

In the general case, for $y = \log_b g(x)$, $b^y = g(x)$, from the definition of logarithms.

Taking derivatives $b^y \ln b \frac{dy}{dx} = g'(x)$,

$$\frac{dy}{dx} = \frac{g'(x)}{b^y \ln b} = \frac{g'(x)}{g(x) \ln b}.$$

For $y = \log_b x$, $\frac{dy}{dx} = \frac{1}{x \ln b}$.

For $y = \log_e x$, $\frac{dy}{dx} = \frac{1}{x}$.

For $y = \log_b g(x)$, $\frac{dy}{dx} = \frac{g'(x)}{g(x) \ln b}$.

EXAMPLE 3

Find the value of $g'(2)$ for the function $g(x) = x^3 \log_2(\sqrt{x^2 + 4})$.

Solution

Using the Product and Chain Rules,

$$\begin{aligned} g'(x) &= 3x^2 \log_2(\sqrt{x^2 + 4}) + x^3 \frac{1}{\sqrt{x^2 + 4} \ln(2)} \frac{2x}{2\sqrt{x^2 + 4}} \\ &= 3x^2 \log_2(\sqrt{x^2 + 4}) + \frac{x^4}{(x^2 + 4) \ln 2}. \end{aligned}$$

Then

$$\begin{aligned} g'(2) &= 12 \log_2 \sqrt{4 + 4} + \frac{16}{(4 + 4) \ln(2)} \\ &= 12 \log_2 \sqrt{8} + \frac{16}{8 \ln 2} \\ &= 12 \log_2 2^{\frac{3}{2}} + \frac{2}{\ln 2} \\ &= 12 \times \frac{3}{2} + \frac{2}{\ln 2} = 18 + \frac{2}{\ln 2}. \end{aligned}$$

EXAMPLE 4

If I_0 is the intensity of barely audible sound, then the decibel (dB) measure of the loudness, L , of a sound of intensity I is given by $L = \log_{10}\left(\frac{I}{I_0}\right)$.

- What is the loudness, in dB, of a sound of intensity I_0 ? $100 I_0$?
- If the intensity of a siren is 7000 units and is increasing at 100 000 units per second, what is the accompanying rate of change of the loudness of the sound?

Solution

a. A sound of intensity I_0 has loudness

$$\begin{aligned} L &= \log_{10}\left(\frac{I_0}{I_0}\right) \\ &= \log_{10} 1 \\ &= 0 \text{ dB.} \end{aligned}$$

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BM King



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