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SYLLABUS

ALGEBRA 2AB

Unit 8: Exponential & Logarithmic Functions

DAY	TOPIC	ASSIGNMENT
1	8.1 Exponential Growth	Pg 427 – 428 #1 – 15 odd; 36, 54, 55
2	8.1 Exponential Decay	Pg 427 – 428 #16 – 23 all; 25 – 31 odd; 35, 37 – 42 all; 45 – 53 all
3	8.2 Properties of Exponential Functions; Continuous Compound Interest (e^x)	Pg 434 – 436 #1 – 23 odd; 24 – 26; 36, 40
4	8.3 Logarithmic Functions; Converting between log and exp.	Pg 441 – 442 #6 – 25 all; 53 – 61 all
5	8.3 Logarithmic Functions; Inverses; Graphs; Domain and Range	Pg 443 # 63 – 83 odd; 89 Graph # 75 – 83 odd
6	8.4 Properties of Logarithms	Pg 449 #13 – 85 every other odd
7	**Quiz (Days 1 – 5)**	
8	8.5 Exponential and Logarithmic Equations	Pg 456 – 458 #1 – 31 odd, 50 – 54, 58, 60, 79 – 81, 89 - 91
9	8.5 Solving Logarithmic Equations	Pg 456 – 458 #33 – 47 odd; 55 – 57; 82 – 84 all; 86 – 94 even
10	Applications of Logarithms	Pg 459 #97 – 99all
11	8.6 Natural Logs	Pg 464 - 466 #1 – 27 odd; 31 – 38 all; 56 – 62 even
12	Applications of Natural Logs	Worksheet
13	**Review**	
14	**Test**	

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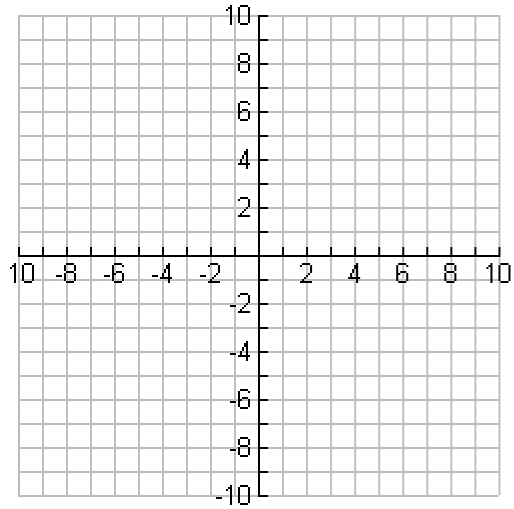
U8D1: Exponential Growth

Objective: To model exponential growth.
Thinking Skill: Examine information from more than one point of view.

A. Warm Up: Complete the table of values below. Plot the coordinates and connect the points with a smooth curve to graph the function $y = 2^x$.

x	2^x	y
-3		
-2		
-1		
0		
1		
2		
3		



Check your graph using your graphing calculator.

B. An exponential function is a function with the general form ______________, where x is a real number, $a \neq 0$, $b > 0$, and $b \neq 1$.

	Equation	a	b
Exponential Growth	$y = ab^x$	$a > 0$	$b > 1$
Exponential Decay	$y = ab^x$	$a > 0$	$0 < b < 1$

When ______________, b is the **growth factor**.

When ______________, b is the **decay factor**.

An exponential function can model growth. If you know the rate of increase *r*, you can find the **growth factor** by using the equation:

$$\boxed{b = \qquad\qquad}$$

To create a model for growth, use the formula:

Initial value

Number of time periods

$$y = ab^x$$

Final value

Growth Factor

C. In 2000, the U.S. population was 281 million people and the annual rate of increase in was about 1.24%.

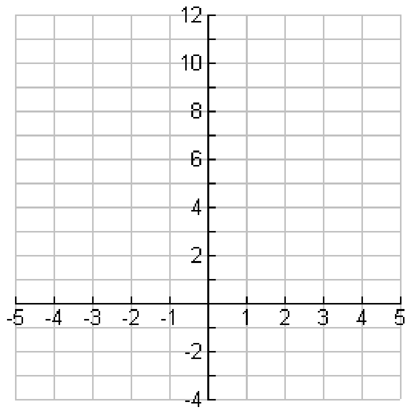
1. Find the growth factor for the U.S. population.

2. Suppose the rate of increase continues to be 1.24%. Write a function to model the population growth.

3. Use your model from above to predict the U.S. populations in 2025 to the nearest million.

D. Graph each function and give its initial value and growth factor. Also, give the domain and range using interval notation. Check on your calculator.

