11

General Mathematics

Quarter 1 – Module 8:

Logarithmic Functions

SELF-LEARNING MODULE

DEPARTMENT OF EDUCATION - SOCCSKSARGEN

General Mathematics – Grade 11
Self-Learning Module (SLM)
Quarter 1 – Module 8: Logarithmic Functions
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Introductory Message

This Self-Learning Module (SLM) is prepared so that you, our dear learners, can continue your studies and learn while at home. Activities, questions, directions, exercises, and discussions are carefully stated for you to understand each lesson.

Each SLM is composed of different parts. Each part shall guide you step-by-step as you discover and understand the lesson prepared for you.

Pre-test are provided to measure your prior knowledge on lessons in each SLM. This will tell you if you need to proceed on completing this module, or if you need to ask your facilitator or your teacher's assistance for better understanding of the lesson. At the end of each module, you need to answer the post-test to self-check your learning. Answer keys are provided for each activity and test. We trust that you will be honest in using these.

In addition to the material in the main text, Notes to the Teachers are also provided to the facilitators and parents for strategies and reminders on how they can best help you on your home-based learning.

Please use this module with care. Do not put unnecessary marks on any part of this SLM. Use a separate sheet of paper in answering the exercises and tests. Read the instructions carefully before performing each task.

If you have any questions in using this SLM or any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator.
Thank you.

What I Need to Know

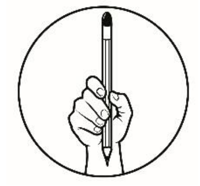
This module was designed and written with you in mind. It is here to help you master the Logarithmic Functions. The scope of this module permits it to be used in many different learning situations. The language used recognizes the diverse vocabulary level of students. The lessons are arranged to follow the standard sequence of the course. But the order in which you read them can be changed to correspond with the textbook you are now using.

This module presents lessons in the following manner:

1. Logarithmic functions including common and natural logarithms;
2. Comparison of Logarithmic Equations, Logarithmic Inequalities, and Logarithmic Functions;
3. Solving logarithmic equations and inequalities; and
4. Application of logarithms to Real- life situations

After going through this module, you are expected to:

1. define logarithmic function including common and natural logarithms, logarithmic equation and logarithmic inequality;
2. distinguish logarithmic function, logarithmic equation and logarithmic inequality
3. solve logarithmic equations and inequalities; and
4. apply logarithms in real- life context.



What I Know

Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. Given the formula R= $\frac{2}{3}\log\frac{E}{10^{4.40}}$, what is the magnitude in the Richter scale of an earthquake that released 10^{16} joules of energy?
   A. 7.5
   B. 7.7
   C. 5.7
   D. 7.6

2. What is the inverse of the exponential function?
   A. Linear function
   B. Polynomial function
   C. Quadratic function
   D. Logarithmic function

3. Which of the following is NOT a logarithmic equation?
   A. $\log_2 32 = 3x$
   B. $\log_4(5x+1) = 2$
   C. $\log_{x-2}(10-3x) < 2$
   D. $\log_4(3x-1) = \log_4(2x+3)$

4. Using the one-to-one, logarithmic equation $\log_6 2x = \log_6 24$ is equal to?
   A. $\log_6 2x - \log_6 24 = 0$
   B. $\log_3 x = \log_3 12$
   C. 2x = 24
   D. None of these

5. You test some ammonia and determine the hydrogen ion concentration to be $[H^+] = 1.3 \text{ x } 10^{-9}$. Thus, the ammonia is ______.
   A. acidic
   B. neutral
   C. basic
   D. none of these

6. Which of the following is a solution to the logarithmic inequality $\log_5 x \geq 3$?
   A. $x>125$
   B. $x<125$
   C. $x\geq125$
   D. $x=125$

7. Grunting while hitting the ball has become a controversial issue in professional tennis. Some people are concerned that such loud sounds are unfair distractions to the opposing player. Serena Williams's grunts have been measured at a sound intensity of $6.31 \cdot 10^{-4} \frac{w}{m^2}$. What is the relative intensity of the sound in decibels?

