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

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

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

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

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

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

EXAMPLE 3

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

Solution

Using the Product and Chain Rules,

$$g'(x) = 3x^2 \log_2\left(\sqrt{x^2 + 4}\right) + x^3 \frac{1}{\sqrt{x^2 + 4}\,\ln(2)} \frac{2x}{2\sqrt{x^2 + 4}}$$

$$= 3x^2 \log_2\left(\sqrt{x^2 + 4}\right) + \frac{x^4}{(x^2 + 4)\ln 2}.$$

Then

$$g'(2) = 12 \log_2 \sqrt{4 + 4} + \frac{16}{(4 + 4)\ln(2)}$$

$$= 12 \log_2 \sqrt{8} + \frac{16}{8 \ln 2}$$

$$= 12 \log_2 2^{\frac{3}{2}} + \frac{2}{\ln 2}$$

$$= 12 \times \frac{3}{2} + \frac{2}{\ln 2} = 18 + \frac{2}{\ln 2}.$$

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 $L = \log_{10}\left(\frac{I}{I_0}\right)$.

a. What is the loudness, in dB, of a sound of intensity I_0? 100 I_0?

b. 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

$$L = \log_{10}\left(\frac{I_0}{I_0}\right)$$

$$= \log_{10} 1$$

$$= 0 \text{ dB}.$$

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