1. $y = 2(1.5)^x$



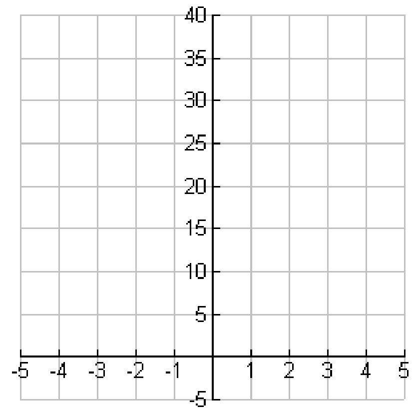
Initial value: ____________

Growth factor: ____________

Domain: ____________

Range: ____________

2. $y = 5(3)^x$



Initial value: ____________

Growth factor: ____________

Domain: ____________

Range: ____________

E. Write an exponential function $y = ab^x$ for a graph that includes the given points.

1. $(4,8),\ (6,32)$

2. $(2,18)$, $(5,60.75)$

F. Closure: On you Own

About 84 million homes used the internet in 2000. The usage grew by about 34% each year until 2005. Write a function to model internet usage in the United States. Use your model to predict the number of homes that used internet in 2005.

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U8D2: Exponential Decay

Objective: To model exponential decay.
Thinking Skill: Examine information from more than one point of view.

	Equation	a	b
Exponential Growth	$y = ab^x$	$a > 0$	$b > 1$
Exponential Decay	$y = ab^x$	$a > 0$	$0 < b < 1$

A. Without graphing, determine if each equation represents exponential growth or decay.

1. $y = 200(4)^x$ growth / decay

2. $y = 3.05(.87)^x$ growth / decay

3. $y = \frac{4}{3}\left(\frac{1}{5}\right)^x$ growth / decay

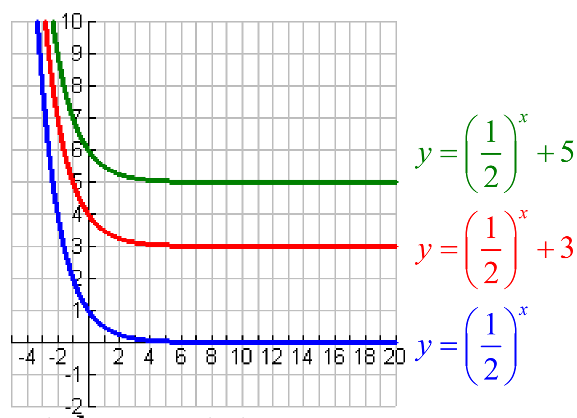
4. $y = \frac{1}{2}(3)^x$ growth / decay

B. **Horizontal Asymptote:** A line that the graph approaches.

1. What is the horizontal asymptote for $y = \left(\frac{1}{2}\right)^x$?

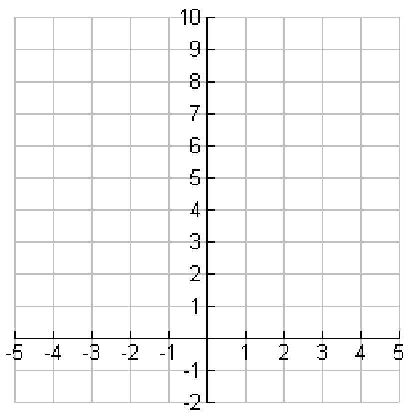
2. For $y = \left(\frac{1}{2}\right)^x + 3$?

3. For $y = \left(\frac{1}{2}\right)^x + 5$?



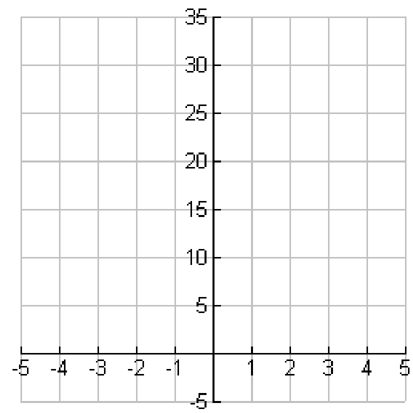
C. Graph each function and then identify the **horizontal asymptote**.

1. $y = 2(0.5)^x - 1$



H.A. ________________

2. $f(x) = \left(\frac{1}{5}\right)^x + 5$



H.A. ________________

Similar to the growth factor, you can identify the **decay factor** if you know the rate of decrease *r*, by using the equation

$$\boxed{b = \quad\quad\quad\quad}$$

Depreciation is the decline in an item's value resulting from age or wear. When an item loses the same percent of its value each year, you can use an exponential function to model the depreciation.

D. Suppose you want to buy a used car that costs $11,800. The expected depreciation of the car is 20% per year. Estimate the depreciated value of the car after 6 years.

E. Write an exponential function to model each situation. **Be careful**, some are growth and some are decay.

1. A tree 3 ft. tall grows 8% each year. How tall will the tree be at the end of 14 years? Round the answer to the nearest hundredth.

2. A motorcycle purchased for $9,000 today will be worth 6% less each year. For what can you expect to sell the motorcycle at then end of 5 years?

3. The price of a new home is $126,000. The value of the home appreciates 2% each year. How much will the home be worth in 10 years?

