Derivative of exp

Continue

$$\frac{d}{dx}\sinh x = \cosh x$$

$$\frac{d}{dx}\cosh x = \sinh x$$

$$\frac{d}{dx}\tanh x = \operatorname{sech}^2 x$$

$$\frac{d}{dx}\coth x = -\operatorname{csch}^2 x$$

$$\frac{d}{dx}\operatorname{sech} x = -\operatorname{sech} x \tanh x$$

$$\frac{d}{dx}\operatorname{csch} x = -\operatorname{csch} x \coth x$$

Unit 5: Differentiation

5.1 Diff. of Exp. & Log. Function

Example:

Find the derivative of $f(x) = \ln(x^2 + 2x - 5)$

Solution:

$$f'(x) = \frac{\frac{d}{dx}(x^2 + 2x - 5)}{(x^2 + 2x - 5)} = \frac{2x + 2}{x^2 + 2x - 5}$$

Integrals Containing e^x:

$$\int e^{cx}dx = \frac{1}{c}e^{cx}$$

$$\int a^{cx}dx = \frac{1}{c\cdot\ln a}a^{cx} \quad \text{for } a>0,\ \ a\neq 1$$

$$\int xe^{cx}\,dx = \frac{e^{cx}}{c^2}(cx-1)$$

$$\int x^2e^{cx}\,dx = e^{cx}\left(\frac{x^2}{c} - \frac{2x}{c^2} + \frac{2}{c^3}\right)$$

$$\int x^ne^{cx}\,dx = \frac{1}{c}x^ne^{cx} - \frac{n}{c}\int x^{n-1}e^{cx}dx$$

$$\int \frac{e^{cx}}{x^n}\,dx = \frac{1}{n-1}\left(-\frac{e^{cx}}{x^{n-1}} + c\int\frac{e^{cx}}{x^{n-1}}\,dx\right) \quad (\text{for } n\neq 1)$$

$$\int e^{cx}\sin(bx)\,dx = \frac{e^{cx}}{c^2+b^2}(c\sin bx - b\cos bx)$$

$$\int e^{cx}\cos(bx)\,dx = \frac{e^{cx}}{c^2+b^2}(c\cos bx + b\sin bx)$$

$$\int xe^{cx^2}dx = \frac{1}{2c}e^{cx^2}$$

$$\int xe^{-cx^2}dx = -\frac{1}{2c}e^{-cx^2}$$

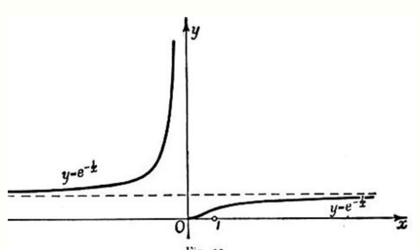
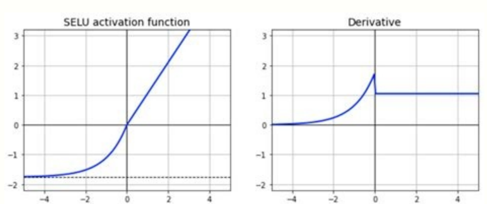


