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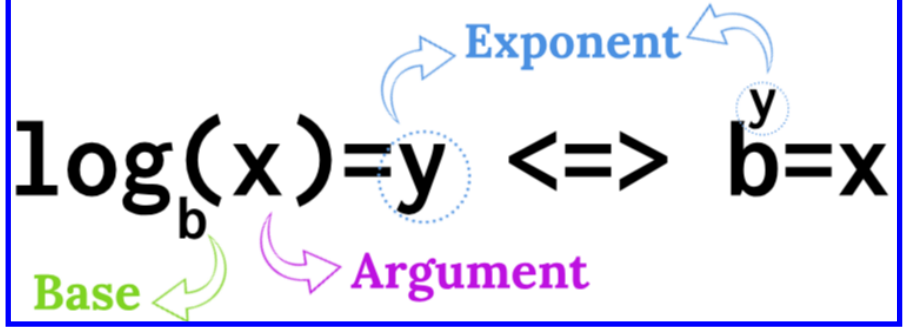
# LOGARITHMS

## LOGARITHM

The logarithm base "b" of "x" is the exponent (y) to which the base (b) must be raised to obtain the number (x); hence:




## PROPERTIES OF LOGARITHMS

1. Logarithms of negative numbers do not exist in the system of real numbers.
2. The logarithm of zero is undefined.
3. $log_b(1) = y \Leftrightarrow b^y = 1$
4. $log_b(b) = 1 \Leftrightarrow b^1 = b$
5. $log_b(b^n) = n \Leftrightarrow b^n = b^n$
6. $log_b(x^n) = n \cdot log_b(x)$
7. $log_b\left(\sqrt[n]{x}\right) = log_b\left(x^{\frac{1}{n}}\right) = \frac{1}{n} \cdot log_b(x)$
8. $log_b\left(\sqrt[n]{x^m}\right) = log_b\left(x^{\frac{m}{n}}\right) = \frac{m}{n} \cdot log_b(x)$
9. $log_b(x \cdot y) = log_b(x) + log_b(y)$
10. $log_b\left(\frac{x}{y}\right) = log_b(x) - log_b(y)$
11. Logarithm change of base rule:

$$log_a(x) = \frac{log_b(x)}{log_b(a)}$$

$$log_a(b) = \frac{1}{log_b(a)}$$

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**EXAMPLE: Find the value of the following logarithm:**

$log_2(8) =$

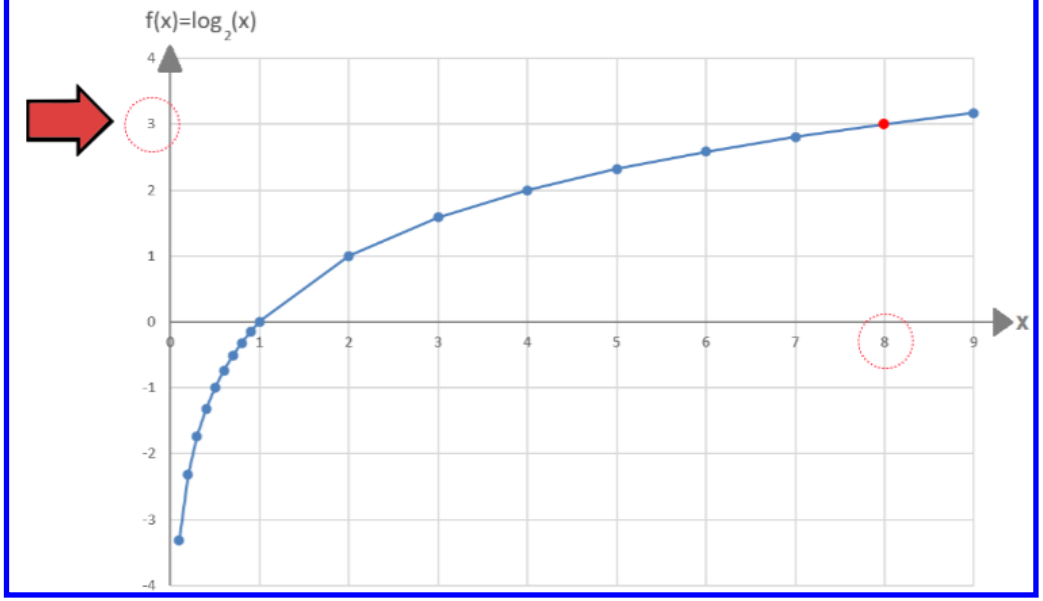
**SOLUTION:** 1) Applying $\boxed{log_b(x) = y \iff b^y = x}$

$$log_2(8) = y \iff 2^y = 8$$

$$log_2(8) = 3 \iff 2^3 = 8$$

$$log_2(8) = 3$$

$$log_2(8) = 3$$

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**EXAMPLE: Simplify the following expression:**

$$4\log_3(x) + \log_3(x) - \frac{\log_3(x)}{2} =$$

**SOLUTION: 1) Applying**

$$\log_b(x^n) = n \cdot \log_b(x)$$

$$= \log_3(x^4) + \log_3(x) - \frac{\log_3(x)}{2} =$$

$$= \log_3(x^4) + \log_3(x) - \frac{1}{2}\log_3(x) =$$

$$= \log_3(x^4) + \log_3(x) - \log_3\left(x^{\frac{1}{2}}\right) =$$

**2) Applying**

$$\log_b(x \cdot y) = \log_b(x) + \log_b(y)$$

$$= \log_3(x^4) + \log_3(x) - \log_3\left(x^{\frac{1}{2}}\right) =$$

$$= \log_3(x^4 \cdot x) - \log_3\left(x^{\frac{1}{2}}\right) =$$

$$= \log_3(x^5) - \log_3\left(x^{\frac{1}{2}}\right) =$$

**3) Applying**

$$\log_b\left(\frac{x}{y}\right) = \log_b(x) - \log_b(y)$$

$$= \log_3\left(\frac{x^5}{x^{\frac{1}{2}}}\right) =$$

$$= \log_3\left(x^5 \cdot x^{-\frac{1}{2}}\right) =$$

$$= \log_3\left(x^{5-\frac{1}{2}}\right) =$$

$$= \log_3\left(x^{\frac{9}{2}}\right) =$$

$$= \log_3\left(\sqrt{x^9}\right)$$

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