   A. 83 decibels
   B. 85 decibels
   C. 88 decibels
   D. 90 decibels

8. Which of the following is equivalent to $(125)^{\frac{1}{3}} = 5$?

   A. $\log_{125}5 = \frac{1}{3}$
   B. $\log_5 125 = \frac{1}{3}$
   C. $\log_{\frac{1}{3}}5 = 125$
   D. $\log_5 \frac{1}{3} = 125$

9. Which of the following ***does not*** describe the use of logarithmic scales?

   A. When the range of values vary greatly, using a logarithmic scale with powers of 10 makes comparisons between values more manageable.

   B. Scales that measure a wide range of values, such as the pH scale, the Richter scale and decibel scales are logarithmic scales.

   C. Logarithmic scales more effectively describe and compare vast or large quantities than they do small or microscopic quantities.

   D. To compare concentrations modelled with logarithmic scales, determine the quotient of the values being compared.

10. Which of the following is equivalent to $\log_2 16 = 4$
   A. $2^4 = 16$
   B. $4^2 = 16$
   C. $16^2 = 4$
   D. $16^4 = 2$

11. Which of the following statements regarding rates of change of exponential and logarithmic functions is ***NOT*** true?
   A. The average rate of change is not constant for exponential and logarithmic functions.
   B. The methods for finding the instantaneous rate of change at a particular point for logarithmic functions are different than those used for finding the instantaneous rate of change at a point for a rational function.
   C. The graph of an exponential or logarithmic function can be used to determine when the average rate of change is the least or greatest.
   D. None of these

12. Determine the value of x if $\log_7 x = 2$

A. 14
B. $\frac{1}{14}$
C. 49
D. $\frac{1}{49}$

13. The magnitude in the Richter scale of an earthquake that released 10^{12} joules of energy is 5.06. How much more energy does this earthquake release than that of the reference earthquake?

A. 39810720 times
B. 39810718 times
C. 39810717 times
D. 39810719 times

14. Given $\log_6(x + 8) > 2$, what should be considered in the expression x + 8?

A. x + 8 must be greater than 2.
B. x + 8 must be less than 0.
C. x + 8 must be nonnegative.
D. x + 8 must be greater than 0.

15. If $\log_5 (3x + 2) < \log_5(2x + 5)$, what is the interval notation?

A. $(-\frac{2}{3} < x < 3)$
B. $(3 < x < \frac{2}{3})$
C. $(\frac{2}{3} < x < 3)$
D. None of these

Lesson 1 Logarithmic Functions, Equations, and Inequalities

Logarithmic functions are very much essential to every sphere of human life. Especially, in solving exponential equations. Some examples of this include sound (decibel measures), earthquakes (Richter scale), and chemistry (pH balance, a measure of acidity and alkalinity).

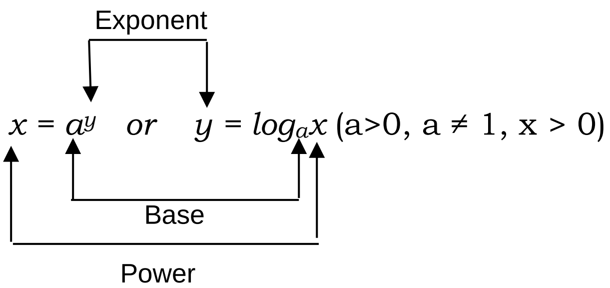
What's In

In the previous module, you have learned about inverse functions. Recall that when the domain of one function is the range and the range is the domain of the other, then they are inverses. Remember also that to determine the inverse of a function given an equation, you have to interchange x and y then solve for y. Look at the illustration below on how to find the inverse of the exponential function, $y = a^x$.

Exponential Function	Inverse function
$y = a^x$	$x = a^y$

You will notice that the inverse of the exponential function shows that "y is the exponent to which the base a is raised in order to obtain the power x".

The inverse of the exponential function above is called *logarithmic function.* The function is defined by the equation



$$x = a^y \quad or \quad y = \log_a x \; (a>0,\ a \neq 1,\ x > 0)$$

The equation of a logarithmic function is read as "**y is the logarithm of x to the base a**". Take note that in the notation, a is the base, x is the power and y is the exponent to which a is raised in order to obtain x.

