identity function on X is its own inverse: id X − 1 = id X . {\displaystyle {\operatorname {id} _{X}}^{-1}=\operatorname {id} _{X}.} More generally, a function f : X → X is equal to its own inverse, if and only if the composition f ∘ f is equal to idX. Such a function is called an involution. Graph of the inverse The graphs of y = f(x) and y = f −1(x). The dotted line is y = x. If f is invertible, then the graph of the function y = f − 1 (x) {\displaystyle y=f^{-1}(x)} is the same as the graph of the equation x = f (y) . {\displaystyle x=f(y).} This is identical to the equation y = f(x) that defines the graph of f, except that the roles of x and y have been reversed. Thus the graph of f −1 can be obtained from the graph of f by switching the positions of the x and y axes. This is equivalent to reflecting the graph across the line y = x.[15][1] Inverses and derivatives The inverse function theorem states that a continuous function f is invertible on its range (image) if and only if it is either strictly increasing or decreasing (with no local maxima or minima). For example, the function f (x) = x 3 + x {\displaystyle f(x)=x^{3}+x} is invertible, since the derivative f′(x) = 3x2 + 1 is always positive. If the function f is differentiable on an interval I and f′(x) ≠ 0 for each x ∈ I, then the inverse f −1 is differentiable on f(I).[16] If y = f(x), the derivative of the inverse is given by the inverse function theorem, (f − 1) ′ (y) = 1 f ′ (x) . {\displaystyle \left(f^{-1}\right)^{\prime }(y)={\frac {1}{f'\left(x\right)}}.} Using Leibniz's notation the formula above can be written as d x d y = 1 d y / d x . {\displaystyle {\frac {dx}{dy}}={\frac {1}{dy/dx}}.} This result follows from the chain rule (see the article on inverse functions and differentiation). The inverse function theorem can be generalized to functions of several variables. Specifically, a differentiable multivariable function f : Rn → Rn is invertible in a neighborhood of a point p as long as the Jacobian matrix of f at p is invertible. In this case, the Jacobian of f −1 at f(p) is the matrix inverse of the Jacobian of f at p. Real-world examples Let f be the function that converts a temperature in degrees Celsius to a temperature in degrees Fahrenheit, F = f (C) = 9 5 C + 32 ; {\displaystyle F=f(C)={\tfrac {9}{5}}C+32;} then its inverse function converts degrees Fahrenheit to degrees Celsius, C = f − 1 (F) = 5 9 (F − 32) , {\displaystyle C=f^{-1}(F)={\tfrac {5}{9}}(F-32),} [17] since f − 1 (f (C)) = f − 1 (9 5 C + 32) = 5 9 ((9 5 C + 32) − 32) = C , for every value of C , and f (f − 1 (F)) = f (5 9 (F − 32)) = 9 5 (5 9 (F − 32)) + 32 = F , for every value of F . {\displaystyle {\begin{aligned}f^{-1}(f(C))={}&f^{-1}\left({\tfrac {9}{5}}C+32\right)={\tfrac {5}{9}}\left(({\tfrac {9}{5}}C+32)-32\right)=C,\\&{\text{for every value of }}C,{\text{ and }}\\[6pt]f\left(f^{-1}(F)\right)={}&f\left({\tfrac {5}{9}}(F-32)\right)={\tfrac {9}{5}}\left({\tfrac {5}{9}}(F-32)\right)+32=F,\\&{\text{for every value of }}F.\end{aligned}}} Suppose f assigns each child in a family its birth year. An inverse function would output which child was born in a given year. However, if the family has children born in the same year (for instance, twins or triplets, etc.) then the output cannot be known when the input is the common birth year. As well, if a year is given in which no child was born then a child cannot be named. But if each child was born in a separate year, and if we restrict attention to the three years in which a child was born, then we do have an inverse function. For example, f (Allan) = 2005 , f (Brad) = 2007 , f (Cary) = 2001 f − 1 (2005) = Allan , f − 1 (2007) = Brad , f − 1 (2001) = Cary {\displaystyle {\begin{aligned}f({\text{Allan}})&=2005,\quad &f({\text{Brad}})&=2007,\quad &f({\text{Cary}})&=2001\\f^{-1}(2005)&={\text{Allan}},\quad &f^{-1}(2007)&={\text{Brad}},\quad &f^{-1}(2001)&={\text{Cary}}\end{aligned}}} Let R be the function that leads to an x percentage rise of some quantity, and F be the function producing an x percentage fall. Applied to $100 with x = 10%, we find that applying the first function followed by the second does not restore the original value of $100, demonstrating the fact that, despite appearances, these two functions are not inverses of each other. The formula to calculate the pH of a solution is pH = −log10[H+]. In many cases we need to find the concentration of acid from a pH measurement. The inverse function [H+] = 10−pH is used. Generalizations Partial inverses The square root of x is a partial inverse to f(x) = x2. Even if a function f is not one-to-one, it may be possible to define a partial inverse of f by restricting the domain. For example, the function f (x) = x 2 {\displaystyle f(x)=x^{2}} is not one-to-one, since x2 = (−x)2. However, the function becomes one-to-one if we restrict to the domain x ≥ 0, in which case f − 1 (y) = y . {\displaystyle f^{-1}(y)={\sqrt {y}}.} (If we instead restrict to the domain x ≤ 0, then the inverse is the negative of the square root of y.) Alternatively, there is no need to restrict the domain if we are content with the inverse being a multivalued function: f − 1 (y) = ± y . {\displaystyle f^{-1}(y)=\pm {\sqrt {y}}.} The inverse of this cubic function has three branches. Sometimes, this multivalued inverse is called the full inverse of f, and the portions (such as √x and −√x) are called branches. The most important branch of a multivalued function (e.g. the positive square root) is called the principal branch, and its value at y is called the principal value of f −1(y). For a continuous function on the real line, one branch is required between each pair of local extrema. For example, the inverse of a cubic function with a local maximum and a local minimum has three branches (see the adjacent picture). The arcsine is a partial inverse of the sine function. These considerations are particularly important for defining the inverses of trigonometric functions. For example, the sine function is not one-to-one, since sin (x + 2 π) = sin (x) {\displaystyle \sin(x+2\pi)=\sin(x)} for every real x (and more generally sin(x + 2πn) = sin(x) for every integer n). However, the sine is one-to-one on the interval [−π/2, π/2], and the corresponding partial inverse is called the arcsine. This is considered the principal branch of the inverse sine, so the principal value of the inverse sine is always between −π/2 and π/2. The following table describes the principal branch of each inverse trigonometric function:[18] function Range of usual principal value arcsin −π/2 ≤ sin−1(x) ≤ π/2 arccos 0 ≤ cos−1(x) ≤ π arctan −π/2 < tan−1(x) < π/2 arccot 0 < cot−1(x) < π arcsec 0 ≤ sec−1(x) ≤ π arccsc −π/2 ≤ csc−1(x) ≤ π/2 Left and right inverses Left and right inverses are not necessarily the same. If g is a left inverse for f, then g may or may not be a right inverse for f; and if g is a right inverse for f, then g is not necessarily a left inverse for f. For example, let f: R → [0, ∞) denote the squaring map, such that f(x) = x2 for all x in R, and let g: [0, ∞) → R denote the square root map, such that g(x) = √x for all x ≥ 0. Then f(g(x)) = x for all x in [0, ∞); that is, g is a right inverse to f. However, g is not a left inverse to f, since, e.g., g(f(−1)) = 1 ≠ −1. Left inverses If f: X → Y, a left inverse for f (or retraction of f) is a function g: Y → X such that composing f with g from the left gives the identity function[citation needed]: g ∘ f = id X . {\displaystyle g\circ f=\operatorname {id} _{X}.