F. Closure: The value of a truck bought new for $33,000 decreases 16.5% each year. Write an exponential function, and graph the function using your calculator and the window settings below. Use the TRACE function to predict when the value will fall to $3000.

window:
x min - 0
x max - 20
x scale - 5
y min - 0
y max - 33000
y scale - 1000

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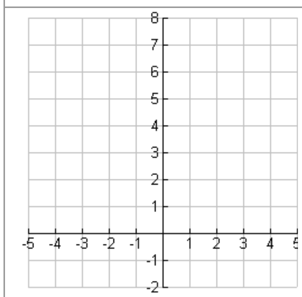
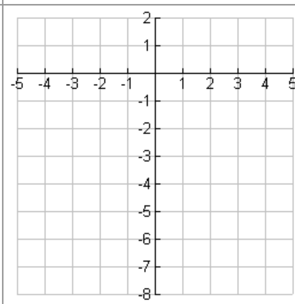
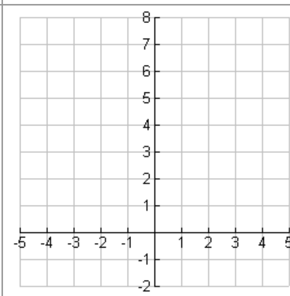
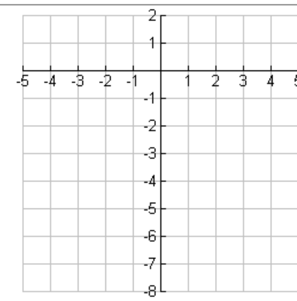
U8D3: Properties of Exponential Functions

Objective: To identify the role of constants in $y = ab^{x-h} + k$ and to use *e* as a base.
Thinking Skill: Explicitly assess information and draw conclusions.

A. Warm Up: Use your calculator to graph each of the functions below. Next, analyze the equation and make some generalizations about how they affect the graph.

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

B. Translations:

If you are able to graph $y = ab^x$ (i.e. $y = 2^x$), then…

To graph: $y = ab^{x-h} + k$, move *h* units ____________________ and move *k* units ____________________.

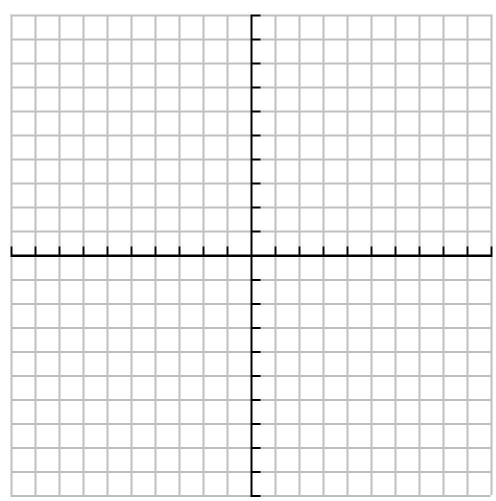
For example,

1. Graph $y = \left(\frac{1}{3}\right)^x$, and then graph…

2. $y = \left(\frac{1}{3}\right)^{x+2}$

3. $y = \left(\frac{1}{3}\right)^x - 3$

4. $y = \left(\frac{1}{3}\right)^{x-1} + 3$



C. Just like π, "e" is an irrational number approximately equal to 2.71828 Exponential functions with a base of e are useful for describing *continuous* growth or decay.

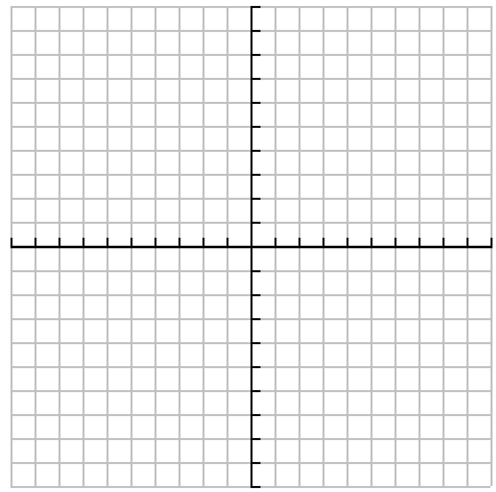
Your graphing calculator has a key for e^x

Graph $y = e^x$ and then evaluate the following (to 4 decimal places).

1. e^2

2. e^4

3. e^{-3}



NOTE: e is a ____________________, not a ____________________.

D. Compound Interest

Continuous exponential growth model: $A = Pe^{rt}$

n times per year: $A = P\left(1+\dfrac{r}{n}\right)^{nt}$

Key:

$A =$ ____________________________

$P =$ ____________________________

$r =$ ____________________________

$t =$ ____________________________

$n =$ ____________________________

1. Suppose you invest $1050 at an annual interest rate of 5.5% compounded continuously. How much will you have in the account after 5 years?

2. How much money would you need to invest at an annual interest rate of 4.3% compounded continuously in order to have $1479 in the account after three years?

