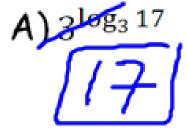
### **Objectives:**

- Understand the properties of Logarithms
- Write a logarithmic expression as a sum or difference of logarithms.
- Write a logarithmic expression as a single logarithm.
- ullet Evaluate logarithms with bases other than 10 and e .

# Inverse Properties of Logarithms:

- 1. If a and M are positive real numbers, with  $a \neq 1$ , then  $a^{\log_a M} = M$
- 2. If a is a positive real number,  $a \neq 1$ , and r is any real number, then  $\log_a a^r = r$

### Examples: Evaluate each logarithm.



D) 
$$\ln e^7$$

# The Product Rule of Logarithms:

If M, N, and a are positive real numbers, with  $a \neq 1$ , then  $\log_a(MN) = \log_a M + \log_a N$ 

Examples: Write each expression as the sum of logs.

E) 
$$\log_3(6.5)$$
=  $\log_3(6) + \log_3(5)$ 

F) 
$$ln(2k)$$

$$= ln(2) + ln(k)$$

# The Quotient Rule of Logarithms:

If M,N, and a are positive real numbers, with  $a \neq 1$ , then

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

Examples: Write each as the difference of logs.

G) 
$$\log_3\left(\frac{7}{5}\right)$$
  
=  $\log_3(7) - \log_3(5)$ 

$$H)\ln\left(\frac{7}{2}\right)$$

$$= \ln(7) - \ln(2)$$

Examples: Write each expression as the sum or difference of logarithms.

I) 
$$\log_4\left(\frac{3x}{y}\right)$$
  
=  $\log_4\left(3\right) + \log_4(x) - \log_4(y)$ 

Examples: Write each expression as the sum or difference of logarithms.

Extra example: 
$$log_3\left(\frac{x}{vz}\right)$$

$$= log_3(x) - \left(log_3(y) + log_3(z)\right)$$

$$= \left(log_3(x) - log_3(y) - log_3(z)\right)$$

# The Power Rule of Logarithms:

If M and a are positive real numbers, with  $a \neq 1$ , and r is any real number, then  $\log_a M^r = r \log_a M$ 

#### **Lesson 9.4: Properties of Logarithms**

Example: Express all powers as factors.

$$\mathbf{J})\log_7 2^4$$

$$\ln x^{\sqrt{2}}$$

#### Lesson 9.4: Properties of Logarithms

Examples: Use the rules of Logarithms to expand the logarithm (write as a sum or difference, with all exponents written as factors).

L) 
$$\log_3(9x^2y^4)$$
 $\log_3(9) + \log_3(x^2) + \log_3(y^4)$ 
 $= \log_3(9) + 2\log_3(x) + 4\log_3(y)$ 
 $= 2 + 2\log_3(x) + 4\log_3(y)$ 

$$M)\log\left(\frac{100x}{\sqrt{y}}\right) = \log(100) + \log(x) - \log(1y)$$

$$= 2 + \log(x) - \log(y)$$

$$= 2 + \log(x) - \log(y)$$

Examples: Use the rules of Logarithms to condense the expression into a single logarithm. Simplify if possible.

N) 
$$\log_4 32 + \log_4 8$$
  
=  $\log_4 (32.8)$   
=  $\log_4 (256) = 4$   
 $4^2 = 256$ 

$$O)\ln(x+3) - \ln x$$

$$= \left(\frac{(x+3)}{x}\right)$$

Examples: Use the rules of Logarithms to condense the expression into a single logarithm. Simplify if possible.

P) 
$$\frac{1}{2}\log_3(x+2) + 2\log_3 x^2$$
  
=  $\log_3(x+2)^{1/2} + \log_3(x^2)$   
=  $\log_3(x+2) + \log_3(x^2)$   
=  $\log_3(x+2) + \log_3(x^2)$   
=  $\log_3(x+2) + \log_3(x^2)$ 

Examples: Use the rules of Logarithms to condense the expression into a single logarithm. Simplify if possible.

Q)
$$\log_2 9 + 2 \log_2 x - \log_2(x - 4)$$
  
=  $\log_2 (9) + \log_2(x^2) - \log_2(x - 4)$   
=  $\log_2 (\frac{9 \times 2}{(x - 4)})$ 

# Change of Base Formula:

To evaluate logarithms that have bases other than 10 or e on the calculator, you must use the Change of Base formula:

$$\log_a M = \frac{\log M}{\log a} = \frac{\ln M}{\ln a}$$

$$ex: \log_3 l + = \frac{\log (17)}{\log (3)} or \frac{\ln (17)}{\ln (3)}$$

#### Lesson 9.4: Properties of Logarithms

**Examples:** Approximate the following expressions.

Round to 3 decimal places. Show your work.

R) 
$$\log_3 11$$
 $= \frac{\log(11)}{\log(3)} \text{ or } \frac{\ln(11)}{\ln(3)}$ 
 $= 2.183$ 

$$= \frac{\log(9)}{\log(2)} \text{ or } \frac{\ln(9)}{\ln(2)}$$

$$= 3.170$$

### **Objectives:**

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# Homework:

```
Pg. 752: #11, 15, 17, 19, 23, 27, 31, 33, 37, 41, 47, 49, 55, 63, 67, 73, 75, 77, 79, 81, 89 (21 problems)
```