} That is, the function g satisfies the rule If f (x) = y {\displaystyle f(x)=y} , then g (y) = x . {\displaystyle g(y)=x.} Thus, g must equal the inverse of f on the image of f, but may take any values for elements of Y not in the image. A function f is injective if and only if it has a left inverse or is the empty function.[citation needed] If g is the left inverse of f, then f is injective. If f(x) = f(y), then g (f (x)) = g (f (y)) = x = y {\displaystyle g(f(x))=g(f(y))=x=y} . If f: X → Y is injective, f either is the empty function (X = ∅) or has a left inverse g: Y → X (X ≠ ∅), which can be constructed as follows: for all y ∈ Y, if y is in the image of f (there exists x ∈ X such that f(x) = y), let g(y) = x (x is unique because f is injective); otherwise, let g(y) be an arbitrary element of X. For all x ∈ X, f(x) is in the image of f, so g(f(x)) = x by above, so g is a left inverse of f. In classical mathematics, every injective function f with a nonempty domain necessarily has a left inverse; however, this may fail in constructive mathematics. For instance, a left inverse of the inclusion {0,1} → R of the two-element set in the reals violates indecomposability by giving a retraction of the real line to the set {0,1}.[citation needed] Right inverses Example of right inverse with non-injective, surjective function A right inverse for f (or section of f) is a function h: Y → X such that[citation needed] f ∘ h = id Y . {\displaystyle f\circ h=\operatorname {id} _{Y}.} That is, the function h satisfies the rule If h (y) = x {\displaystyle \displaystyle h(y)=x} , then f (x) = y . {\displaystyle \displaystyle f(x)=y.} Thus, h(y) may be any of the elements of X that map to y under f. A function f has a right inverse if and only if it is surjective (though constructing such an inverse in general requires the axiom of choice). If h is the right inverse of f, then f is surjective. For all y ∈ Y {\displaystyle y\in Y} , there is x = h (y) {\displaystyle x=h(y)} such that f (x) = f (h (y)) = y {\displaystyle f(x)=f(h(y))=y} . If f is surjective, f has a right inverse h, which can be constructed as follows: for all y ∈ Y {\displaystyle y\in Y} , there is at least one x ∈ X {\displaystyle x\in X} such that f (x) = y {\displaystyle f(x)=y} (because f is surjective), so we choose one to be the value of h(y).[citation needed] Two-sided inverses An inverse that is both a left and right inverse (a two-sided inverse), if it exists, must be unique. In fact, if a function has a left inverse and a right inverse, they are both the same two-sided inverse, so it can be called the inverse. If g {\displaystyle g} is a left inverse and h {\displaystyle h} a right inverse of f {\displaystyle f} , for all y ∈ Y {\displaystyle y\in Y} , g (y) = g (f (h (y)) = h (y) {\displaystyle g(y)=g(f(h(y))=h(y)} . A function has a two-sided inverse if and only if it is bijective. A bijective function f is injective, so it has a left inverse (if f is the empty function, f : ∅ → ∅ {\displaystyle f\colon \varnothing \to \varnothing } is its own left inverse). f is surjective, so it has a right inverse. By the above, the left and right inverse are the same. If f has a two-sided inverse g, then g is a left inverse and right inverse of f, so f is injective and surjective. Preimages If f: X → Y is any function (not necessarily invertible), the preimage (or inverse image) of an element y ∈ Y is defined to be the set of all elements of X that map to y: f − 1 ({ y }) = { x ∈ X : f (x) = y } . {\displaystyle f^{-1}(\{y\})=\left\{x\in X:f(x)=y\right\}.