Check-Up Time...
Evaluate each of the following:

1.
$$\log_{2} 8\sqrt{32} = \chi$$

$$2^{\chi} = 8\sqrt{32} = \chi$$

$$3^{\chi} = 3^{3}(2^{5})^{\chi}$$

3.
$$\log_5 \frac{1}{125} = \chi$$

$$S_{x=1}^{x=1}$$

 $S_{x=1}^{x=1}$
 $S_{x=3}^{x=3}$

2.
$$-\frac{2}{3} = \log_{x} 81$$

 $(\chi^{-\frac{2}{3}}) = (81)$
 $\chi' = (\sqrt{81})$
 $\chi = \frac{1}{9^{3}} = \frac{1}{730}$

4.
$$\log_{\sqrt{6}} 36 = \chi$$

$$\sqrt{6} = 36$$

$$\sqrt{6} = 36$$

$$\sqrt{6} = 36$$

$$\sqrt{6} = 36$$

What is the value of any logarithm with an argument of 1? Why?

General Properties of Logarithms:

$$\int_{0}^{\infty} d^{2}x = \int_{0}^{\infty} d^{2}x$$

$$\int_{0}^{\infty} d^{2}x = \int_{0}^{\infty} d^{2}x$$

$$\vdots \quad \forall = 0$$

If
$$a > 0$$
 and $a \ne 1$, then...

(i)
$$\log_a 1 = 0$$

(ii) $\log_a a^x = x$

(iii)
$$a^{\log_a x} = x$$

Laws of Logarithms: If a > 0, M > 0, N > 0 and $n \in R$ then...

1) Product Law → the logarithm of a product is equal to the <u>sum</u> of the logarithms of the factors.

PROOF: Let
$$\log_a M = b$$
 and $\log_a N = c$
 $go = a^b = M$ $a^c = N$

then.

$$\log_{a}(MN) = \log_{a}(a^{b} \cdot a^{c})$$

$$= \log_{a}(a^{b+c})$$

$$= b + c$$

$$\therefore \log_{a}(MN) = \log_{a}M + \log_{a}N$$

Roduct

examples: a)
$$\log_{10}(6 \times 9)$$

b)
$$\log_2 12 + \log_2 7$$

$$log_b(x^2-1)$$
 Factoring $log_b(x+1)(x-1) = log_b(x+1) + log_b(x-1)$

2) Quotient Law \rightarrow the logarithm of a quotient is equal to the logarithm of the numerator minus the logarithm of the denominator.

PROOF: Let
$$\log_a M = b$$
 and $\log_a N = c$

$$\sup_a a^b = M \qquad \qquad a^c = N$$
then,
$$\log_a \left(\frac{M}{N}\right) = \log_a \left(\frac{a^b}{a^c}\right)$$

$$= \log_a (a^{b-c})$$

$$= b - c$$

$$\therefore \qquad \log_a \left(\frac{M}{N}\right) = \log_a M - \log_a N$$

examples: a)
$$\log_{5}\left(\frac{97}{62}\right)$$
 b) $\log_{2}15 - \log_{2}3$ c) $\log_{10}\left(\frac{1}{9}\right)$
(a) $\log_{5}97 - \log_{5}62$ c) $\log_{10}\log_{10}\left(\frac{1}{9}\right)$
(b) $\log_{5}(5) = \log_{5}5$

3) Law of Logarithms for Powers → the logarithm of a power of a number is equal to the exponent multiplied by the logarithm of the number

PROOF: Let
$$\log_a M = b$$

so $a^b = M$

then,
$$\log_a M^p = \log_a (a^b)^p$$

$$= \log_a (a^{b \times p})$$

$$= b \times p$$

$$\vdots$$

$$\log_a M^p = p \times \log_a M$$

examples: a)
$$\log_{10} 8^9$$
 b) $2\log_3 5$

$$= 9/038$$

$$(10337) \text{ Not}$$

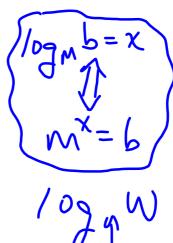
$$- 3 \text{ Not}$$

$$- 9 \text{ Not}$$

c)
$$\log_{5} \sqrt{125}$$
 $\log_{5} \sqrt{25}$
 $\log_{5} \sqrt{25}$

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3 Properties of Logarithms: Dlogb = 0



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3 Laws of Logarithms



Use the Laws of Logarithms to Expand Expressions

Write each expression in terms of individual logarithms of x, y, and z.

a)
$$\log_6 \frac{X}{y}$$

a)
$$\log_6 \frac{x}{y}$$
 (a) $\log_6 x - \log_6 y$

b)
$$\log_5 \sqrt{xy}$$

c)
$$\log_3 \frac{9}{\sqrt[3]{X^2}}$$

d)
$$\log_7 \frac{x^5 y}{\sqrt{z}}$$

c)
$$\log_3 \frac{9}{\sqrt[3]{x^2}}$$
 (b) $\log_7 \frac{x^5y}{\sqrt{z}}$ (c) $\log_7 \frac{x^5y}{\sqrt{z}}$ (d) $\log_7 \frac{x^5y}{\sqrt{z}}$ (e) $\log_7 \frac{y^{1/2}}{\sqrt{z}}$

$$= \frac{1}{2} \left(\log_5 (xy) \right)$$

$$= \frac{1}{2} \left(\log_5 x + \log_5 y \right)$$

$$= 5 - \frac{3}{5} \sqrt{93} \times \frac{3}{5} = \sqrt{93} \times \frac{3}{5} \times \frac{3}{5} = \sqrt{93} \times \frac{3}{5} \times \frac{3}{5$$

d)
$$|097 \times 4 = |097 \times 4 - |097 =$$

$$= |097 \times$$

Example 2

Use the Laws of Logarithms to Evaluate Expressions

Use the laws of logarithms to simplify and evaluate each expression.