3. Suppose you invest $2000 at an annual interest rate of 4.5%. How much will you have after 5 years?

   Annually:

   Quarterly:

   Monthly:

   Daily:

   Continuously:

   Which method gives you the most? By how much?

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U8D4: Introduction to Logarithms

Objective: To write and evaluate logarithmic expressions.
Thinking Skill: Explicitly assess information and draw conclusions.

A. Logarithm Definition:

A **logarithm** is the ___________________ that a specified base must be raised to in order to get a certain value.

$$\text{If } b^x = a\text{, then } \log_b a = x$$

$$(b > 0 \text{ and } b \neq 1)$$

A logarithmic function is the _____________________ of an exponential function.

What does that mean?! (more on this later)

B. Write the exponential equation in logarithmic form.

1. $5^3 = 125$
2. $6^1 = 6$
3. $9^0 = 1$
4. $10^{-2} = \frac{1}{100}$
5. $4^x = 16$

Special Properties of Logarithms

$\log_b b = 1$ $\log_b 1 = 0$

C. Write the logarithmic equation in exponential form.

1. $\log_5 25 = 2$

2. $\log_2 8 = 3$

3. $\log_5 \left(\frac{1}{5}\right) = -1$

4. $\log_3 3 = 1$

5. $\log_8 1 = 0$

D. Evaluate each logarithm.

A **common logarithm** is a logarithm whose base is __________, denoted just **log**.

1. $\log 100$

2. $\log_3 81$

3. $\log_9 27$

4. $\log_8 16$

5. $\log_3 (-9)$

6. $\log_{64} \frac{1}{32}$

Change of Base Formula

$$\log_b a = \frac{\log_n a}{\log_n b}$$

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U8D5: Graphing Logarithmic Functions

Objective: To graph logarithmic functions.
Thinking Skill: Examine information from more than one point of view.

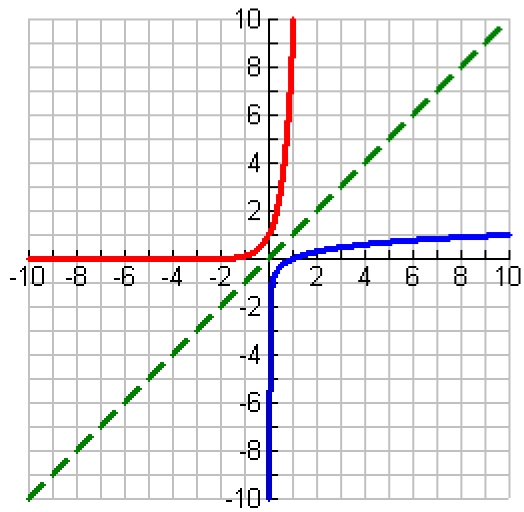
A. Vocabulary

1. A **logarithm** is the ____________________ that a specified base must be raised to in order to get a certain value.

2. A **common logarithm** is a logarithm whose base is __________, denoted $\log_{10}$ or just $\log$.

3. Because **logarithms** are the ____________________ of exponents, the inverse of an exponential function, such as $y = 2^x$, is a logarithmic function, $y = \log_2 x$.

	$y = 10^x$	$y = \log x$
Asymptote:		
Domain:		
Range:		



Notice, $y = 10^x$ and $y = \log x$ are *inverses* because they are reflected over the line _______________.

B. Graph $y = \log_3 x$

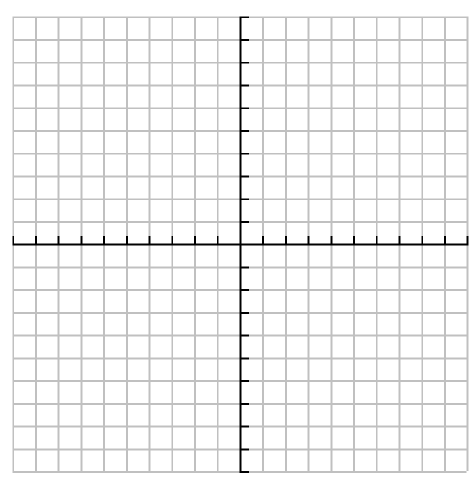
Step 1: Write in exponential form.

Step 2: Make a table of values.

Step 3: Pick values for *y*, and solve for *x*.
(this is backwards of what you're used to)

Step 4: Graph the points & connect

x	y



Domain: _______________ Range: _______________

C. Now that we know how to graph logs, we can use ____________________ to graph other logs!

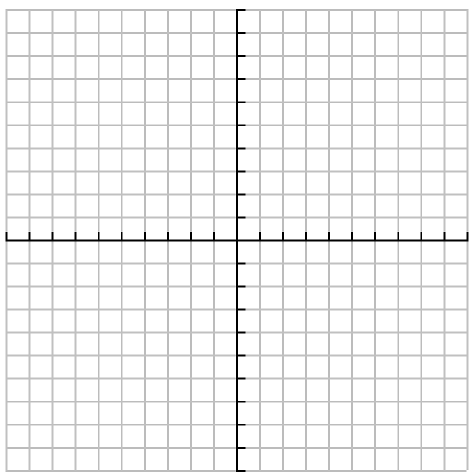
1. $y=\log_2(x-3)+4$ and state the domain, range, and asymptote.

