Differentiating Transcendental Functions Encyclopedia Article

Differentiating Transcendental Functions

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Contents

Differentiating Transcendental Functions Encyclopedia Article.....1

Contents.....2

Differentiating Transcendental Functions.....3

Differentiating Transcendental Functions

One of the surprises of **calculus** is the fact that the derivatives and integrals of some **functions** look very different from the original functions. This is usually the case for inverse trigonometric and logarithm functions. These functions are "transcendental," in the sense that they cannot be written as **polynomials**, quotients of polynomials, or **roots** of polynomials. Yet their derivatives are rational functions or roots of rational functions. The simplest illustrations are:

- the natural logarithm of x, whose derivative is $1/x$;
- the inverse tangent of x, whose derivative is $1/(1 + x^2)$;
- and the inverse **sine** of x, whose derivative is $1/((1-x^2)$.

A common feature of all of these examples is the fact that the transcendental function is the inverse of a function that satisfies a simple first-order differential equation. The natural logarithm, for example, is the inverse of the exponential function, which satisfies the equation $dy/dx = y$. In each case, the formula for the derivative of the **inverse function** follows easily from the corresponding differential equation and from the inverse function **theorem**.

For the student of calculus, it is also important to realize that each of these derivative formulas leads to a corresponding integral formula, and hence that the integral of an innocuous-appearing rational function may be a transcendental function.