Fig. 23



An Approach to C A L C U L U S Table of Contents | Home 14 DERIVATIVES OF LOGARITHMIC The derivative of ln x The derivative of e with a functional exponent The derivative of ln u(x) The general power rule THE SYSTEM OF NATURAL LOGARITHMS has the number called e as it base; it is the system we use in all theoretical work. (In the next Lesson, we will see that e is approximately 2.718.) The system of natural logarithms is in contrast to the system of common logarithms, which has 10 as its base and is used for most practical work. We denote the logarithmic function with base e as "ln x." ln x = logex. y = ln x implies e y = x. In other words, this logarithm function -- y = ln x -- has for its inverse the exponential function, y = ex. Here are the inverse relations: And the logarithm of the base itself is always 1: (Topic 20 of Precalculus.) The function y = ln x is continuous and defined for all positive values of x. It will obey the usual laws of logarithms: 1. ln ab = ln a + ln b. 3. ln an = n ln a. (Topic 20 of Precalculus.) Like all the rules of algebra, they will obey the rule of symmetry. For example, n ln a = ln an. The derivative of ln x We will now apply the definition of the derivative to prove: In the course of the proof, it will make for a great simplification if we define the base of the system of natural logs, the number we call e, as the following limit: A limit in the proof will have that same form. Later, we will call the variable x rather than v. And in the next lesson, upon changing the variable from v to , the familiar definition follows. Here is the difference quotient: according to the 2nd law; = on multiplying by x/x; = according to the 3rd law. We now take the limit as h approaches 0. = The limit does not apply to 1x , because h is the variable that is approaching 0. 1x is a constant factor. We now define that limit to be the base of the natural logarithms, the number we will call e. (That limit is the one above, with v = ; when 0, 0.) Therefore, = = = Which is what we wanted to prove. To see that this limit -- -- that is, e, exists as x approaches 0, here is the graph of y has a definite value as x approaches 0. And in the next Lesson we will see that it is approximately 2.718. The derivative of ex We will now prove: "The derivative of ex with respect to x is equal to ex." Since y = ex is the inverse of y = ln x, we can obtain its derivative as follows: y = ex implies ln y = ln ex = x. Therefore on taking the derivative of both sides with respect to x, and applying the chain rule to ln y: = 1. y' = y. That is, = ex. ex is its own derivative. What does that imply? It implies the meaning of exponential growth. For we say that a quantity grows "exponentially" when it grows at a rate that is proportional to its size. The bigger it is at any given time, the faster it's growing at that time. A typical example is population. The more individuals there are, the more births there will be, and hence the greater the rate of change of the population -- the number of births in each year. All exponential functions have the form ax, where a is the base. Therefore, to say that the rate of growth is proportional to its size, is to say that the derivative of ax is proportional to ax. where k is the constant of proportionality. (Lesson 39 of Algebra.) When we calculate that derivative below, we will see that that constant becomes ln a. In the system of natural logarithms, in which e is the base, we have the simplest constant possible, namely 1. The derivative of e with a functional exponent When y = eu(x), then according to the chain rule: That is, "The derivative of e with a functional exponent is equal to e with that exponent times the derivative of that exponent." Example 1. Calculate the derivative of e2x + 3. Solution. Problem 1. Calculate the derivative of ex2. To see the answer, pass your mouse over the colored area. To cover the answer again, click "Refresh" ("Reload").Do the problem yourself first! ex2· 2x = 2x ex2 Problem 2. Calculate the derivative of the following. a) esin x. esin x cos x b) e−x. e−x (−1) = −e−x c) x2ex. x2ex + 2x ex According to the product rule. d) According to the quotient rule: = = The derivative of ln u(x) When y = ln u(x), then according to the chain rule: That is, Example 2. Example 3. d dx ln sin x = 1 sin x · cos x = cos xsin x = cot x. Example 4. Find the derivative of ln x2. Solution. We may apply the laws of logarithms: d dx ln x2 = d dx 2 ln x, 3rd law, = 2 d dx ln x = 2x . Example 5. Find the derivative of ln x 3x − 4 . Solution. According to the 2nd Law: d dx ln x 3x − 4 = d dx [ln x − ln (3x − 4)] = = = Problem 3. Differentiate the following. a) ln x3. d dx ln x3 = d dx 3 ln x = 3x b) (ln x)3. 3(ln x)2· 1x = 3(ln x)2 x c) ln (3x2 − 4x). 1 3x2 − 4x · (6x − 4) = 6x − 4 3x2 − 4x d) ln (3x − 4)2. 