$y=\log_2 x$

x	y

Translate!

$y=\log_2(x-3)+4$	
x	y

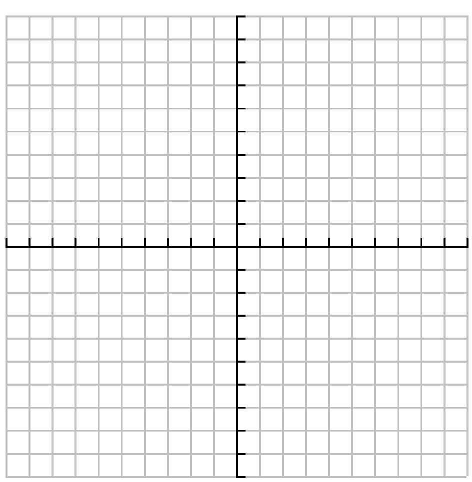


Asymptote: _______________

Domain: _______________

Range: _______________

2. Graph $y=\log_3(x+3)$

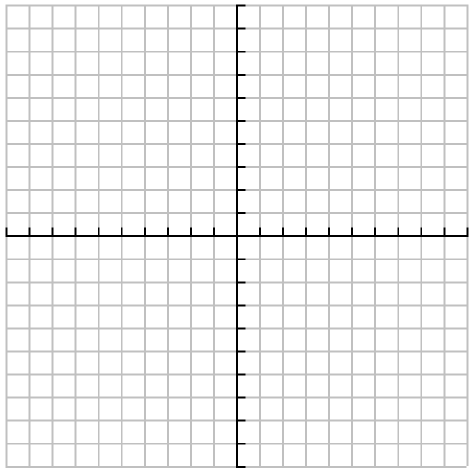


Asymptote: _______________

Domain: _______________

Range: _______________

3. Graph $y = \log_6(x+1) - 2$



Asymptote: ________________

Domain: ________________

Range: ________________

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U8D6: Properties of Logarithms

Objective: To use the properties of logarithms.
Thinking Skill: Demonstrate understanding of concepts.

A. Warm Up: Complete the table below using your calculator. Round each value to the nearest thousandth.

x	1	2	3	4	5	6	7	8	9	10	15	20
log *x*												

<u>Directions</u>: Complete each pair of statements below by using the information in the table you completed.

1. $\log 3 + \log 5 =$ ____________________ $\log(3 \cdot 5) = \log(15) =$ ____________________

2. $2\log 3 =$ ____________________ $\log\left(3^2\right) =$ ____________________

3. $\log 9 - \log 3 =$ ____________________ $\log \frac{9}{3} =$ ____________________

4. $\log 10 + \log 2 =$ ____________________ $\log(10 \cdot 2) = \log 20 =$ ____________________

<u>Properties of Logarithms:</u>

Product Property: $\log_b MN = \log_b M + \log_b N$

Quotient Property: $\log_b \frac{M}{N} = \log_b M - \log_b N$

Power Property: $\log_b M^x = x\log_b M$

Note: *M*, *N*, and *b* must be positive and $b \neq 0$

B. State the property or properties used to rewrite each expression.

1. $\log_2 8 - \log_2 4 = \log_2 2$

2. $\log_b x^3 y = 3\log_b x + \log_b y$

C. Write each logarithmic expression as a single logarithm.

1. $\log_3 20 - \log_3 4$

2. $3\log_2 x + \log_2 y$

3. $3\log 2 + \log 4 - \log 16$

4. Can you express $3\log_2 9 - \log_6 9$ as a single logarithm? Why/why not?

D. Expand each logarithm.

1. $\log_5 \frac{x}{y}$

2. $\log 3r^4$

3. $\log_2 7b$

4. $\log\left(\frac{y}{3}\right)^2$

5. $\log_7 a^3b^4$

6. $\log_8 8\sqrt{3a^5}$

7. $\log \frac{m^3}{n^4 p^{-2}}$

8. $\log_b \left(\frac{x}{5}\right)^{2y}$

9. $\log_5 2x^3$

Review for Quiz:

Look back at all your notes and homework! Know your formulas!

Day 1 – Day 5: You will be able to use a calculator.

1. A student wants to save \$8000 for college in five years. How much should be put into an account that earns 5.2% annual interest <u>compounded continuously</u>? Round your answer to the nearest hundredth.

2. Write an exponential function for a graph that includes (–3, 24) and (–2, 12).

Solve for *x*.