} The preimage of y can be thought of as the image of y under the (multivalued) full inverse of the function f. Similarly, if S is any subset of Y, the preimage of S, denoted f − 1 (S) {\displaystyle f^{-1}(S)} , is the set of all elements of X that map to S: f − 1 (S) = { x ∈ X : f (x) ∈ S } . {\displaystyle f^{-1}(S)=\left\{x\in X:f(x)\in S\right\}.} For example, take the function f: R → R; x ↦ x2. This function is not invertible as it is not bijective, but preimages may be defined for subsets of the codomain, e.g. f − 1 ({ 1 , 4 , 9 , 16 }) = { − 4 , − 3 , − 2 , − 1 , 1 , 2 , 3 , 4 } {\displaystyle f^{-1}(\left\{1,4,9,16\right\})=\left\{-4,-3,-2,-1,1,2,3,4\right\}} . The preimage of a single element y ∈ Y – a singleton set {y} – is sometimes called the fiber of y. When Y is the set of real numbers, it is common to refer to f −1({y}) as a level set. See also Lagrange inversion theorem, gives the Taylor series expansion of the inverse function of an analytic function Integral of inverse functions Inverse Fourier transform Reversible computing Notes ^ Not to be confused with numerical exponentiation such as taking the multiplicative inverse of a nonzero real number. References ^ a b c Weisstein, Eric W. "Inverse Function". mathworld.wolfram.com. Retrieved 2020-09-08. ^ Herschel, John Frederick William (1813) [1812-11-12]. "On a Remarkable Application of Cotes's Theorem". Philosophical Transactions of the Royal Society of London. London: Royal Society of London, printed by W. Bulmer and Co., Cleveland-Row, St. James's, sold by G. and W. Nicol, Pall-Mall. 103 (Part 1): 8–26 [10]. doi:10.1098/rstl.1813.0005. JSTOR 107384. S2CID 118124706. ^ Herschel, John Frederick William (1820). "Part III. Section I. Examples of the Direct Method of Differences". A Collection of Examples of the Applications of the Calculus of Finite Differences. Cambridge, UK: Printed by J. Smith, sold by J. Deighton & sons. pp. 1–13 [5–6]. Archived from the original on 2020-08-04. Retrieved 2020-08-04. [1] (NB. Inhere, Herschel refers to his 1813 work and mentions Hans Heinrich Bürmann's older work.) ^ Peirce, Benjamin (1852). Curves, Functions and Forces. Vol. I (new ed.). Boston, USA. p. 203. ^ Peano, Giuseppe (1903). Formulaire mathématique (in French). Vol. IV. p. 229. ^ a b c d Cajori, Florian (1952) [March 1929]. "§472. The power of a logarithm / §473. Iterated logarithms / §533. John Herschel's notation for inverse functions / §535. Persistence of rival notations for inverse functions / §537. Powers of trigonometric functions". A History of Mathematical Notations. Vol. 2 (3rd corrected printing of 1929 issue, 2nd ed.). Chicago, USA: Open court publishing company. pp. 108, 176–179, 336, 346. ISBN 978-1-60206-714-1. Retrieved 2016-01-18. [...] §473. Iterated logarithms [...] We note here the symbolism used by Pringsheim and Molk in their joint Encyclopédie article: "2logb a = logb (logb a), ..., k+1logb a = logb (klogb a)." [...] §533. John Herschel's notation for inverse functions, sin−1 x, tan−1 x, etc., was published by him in the Philosophical Transactions of London, for the year 1813. He says (p. 10): "This notation cos.−1 e must not be understood to signify 1/cos. e, but what is usually written thus, arc (cos.=e)." He admits that some authors use cos.m A for (cos. A)m, but he justifies his own notation by pointing out that since d2 x, Δ3 x, Σ2 x mean dd x, ΔΔΔ x, ΣΣ x, we ought to write sin.2 x for sin. sin. x, log.3 x for log. log. log. x. Just as we write d−n V=∫n V, we may write similarly sin.−1 x=arc (sin.=x), log.−1 x.=cx. Some years later Herschel explained that in 1813 he used fn(x), f−n(x), sin.