### Warm Up 12/02

Identify the base of each log or exponential function.

1) 
$$2^x = 8$$



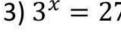
4)  $log_9 x = 625$ 

2) 
$$log_4 x = 2$$

2) 
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 3)  $3^x = 27$ 



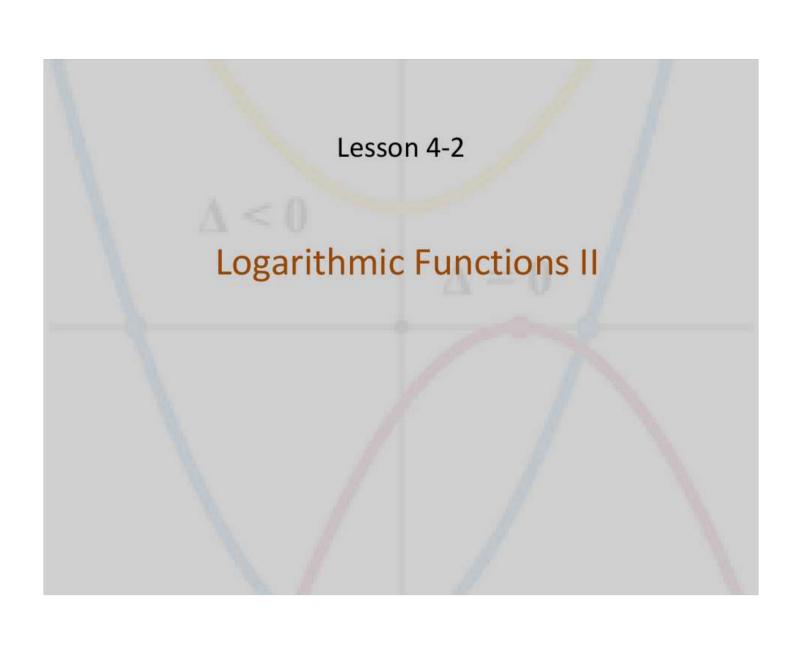
$$5) e^x = 1$$











### Objective

#### Students will...

- Be able to define natural logarithmic function.
- Be able to know and apply the properties of natural logarithms.
- Be able to use calculators to compute natural logarithms.

#### **Natural Logarithms**

We've learned that any logarithm with base 10 is known as the common logarithm, without the base written. In our previous section of exponential function, we learned about a very special number denoted, e. Naturally (no pun intended as we'll see), logarithms with base e is also considered special, and it is given a special name.

Natural Logarithm - The logarithm with base e is called the <u>natural</u> <u>logarithm</u> and is denoted by <u>ln</u>:

 $\ln x = log_e x$ 

### The Inverse of Exponential Function

Like all other exponential and logarithmic functions, the natural logarithmic function  $y = \ln x$  is the inverse function of the exponential function  $y = e^x$ . Hence, by definition we have

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

$$\log_e X = y$$

Example:

$$e^6 \approx 403.43 \rightarrow \ln 403.43 \approx 6$$

$$\ln 8 \approx 2.08 \rightarrow e^{2.08} \approx 8$$

#### **Properties of Natural Logarithms**

We have learned about some of the basic properties of logarithms. Always remember that, although it's given a special name, natural logarithms is still a logarithmic function! Thus, the properties of natural logarithm naturally (again, no pun intended 3) follow the properties of logarithms. Simply replace a with e and  $log_a$  with ln.

Property	Reason
$1.\ln 1 = 0$	Anything raised to the zero power is 1
$\frac{\log_{a}}{2 \ln e} = 1$	
$2 \frac{\ln e}{2} = 1$	Anything raised to the 1st power is itself
Logol	

 $3. \ln e^x = x$ 

4. 
$$e^{\ln x} = x$$
  $\ln x$  is the power to which  $e$  must be raised to get  $x$ 

e raised to the x power is  $e^x$ 

### **Examples**

For base 5...

By property 1:

$$ln 1 = 0$$

By property 2:

$$lne = 1$$

By property 3:

$$\ln e^{8} = 8$$

By property 4:

$$e^{\ln 12} = 12$$

# You try

By property 1:

$$ln 1 = \bigcirc$$

By property 2:

By property 3:

$$\ln e^4 = 4$$

By property 4:
$$e^{\ln 19} = \bigcirc$$

### Using a Calculator

For most logarithmic, as well as exponential functions, we've learned that having a calculator is a must. Computing natural logarithm on a calculator is easy. We simply need to find where the ln button is. Almost all calculators place  $e^x$  and ln together (usually "2<sup>nd</sup>"  $e^x$ ).

Example:

To compute ln 5, we would input "2nd" ex, then "5".

The answer should read:  $\ln 5 = 1.6094379124341$ 

### In Closing

Compute the following natural logarithms using a calculator and check your answers with a partner.

1) 
$$\ln 4 = \frac{38}{3}$$

1) 
$$\ln 4 = \frac{1}{38}$$
 2)  $2(\ln 9) = 4.394$  3)  $9(\ln 11) = 21.591$ 

## Homework 12/02

TB pg. 349-350 #7, 8, 13, 14, 22a, 23b, 23c, 35, 36