

## Exponential and Logarithmic Functions:

$$\log_a x = y \Leftrightarrow a^y = x$$

$$\ln x = \log_e x, \quad \text{where } \ln e = 1$$

$$\ln x = y \Leftrightarrow e^y = x$$

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### Laws of Logs:

1.  $\log_a MN = \log_a M + \log_a N$

2.  $\log_a \frac{M}{N} = \log_a M - \log_a N$

3.  $\log_a M^p = p \log_a M$

*(This law can be very useful in solving equations which have an unknown in the exponent of an expression.)*

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**Be Careful:** The above Laws of Logs do not apply to the following. *Why?*

$\log_a(M + N)$  *(Law 1 involves the sum of two different log terms. This has a sum in the ARGUMENT of a single log term.)*

$(\log_a M)(\log_a N)$  *(Law 1 involves a product in the ARGUMENT of a single log term. This is a product of two different log terms.)*

$\frac{\log_a M}{\log_a N}$  *(Law 2 involves a quotient in the argument. of a single log term. This is a quotient of two different log terms.)*

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### Cancellation Laws:

$$a^{\log_a M} = M$$

$$e^{\ln M} = M$$

$$\log_a a^r = r$$

$$\ln e^r = r$$

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### Helpful to remember:

$$\log_a 1 = 0$$

$$\log_a a = 1$$

$$\ln 1 = 0$$

$$\ln e = 1$$