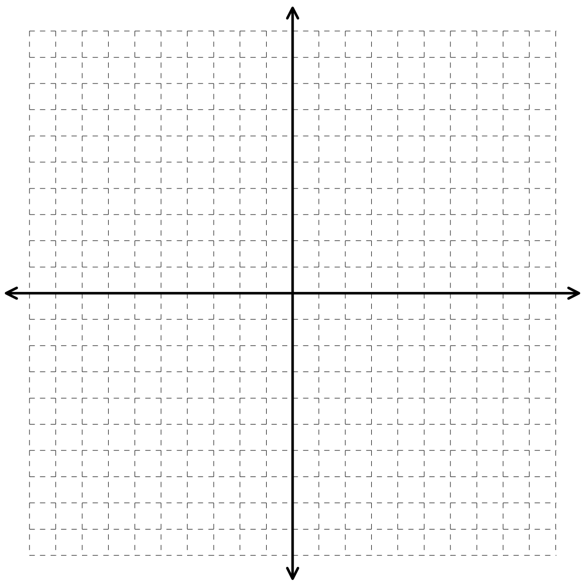
3. $\log_3 \frac{1}{27} = x$

4. $x = \log_8 4$

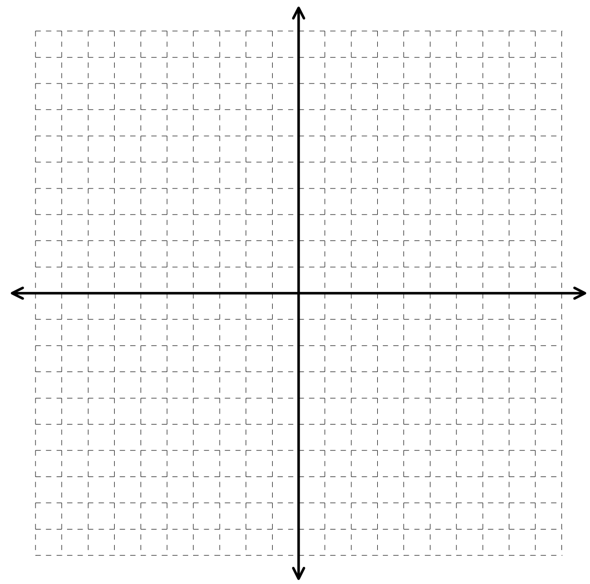
5. $\log_4 x = \frac{3}{2}$

Graph the following. Then, state the domain, range, and asymptote.

6. $y = -\left(\frac{1}{3}\right)^{x-2} + 3$



7. $y = \log_2(x-3)$



8. Suppose you purchase a home that costs $235,000. If the expected rate of appreciation of the home is 3% per year. Estimate the value of the home after 30 years.

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U8D8: Exponential Equations

Objective: To solve exponential equations.
Thinking Skill: Explicitly assess information and draw conclusions.

A. Warm Up: Write the expression as a single logarithm. Then, simplify if possible.

1. $\log_2 24 - \log_2 3$

2. $\log_2 225 - \log_2 5 + \log_2 3$

3. $\log_2 x - 4\log_2 y$

4. $2\log 3 - \frac{1}{2}\log 4 + \frac{1}{2}\log 9$

5. $\frac{1}{4}\log_3 2 + \frac{1}{4}\log_3 x$

6. $\log 1 + \log 100$

B. An exponential equation is an equation containing one or more expressions that have a variable as an exponent.

Strategies to solve exponential equations:

- Express each side with the same base.
- Use the One-to-One property: If $a^x = a^y$, then $x = y$.
- Take the logarithm of both sides.

Solve.

1. $27^x = 3^{x+8}$

2. $7^{x-3} = 350$

C. Solve these exponential equations.

1. $3^{2x} = 27$

2. $2^{3x} = 15$

3. $5^{x-2} = 200$

D. You can choose a prize of either a $25,000 car or one penny on the first day, triple that (3 cents) on the second day, and so on for a month. On what day would you would you receive more than the value of the car?

Closure: What are two ways to solve an exponential equation?

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U8D9: Logarithmic Equations

Goal: To solve logarithmic equations.
Thinking Skill: Examine information from more than one point of view.

A. Warm Up: Solve. Round to the nearest ten-thousandth.

1. $8^x = 2^{x+6}$
2. $7^{-x} = 21$
3. $5 - 3^x = -40$

Strategies for solving Logarithmic Equations

1) Write as a single log using properties of logs (when necessary).
2) Convert to exponential form: If $\log_b a = y$, then $b^y = a$.
3) Use the One-to-One property: If $\log_b M = \log_b N$, then $M = N$.
4) Check for extraneous solutions. (The argument should never be negative.)

B. Solve the logarithmic equation.

1. $\log_4(x-1) = 3$
2. $\log 30x - \log 6 = 4$
3. $\log_3 x^2 = 8$
4. $\log x + \log(x+3) = 1$
5. $\log 3 + \log(x-2) = \log 9$

C. Solve on your own.

1. $\log_6(2x-1)=-1$

2. $\log_4 100-\log_4(x+1)=1$

3. $\log_5 x^4=8$

4. $\log_{12} x+\log_{12}(x+1)=1$

5. $\log_8 x=\log_8 2+\log_8(x+5)$

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U8D10: Application of Exponents / Logarithms

Objective: To learn how logarithms are used in real-life scenarios.
Thinking Skill: Explicitly assess information and draw conclusions.