What's New

To help you understand logarithmic functions, do the given activity.

An amoeba multiplies by dividing. That is, if it has grown to a certain size, that single cell divides in half to produce two amoebas. In a day, those two amoebas are ready to divide and form four amoebas. At the end of the seventh day, how many amoebas will be formed? Enter your answer in the table below.

Time(in days)	0	1	2	3	4	5	6	7
Number of amoebas								

Questions:

(a) At the end of the seventh day, how many amoebas will be formed?

(b) What pattern can be observed from the data?

(c) Define a formula for the number of amoebas as a function of the time that has passed.

Answers:

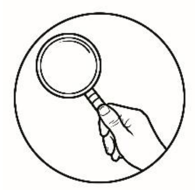
Time(in days)	0	1	2	3	4	5	6	7
Number of amoebas	1	2	4	8	16	32	64	128

It can be observed that as the time (in days) increases by 1, the number of amoeba doubles. The formula for the given table is

$$y(x) = 2^x$$

where y represents a number in the geometric sequence and x represents the logarithm of y.

Note: The logarithm, x, is the exponent of 2. For example, the logarithm of 32 is 5 because $32 = 2^5$, the logarithm of 16 is 4 because $16 = 2^4$, and so on.



What is It

Logarithmic Function

Definition

Let a, b, and c be positive real numbers such that b ≠ 1. The **logarithm** of a with base b is denoted by log_ba, and is defined as

$$c = log_b\, a \text{ if and only if } a = b^c$$

Note:

1. In both the logarithmic and exponential forms, b is the base. In the exponential form, c is an exponent; this means that the logarithm is actually an exponent. Hence, logarithmic and exponential functions are inverses.
2. In the logarithmic form $log_b\, x$, x cannot be negative.
3. The value of $log_b\, x$ can be negative.

Definition

Common logarithms are logarithms with base 10; log x is a short notation for $\log_{10} x$.

Example 1: Consider the following:

$\log_{10} 10$	= log 10 = 1	because $10^1 = 10$
$\log_{10} 100$	= log 100 = 2	because $10^2 = 100$
$\log_{10} 1000$	= log 1000 = 3	because $10^3 = 1000$
$\log_{10} 1$	= log 1 = 0	because $10^0 = 1$

Definition

Natural logarithms are logarithms to the base *e* (approximately 2.71828), and are denoted by "ln". In other words, lnx is another way of writing $\log_e x$.

Example 2: The natural logarithmic function is defined as $y = ln\, x$ f and only if $e^x = y$ Since the base of the natural logarithmic function is *e,* we choose the x values to be powers of *e*, so that the y values may be easily computed.

Example 3. Rewrite the following exponential equations in logarithmic form, whenever possible.

1. $5^3 = 125$
2. $7^{-2} = 1/49$
3. $10^2 = 100$
4. $(2/3)^2 = 4/9$
5. $(0.1)^{-4} = 10000$
6. $4^0 = 1$
7. $7^b = 21$
8. $e^2 = x$
9. $(-2)^2 = 4$

Solution.

1. $\log_5 125 = 3$
2. $\log_7(\frac{1}{49}) = -2$
3. $\log 100 = 2$
4. $\log_{2/3}(4/9) = 2$
5. $\log_{0.1} 10000 = -4$
6. $\log_4 1 = 0$
7. $\log_7 21 = b$
8. $\ln x = 2$
9. cannot be written in logarithmic form

Example 4. Rewrite the following logarithmic equations in exponential form.

1. $\log m = n$
2. $\log_3 81 = 4$
3. $\log_{\sqrt{5}} 5 = 2$
4. $\log_{\frac{3}{4}} (64/27) = -3$
5. $\log_4 2 = ½$
6. $\log 0.001 = -3$
7. $\ln 8 = a$

Solution.