- a) $\log_{3}(9\sqrt{3})$
- **b)** $\log_5 1000 \log_5 4 \log_5 2$
- c) $2 \log_3 6 \frac{1}{2} \log_3 64 + \log_3 2$

c)
$$2 \log_3 6 - \frac{1}{2} \log_3 64 + \log_3 2$$

$$\log_3 6^2 - \log_3 6 + \log_3 2$$

$$\log_3 36 - \log_3 8 + \log_3 2$$

$$\log_3 (\frac{34}{8}) + \log_3 2$$

$$\log_3 (\frac{36}{8}) + \log_3 2$$

Example 3

Use the Laws of Logarithms to Simplify Expressions

Write each expression as a single logarithm in simplest form. State the restrictions on the variable.

a)
$$4 \log_3 x - \frac{1}{2} (\log_3 x + 5 \log_3 x)$$

b)
$$\log_2 (x^2 - 9) - \log_2 (x^2 - x - 6)$$

a)
$$4 \log_{3} x - \frac{1}{2} \log_{3} x - \frac{5}{2} \log_{3} x \left(\log_{3} x - \frac{1}{2} \log_{3} x \right)$$

$$\log_{3} x^{4} - \log_{3} x^{2} - \log_{3} x + \log_{3} x \right)$$

$$\log_{3} \left(\frac{x}{x^{1/2}} \right) - \log_{3} x + \log_{3} x \right)$$

$$\log_{3} \left(\frac{x}{x^{1/2}} \right) - \log_{3} x + \log_{3} x \right)$$

$$\log_{3} \left(\frac{x}{x^{1/2}} \right) - \log_{3} x + \log_{3} x \right)$$

$$\log_{3} \left(\frac{x}{x^{1/2}} \right) - \log_{3} x + \log_{3} x \right)$$

$$\log_{3} \left(\frac{x}{x^{1/2}} \right)$$

$$\log_{3} \left(\frac{x}{x^{1/2}} \right)$$

$$\log_{3} x + \log_{3} x + \log_{3} x \right)$$

$$\log_{3} x + \log_{3} x + \log_{3} x + \log_{3} x \right)$$

$$\log_{3} x + \log_{3} x + \log_{3} x + \log_{3} x \right)$$

$$\log_{3} x + \log_{3} x + \log_{3} x + \log_{3} x + \log_{3} x \right)$$

$$\log_{3} x + \log_{3} x +$$

b)
$$\log_{2}(x^{2}-9) - \log_{2}(x^{2}-x-6)$$
 $\log_{2}(x^{2}-9) - \log_{2}(x^{2}-x-6)$
 $\log_{2}(x^{2}-x-6)$
 $\log_{2}(x^{2}-x-6)$
 $\log_{2}(x^{2}-x-6)$
 $\log_{2}(x^{2}-x-6)$
 $\log_{2}(x^{2}-x-6)$
 $\log_{2}(x^{2}-x-6)$

Key Ideas

• Let P be any real number, and M, N, and c be positive real numbers with $c \neq 1$. Then, the following laws of logarithms are valid.

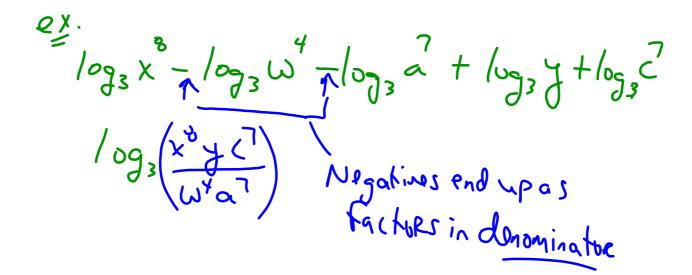
Name	Law	Description
Product	$\log_c MN = \log_c M + \log_c N$	The logarithm of a product of numbers is the sum of the logarithms of the numbers.
Quotient	$\log_c \frac{M}{N} = \log_c M - \log_c N$	The logarithm of a quotient of numbers is the difference of the logarithms of the dividend and divisor.
Power	$\log_c M^p = P \log_c M$	The logarithm of a power of a number is the exponent times the logarithm of the number.

• Many quantities in science are measured using a logarithmic scale. Two commonly used logarithmic scales are the decibel scale and the pH scale.

Do I really understand??...

- a) Express the following as a single logarithm... $2\log_2 3^2 + \log_2 6 3\log_2 3$
- b) Evaluate the following... $\log_2(32)^{\frac{1}{3}}$ | $\log_2(32)^{\frac{1}$

c) Express the following as a single logarithm... $\frac{1}{2} [(\log_5 a + 2\log_5 b) - 3\log_5 c]$



d) Express as a single logarithm in simplest form...

$$\frac{3}{4} \left[12 \left(\log_b x^2 - 2\log_b x \right) + 8\log_b \sqrt{x} - 4\log_b \frac{1}{x^7} \right]$$

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