A. Warm up: Solve for x. If there is no solution, write "no solution".

1. $5+\log_3(x-8)=9$
2. $-3\log_4(-4x)=-6$
3. $-\log_5(x-4)=1-\log_5(x-8)$
4. $\log_6 8=\log_6 2+\log_6(x-8)$

B. Suppose that the number of bacteria per square millimeter in a culture in your biology lab is increasing exponentially with time. On Tuesday there are 2000 bacteria per square millimeter. On Thursday, the number has increased to 4500.

1. Write an exponential equation to represent the growth.

2. Predict the number of bacteria per square millimeter that will be in the culture on Tuesday next week.

3. Predict the time when the number of bacteria per square millimeter reaches 10,000.

Assignment

1. The pressure of the air in the Earth's atmosphere decreases exponentially with altitude above the surface of the Earth. The pressure at the Earth's surface (sea level) is about 14.7 pounds per square inch (PSI) and the pressure at 2000 feet is approximately 13.5 PSI.

    a. Write the equation expressing pressure in terms of altitude.

    b. Predict the pressure at Mexico City (7500 feet) and Mount Everest (29,000).

    c. Human blood at body temperature will boil if the pressure is below 0.9 PSI. At what altitude would your blood start to boil if you were in an unpressurized airplane?

2. The intensity of sunlight reaching points below the surface of the ocean varies exponentially with the depth of the point below the surface of the water. Suppose that when the intensity at the surface is 1000 units, the intensity at a depth of 2 meters is 60 units.

   a. Write the particular equation expressing intensity in terms of depth.

   b. Predict the intensity at depths of 4, 6, 8, and 10 meters.

   c. Plants cannot grow beneath the surface if the intensity of sunlight is below 0.001 units. What is the maximum depth at which plants will grow?

3. During the first stages of an epidemic, the number of sick people increases exponentially with time. Suppose that at time $t = 0$ days there are 40 people sick. By the time $t = 3$ days, 200 people are sick.

   a. Find the particular equation expressing number of sick people in terms of time.

   b. How many people will be sick by the time $t = 6$ days?

   c. Predict the number of sick people by the end of the first week.

   d. At what time t does the number of sick people reach 7,000?

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U8D11: Natural Logs

Objective: To evaluate natural logarithmic expressions and to solve equations using natural logarithms.
Thinking Skill: Explicitly assess information and draw conclusions.

A. Remember *e*? We use *e* (approximately 2.71828) to graph exponential equations of the form $y = e^x$.

Just as $y = b^x$ has an *inverse*, $y = e^x$ has an *inverse* called a **natural log**.

Natural logarithms are written as $\ln(x)$, rather than $\log_e(x)$.

The properties of common logs apply to natural logs as well.

B. Simplify: write each expression as a single logarithm.

1. $3\ln x - \ln 8$

2. $3\ln x + \ln y$

C. Solve each equation

1. $\ln x = 6$

2. $\ln(3x+5) = 4$

3. $\ln(2x-9) = 3$

4. $\ln\left(\dfrac{x+2}{3}\right) = 12$

D. Use natural logarithms to solve each equation.

1. $7e^{2x} + 2.5 = 20$

2. $e^{x+1} = 30$

3. $e^{\frac{2x}{5}} + 7.2 = 9.1$

4. An initial investment of $100 is now valued at $149.18. The interest rate is 8%, compounded continuously. How long has the money been invested? Do not round any intermediate computations, and round your answer to the nearest hundredth.

5. Suppose that $1900 is initially invested in an account at a fixed interest rate, compounded continuously. Suppose also that, after two years, the amount of money in the account is $1984. Find the interest rate per year. Write your answer as a percentage. Do not round any intermediate computations, and round your percentage to the nearest hundredth.

E. Closure: Solve for *x*.

1. $\ln e^{\frac{2}{3}} = x$

2. $\ln 1 = x$

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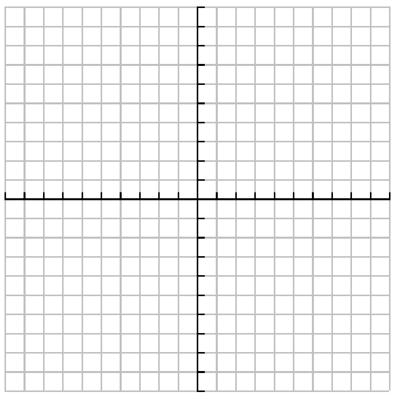
U8D12: Applications of Natural Logs

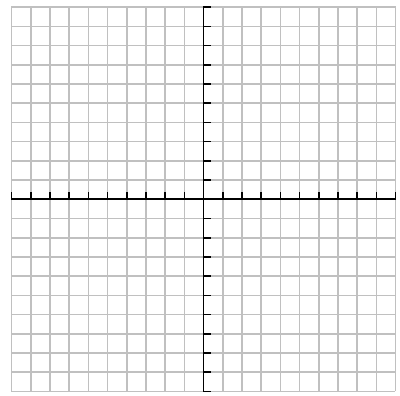
Objective: To continue using natural logs.
Thinking Skill: Examine information from more than one point of view.