1. $10^n = m$
2. $3^4 = 81$
3. $(\sqrt{5})^2 = 5$
4. $(3/4)^{-3} = 64/27$
5. $4^{\frac{1}{2}} = 2$
6. $10^{-3} = 0.001$
7. $e^a = 8$

Example 5. Find the value of the following logarithmic expressions.

1. $\log_2 32$ 2. $\log_9 729$ 3. $\log 0.001$ 4. $\log_{\frac{1}{2}} 16$ 5. $\log_7 1$ 6. $\log_5 \frac{1}{\sqrt{5}}$

Solution.

(1) What exponent of 2 will give 32? **Answer: 5**

(2) What exponent of 9 will give 729? **Answer: 3**

(3) What exponent of 10 will give 0.001? **Answer: -3**

(4) What exponent of 1/2 will give 16? **Answer: −4**

(5) What exponent of 7 will give 1? **Answer: 0**

(6) What exponent of 5 will give $\frac{1}{\sqrt{5}}$? **Answer: −1/2**

Logarithmic Equations, Logarithmic Inequalities and Logarithmic Functions

The definitions of logarithmic equations, logarithmic inequalities and logarithmic functions are shown below.

	Logarithmic Equation	**Logarithmic Inequality**	**Logarithmic Function**
Definition	An equation involving logarithms.	An inequality involving logarithms.	Function of the form f(x) = $\log_b x$ $(b > 0, b \neq 1)$
Example	$\log_x 2 = 4$	$\ln x^2 > (\ln x)^2$	g(x) = $\log_3 x$

A logarithmic equation or inequality can be solved for all x values that satisfy the equation of inequality. A logarithmic function expresses a relationship between two variables (such as x and y), and can be represented by a table of values or a graph.

Solving Logarithmic Equation and Inequalities

Property of Logarithmic Equations

If b > 1, then the logarithmic function y = $\log_b x$ is increasing for all x. If 0 < b <1, then the logarithmic function y = $\log_b x$ is decreasing for all x. This means that $\log_b u = \log_b v$ if and only if u = v.

Techniques. Some strategies for solving logarithmic equations:

1. Rewriting to exponential form;
2. Using logarithmic properties;
3. Applying the one-to-one property of logarithmic functions; and
4. The Zero Factor Property: If ab = 0, then a = 0 or b = 0.

Example 6. Find the value of x in the following logarithmic equations.

a. $\log_5 x = 4$

Solution. $\log_5 x = 4$

$x = 5^4$ (change into exponential form)

$x = 625$

b. $\log_x 36 = 2$

Solution. $\log_x 36 = 2$

$x^2 = 36$ (change into exponential form)

$x^2 - 36 = 0$

$(x+6)(x-6) = 0$ (factoring difference of two squares)

$x = 6, -6$ **Note:** -6 is not defined in the given logarithmic equation since the base cannot be negative.

c. $\log_2 x + \log_2(x-6) = 4$

Solution. $\log_2 x + \log_2(x-6) = 4$

$\log_2 x(x-6) = 4$ (applying law of logarithm)

$x(x-6) = 2^4$ (change into exponential form)

$x^2 - 6x = 16$ (distributive property)

$x^2 - 6x - 16 = 0$ (subtract 16 both sides)

$(x-8)(x+2) = 0$ (factor)

$x = 8, -2$

d. $\log_3 6x = \log_3 24$

Solution. $\log_3 6x = \log_3 24$

$6x = 24$ (one-to-one property)

$x = 4$ (divide both sides by 6)

e. $4 \ln 2x = 12$

Solution. $4 \ln 2x = 12$

$4 \ln 2x = 3$ (divide both sides by 4)

$\log_e 2x = 3$ (equivalent form)

$2x = e^3$ (change into exponential form)

$x = \frac{e^3}{2}$ (divide both sides by 2)

$x \approx 10.04277$ (use a calculator)

f. $2^x = 9$

Solution. $2^x = 9$

$\log_2 2^x = \log_2 9$ (take $\log_2$ of each side)

$x = \log_2 9$ ($\log_b b^x = x$)

$x = \log 9/\log 2$ (change of the base formula)

$x \approx 3.170$

Property of Logarithmic Inequalities

If $0 < b < 1$, then $x_1 < x_2$ if and only if $\log_b x_1 > \log_b x_2$.