1 (3x − 4)2 · 2(3x − 4)· 3 = 6(3x − 4)(3x − 4)2 = 6 3x − 4 e) ln cos x. 1 cos x (−sin x) = − sin xcos x = −tan x Problem 4. Calculate the derivative of ln 2x . d dx ln 2x = d dx (ln 2 − ln x) = 0 − 1x = − 1x Problem 5. The derivative of logax. According to the rule for changing from base e to a different base a: Topic 20 of Precalculus. Calculate the limit of that derivative a) when x is greater than 1 and becomes larger. That derivative approaches 0, that is, becomes smaller. b) when x is less than 1 and becomes smaller. That derivative becomes larger. The general power rule We can now prove that the derivative of f(x) = xn, where n is any rational exponent, is as follows: Let y = xn. Then ln y = n ln x (3rd Law). Therefore, on taking the derivative with respect to x: = nx so that y' = nx · y = nx · xn = nxn−1. That is what we wanted to prove. (If n is 0, then x0 = 1, a constant; its derivative is 0. If n is irrational, a rational approximation will be necessary.) Problem 6. Calculate the derivative of The derivative of ax We will prove: "The derivative of an exponential function with base a is equal to the natural logarithm of that base times the exponential function." Let y = ax. Then on taking the natural logarithm of both sides: ln y = x ln a. (3rd Law) Therefore, = But by the chain rule: = Therefore, = ln a. = ln a y' = ln a· y That is, = ln a· ax. This is what we wanted to prove. Example 6. d dx 2x = ln 2· 2x. Problem 7. Calculate the derivative of y = 105x. By the chain rule: Next Lesson: Evaluating e Table of Contents | Home Please make a donation to keep TheMathPage online.Even $1 will help. Copyright © 2021 Lawrence Spector Questions or comments? E-mail: Do you want to learn an easy method for differentiating any exponential function? Jenn, Founder Calcworkshop®, 15+ Years Experience (Licensed & Certified Teacher) I thought so. What Is An Exponential Function As you probably know, an exponential function is when the variable is the power rather than the base. The base is always a positive integer greater than 1 and is written in the form: Exponential Function Equation Rules Of Exponents Additionally, some vital exponent properties, listed below, allow us to simplify and solve exponential functions that are pivotal to our successful ability to simplify derivatives of exponential functions. Properties Of Exponents Likewise, I should remind you probably the most famous exponential function in calculus is the natural exponential function, e, in which e = 2.7182…, and is denoted by: Natural Exponential Function The Steps So, now that we've reviewed the basics of exponents, it's now time to turn our attention to differentiation. How do you take a derivative of a function when the variable is in the exponent? All we have to do is follow these three easy steps: Rewrite Multiply by the natural log of the base Multiply by the derivative of the exponent Derivative Of Exponential In fact, this formula and method work for any exponential function! Examples Let's find the derivative, using our new derivative rule, for the following exponential functions. Taking The Derivative Of An Exponential Function See, differentiating exponential functions is a snap — it's as easy as 1-2-3! is derived from a This video lesson will look at exponential properties and how to take a derivative of an exponential function, all while walking through several examples in detail. Let's jump right in. Video Tutorial w/ Full Lesson & Detailed Examples (Video) Get access to all the courses and over 450 HD videos with your subscription Monthly and Yearly Plans Available Get My Subscription Now Formulas and examples of the derivatives of exponential functions, in calculus, are presented. Several examples, with detailed solutions, involving products, sums and quotients of exponential functions are examined. The derivative of f(x) = b x is given by f '(x) = b x ln b Note: if f(x) = e x , then f '(x) = e x Find the derivative of f(x) = 2 x Apply the formula above to obtain f '(x) = 2 x ln 2 Find the derivative of f(x) = 3 x + 3x 2 Let g(x) = 3 x and h(x) = 3x 2, function f is the sum of functions g and h: f(x) = g(x) + h(x). Use the sum rule, f '(x) = g '(x) + h '(x), to find the derivative of function f f '(x) = 3 x ln 3 + 6x Find the derivative of f(x) = e x / (1 + x) Let g(x) = e x and h(x) = 1 + x, function f is the quotient of functions g and h: f(x) = g(x) / h(x). Hence we use the quotient rule, f '(x) = [h(x) g '(x) - g(x) h '(x)] / h(x) 2, to find the derivative of function f. g '(x) = e x h '(x) = 1 f '(x) = [h(x) g '(x) - g(x) h '(x)] / h(x) 2 = [(1 + x)(e x) - (e x)(1)] / (1 + x) 2 Multiply factors in the numerator and simplify f '(x) = x e x / (1 + x) 2 Find the derivative of f(x) = e 2x + 1 Let u = 2x + 1 and y = e u, Use the chain rule to find the derivative of function f as follows. f '(x) = (dy / du) (du / dx) dy / du = e u and du / dx = 2 f '(x) = (e u)(2) = 2 e u Substitute u = 2x + 1 in f '(x) above f '(x) = 2 e 2x + 1 Find the derivative of each function. 1 - f(x) = e x 2 x 2 - g(x) = 3 x - 3x 3 3 - h(x) = e x / (2x - 3) 4 - j(x) = e (x2 + 2) 1 - f '(x) = e x 2 x (ln 2 + 1) 2 - g '(x) = 3 x ln 3 - 9x 2 3 - h '(x) = e x(2x -5) / (2x - 3) 2 4 - j '(x) = 2x e (x2 + 2)differentiation and derivatives Exponential Functions Tutorial on Exponential Functions (1)

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