Graph each logarithm.

1. $y = \log_6 x$



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



Expand each logarithm.

3. $\log \frac{s^3}{r^5}$

4. $\log_6 (3xy)^2$

5. $\log_6 4\sqrt{x}$

Solve each equation

6. $7 - 2^x = -1$

7. $\log 5x = 2$

8. $3\log x = 9$

9. If \$1000 is invested at 16% interest compounded annually, how long will it take (to the nearest year) for the money to quadruple?

10. If \$1000 is invested at 12% interest compounded quarterly, how long will it take (to the nearest quarter) for the money to reach \$2500?

11. If \$1000 is invested at 15% interest compounded continuously, how long will it take (to the nearest year) for the money to triple?

12. The "learning curve" describes the rate at which a person learns certain tasks. If a person sets a goal of typing N words per minute (wpm), the length of time t days to achieve this goal is given by: $t = -62.5\ln\left(1 - \frac{N}{80}\right)$

    a.) How long would it take to learn to type 30 wpm?

    b.) If we accept this formula, is it possible to learn to type 80 wpm?

    c.) Solve for *N*.

Solve the following equations.

13. $\log_5 25 = x$

14. $\log_x 28 = 2$

15. $\ln x = 2$

16. $\ln 9.3 = \ln x$

17. $\log_3 x^2 = \log_3 125$

18. $\log_3 27\sqrt{3} = x$

19. $\log_x 10 = 0$

20. $\ln x^2 = \ln 12$

21. $\log_x 84 = 2$

22. $e^{2x} = 10$

23. $e^{1-2x} = 3$

24. $e^{1-5x} = 15$

25. $\log_8 5 + \frac{1}{2}\log_8 9 = \log_8 x$

26. $\log_7 x - \frac{1}{2}\log_7 4 = \frac{1}{2}\log_7 (2x-3)$

27. $2\ln x - \frac{1}{2}\ln 9 = \ln 3(x-2)$

28. $\ln 10 - \frac{1}{2}\ln 25 = \ln x$

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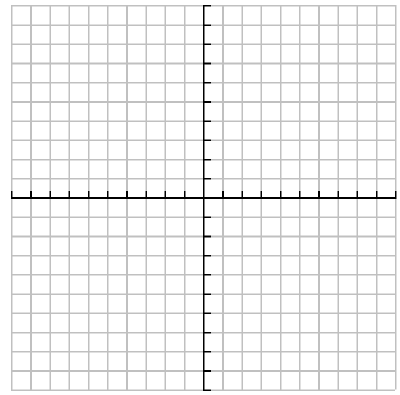
U8D13: Test Review

Objective: To review in preparation for the test.
Thinking Skill: Demonstrate understanding of concepts.

1. Consider the function: $y = \log_2(x+1)$



   a. Sketch the graph by using a table.

   b. Identify the asymptote (write its equation!!)

   c. Find the inverse of the function.

   d. On the same axis, sketch the inverse. Be sure to label which is which!

2. Evaluate each logarithm. If you need to use a calculator, do it!

   a. $\log_3 \frac{1}{27}$ b. $\log_4 6$ c. $2\log_5 10 + \log_8 16$

3. Write as a single logarithm. $3\log x - 2\log y + \frac{2}{3}\log z$

4. Use the properties of logarithms to expand each logarithm.

a. $\log \frac{xy^3}{z^2}$

b. $\ln\left(2x^3\right)^5$

c. $\log \sqrt{\frac{x^2 y^3}{z^4}}$

5. Solve for x in each equation. Be sure to check your solution!

a. $\log_2\left(3x+5\right)=0$

b. $\log_3 \sqrt{x}=2$

c. $20=3^{1-5x}$

d. $\frac{1}{4}e^{3x}=15$

e. $\log_4\left(x+1\right)=2+\log_4\left(3x-2\right)$

f. $2^{x+1}=3^{-4x}$

g. $e^{\ln(x+2)}=3$

h. $\log_x 2=\frac{1}{3}$

6. You decide to plant asparagus in your kitchen garden. You harvest 10 stalks on Jan. 1, 1986. By 1988, you produce 50 stalks. Assume the number of stalks you harvest varies exponentially with the number of years since you started harvesting the plants.

   a) Find the particular equation of this function.

   b) You will need 100 stalks to enter the gardening contest at the local fair. In what year will you harvest 100 stalks?

   c) What was your production in the year 2000?