If $b > 1$, then $x_1 < x_2$ if and only if $\log_b x_1 < \log_b x_2$.

Example 7. Solve each logarithmic inequality.

a. $\log_4 x \geq 3$

Solution. $x \geq 4^3$ (change into exponential form)

$x \geq 64$

b. $\log_3 x \leq 5$

Solution. $x \leq 3^5$ (change into exponential form)

$x \leq 243$ (evaluate the power)

$0 < x \leq 243$ (exclude zero and negative numbers)

or $(0,243]$ (solution in interval notation)

c. $\log_3(x+1) \leq 2$

Solution.

i. $x + 1 > 0$

$x > -1$

ii. $x+1 \leq 3^2$ (change into exponential form)

$x \leq 8$ (evaluate the power and subtract both sides by 1)

Hence, the solution is the interval notation **(-1,8**].

d. $\log_6(2x+1) < \log_6(x+4)$

Solution.

i. $2x + 1 > 0$

$x > -\frac{1}{2}$

ii. $x + 4 > 0$

$x > -4$

iii. $\log_6(2x+1) < \log_6(x+4)$

$(2x+1) < (x+4)$ (one-to-one property)

$x < 3$ (solve the inequality)

Hence, the solution is the interval notation **(-1/2,3)**.

Applications of Logarithms to Real-Life Context

Some of the most common applications in real-life of logarithms are the Richter scale, sound intensity, and pH level.

The Richter scale. In 1935, Charles Richter proposed a logarithmic scale to measure the intensity of an earthquake. He defined the magnitude of an earthquake as a function of its amplitude on a standard seismograph. The following formula produces the same results, but is based on the energy released by an earthquake.

Earthquake Magnitude on a Richter scale

The magnitude *R* of an earthquake is given by

$$R = \frac{2}{3} \log \frac{E}{10^{4.40}}$$

where E (in joules) is the energy released by the earthquake (the quantity $10^{4.40}$ joules is the energy released by a very small reference earthquake).

The formula indicates that the magnitude of an earthquake is based on the logarithm of the ratio between the energy it releases and the energy released by the reference earthquake.

Example 8. Suppose that an earthquake released approximately 1012 joules of energy.

(a) What is its magnitude on a Richter scale?

(b) How much more energy does this earthquake release than the reference earthquake?

Solution.

(a) Since $E = 10^{12}$, then $R = \frac{2}{3} \log \frac{E}{10^{4.40}} = \frac{2}{3} \log 10^{7.6}$.

Since by definition, $\log 10^{7.6}$ is the exponent by which 10 must be raised to obtain $10^{7.6}$, then $\log 10^{7.6} = 7.6$.

Thus, $R = \frac{2}{3}(7.6) \approx 5.1$.

(b) This earthquake releases $\frac{10^{12}}{10^{4.40}} = 10^{7.6} \approx 39810717$ times more energy than the reference earthquake.

Example 9. The decibel level of sound in a quiet office is 10^{-6} watts/m^2.

(a) What is the corresponding sound intensity in decibels?

(b) How much more intense is this sound than the least audible sound a human can hear?

Sound Intensity

In acoustics, the decibel (dB) level of a sound is

$$D = 10 \log \frac{I}{10^{-12}}$$

where I is the sound intensity in watts/m^2 (the quantity 10^{-12} watts/m^2 is least audible sound a human can hear).

Solution.

(a) $D = 10 \log \frac{10^{-6}}{10^{-12}} = 10 \log 10^{6}$. Since by definition, log 10^6 is the exponent by which 10 must be raised to obtain 10^6, then log 10^6 = 6.

Thus, D = 10(6) = 60 decibels.

(b) This sound is $10^{-6}/10^{-12} = 10^6$ = 1,000,000 times more intense than the least audible sound a human can hear.

Definition:

Acidity and the pH scale

The pH level of a water-based solution is defined as

$$pH = -\log[H+],$$

where [H+] is the concentration of hydrogen ions in moles per liter. Solutions with a pH of 7 are defined **neutral**; those with pH < 7 are **acidic**, and those with pH > 7 are **basic**.