−1 x, etc., "as he then supposed for the first time. The work of a German Analyst, Burmann, has, however, within these few months come to his knowledge, in which the same is explained at a considerably earlier date. He[Burmann], however, does not seem to have noticed the convenience of applying this idea to the inverse functions tan−1, etc., nor does he appear at all aware of the inverse calculus of functions to which it gives rise." Herschel adds, "The symmetry of this notation and above all the new and most extensive views it opens of the nature of analytical operations seem to authorize its universal adoption."[a] [...] §535. Persistence of rival notations for inverse function.— [...] The use of Herschel's notation underwent a slight change in Benjamin Peirce's books, to remove the chief objection to them; Peirce wrote: "cos[−1] x," "log[−1] x."[b] [...] §537. Powers of trigonometric functions.—Three principal notations have been used to denote, say, the square of sin x, namely, (sin x)2, sin x2, sin2 x. The prevailing notation at present is sin2 x, though the first is least likely to be misinterpreted. In the case of sin2 x two interpretations suggest themselves; first, sin x · sin x; second, [c] sin (sin x). As functions of the last type do not ordinarily present themselves, the danger of misinterpretation is very much less than in case of log2 x, where log x · log x and log (log x) are of frequent occurrence in analysis. [...] The notation sinn x for (sin x)n has been widely used and is now the prevailing one. [...] (xviii+367+1 pages including 1 addenda page) (NB. ISBN and link for reprint of 2nd edition by Cosimo, Inc., New York, USA, 2013.) ^ Thomas 1972, pp. 304–309 ^ a b Korn, Grandino Arthur; Korn, Theresa M. (2000) [1961]. "21.2.-4. Inverse Trigonometric Functions". Mathematical handbook for scientists and engineers: Definitions, theorems, and formulars for reference and review (3 ed.). Mineola, New York, USA: Dover Publications, Inc. p. 811. ISBN 978-0-486-41147-7. ^ a b c d e Oldham, Keith B.; Myland, Jan C.; Spanier, Jerome (2009) [1987]. An Atlas of Functions: with Equator, the Atlas Function Calculator (2 ed.). Springer Science+Business Media, LLC. doi:10.1007/978-0-387-48807-3. ISBN 978-0-387-48806-6. LCCN 2008937525. ^ Hall, Arthur Graham; Frink, Fred Goodrich (1909). "Article 14: Inverse trigonometric functions". Written at Ann Arbor, Michigan, USA. Plane Trigonometry. New York: Henry Holt & Company. pp. 15–16. Retrieved 2017-08-12. α = arcsin m This notation is universally used in Europe and is fast gaining ground in this country. A less desirable symbol, α = sin-1m, is still found in English and American texts. The notation α = inv sin m is perhaps better still on account of its general applicability. [...] A similar symbolic relation holds for the other trigonometric functions. It is frequently read 'arc-sine m' or 'anti-sine m', since two mutually inverse functions are said each to be the anti-function of the other. ^ Lay 2006, p. 69, Example 7.24 ^ a b Wolf 1998, p. 208, Theorem 7.2 ^ Smith, Eggen & St. Andre 2006, pg. 141 Theorem 3.3(a) ^ Lay 2006, p. 71, Theorem 7.26 ^ Briggs & Cochran 2011, pp. 28–29 ^ Lay 2006, p. 246, Theorem 26.10 ^ "Inverse Functions". www.mathsisfun.com. Retrieved 2020-09-08. ^ Briggs & Cochran 2011, pp. 39–42 Bibliography Briggs, William; Cochran, Lyle (2011). Calculus / Early Transcendentals Single Variable. Addison-Wesley. ISBN 978-0-321-66414-3. Devlin, Keith J. (2004). Sets, Functions, and Logic / An Introduction to Abstract Mathematics (3 ed.). Chapman & Hall / CRC Mathematics. ISBN 978-1-58488-449-1. Fletcher, Peter; Patty, C. Wayne (1988). Foundations of Higher Mathematics. PWS-Kent. ISBN 0-87150-164-3. Lay, Steven R. (2006). Analysis / With an Introduction to Proof (4 ed.). Pearson / Prentice Hall. ISBN 978-0-13-148101-5. 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