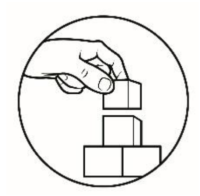
Example 10. A 1-liter solution contains 0.00001 moles of hydrogen ions. Determine its pH level.

Solution.

Since there are 0.00001 moles of hydrogen ions in 1 liter, then the concentration of hydrogen ions is 10^{-5} moles per liter.

The pH level is $-\log 10^{-5}$. log 10^{-5} Since log 10^{-5} is the exponent by which 10 must be raised to obtain 10^{-5}, then log $10^{-5} = -5$.

Therefore, pH = $-\log 10^{-5} = -(-5) = 5$.



What's More

Activity 1. Guess What?

Read and analyze carefully the statements below. Put a check mark that corresponds to the correct answer.

Entry Card		
Tell whether each statement is TRUE or FALSE	**TRUE**	**FALSE**
1. The equation $a^5 = 3$ is equivalent to $\log_a 3 = 5$.		
2. $\log_{64} 8 = 2$		
3. The inverse of $y = x - 1$ is $y = x + 1$		
4. If $2^x = 64$, then $x = 6$.		
5. $\log_{10}(0) = 0$		
6. $\log_{10}(-10) = 0$		
7. A logarithm is an exponent.		
8. $\log_x 2 = 2$ is a logarithmic equation.		
9. $\log_{\frac{1}{5}}(5x - 1) \geq 0$ is a logarithmic inequality.		
10. $\log_5(3 - 2x) \geq \log_5(4x + 1)$ is NOT a logarithmic inequality.		

Activity 2. Complete Me

Complete the following table by rewriting the given exponential expressions to logarithmic form whenever possible and/or vice versa.

Exponential Form	Logarithmic Form
1. $16 = 2^4$	
2. $9 = \sqrt{81}$	
3. $\frac{1}{9} = 3^{-2}$	
4.	$\log_3 9 = 2$
5.	$\log_5 \frac{1}{25}$

Activity 3. Tell Me!

Determine whether the given statement is a *logarithmic equation*, *logarithmic inequality*, or *logarithmic function.*

1. $g(x) = \log_5 x$
2. $\log_3(2x - 1) = 2$
3. $f(x) = \log_{\frac{1}{2}}(x - 1)$
4. $y = 5 - \log_8 x$
5. $x \log_2(x - 1) > 0$

Activity 4. Think of Me!

A. Determine the value of the following logarithmic expressions.

1. $\log_3 81$ 2. $\log_{169} 13$ 3. $\log_5 \frac{1}{5}$ 4. $\log_3 \frac{1}{243}$ 5. $\log_{27} 3$

B. Solve each of the following logarithmic equations.

1. $\log_3 x = 5$
2. $\ln x = 1$
3. $\log_2(2x+1) = 3$
4. $\log_6 x^2 = 2$
5. $\log_2(x) + \log_2(x+1) = 1$
6. $\log_x 0.01 = -2$
7. $\log_4 5x = \log_4(x+4)$
8. $\log_x e^{12} = 12$
9. $\text{Log}_5(2x-1) = 2$
10. $5 \ln 3x = 15$

C. Write the solution to each of the following inequalities.

1. $\log_4(x+7) > 3$
2. $\log_2(x+18) \geq 5$
3. $\log_6(2x-3) \geq 2$
4. $\log_4(3x-5) > 1$
5. $\text{Log}_{12}(x-1) < 2$

Activity 5. Applications of logarithms in real-life scenario

Apply your learnings on logarithmic functions to answer the following situations:

1. What is the magnitude in the Richter scale of an earthquake that released 10^{14} joules of energy? How much more energy does this earthquake release than that of the reference earthquake?

2. Suppose the intensity of sound of a jet during takeoff is 100 watts/m^2. What is the corresponding sound intensity in decibels? How much more intense is this sound than the least audible sound a human can hear?

3. A 1-liter solution contains 10^{-8} moles of hydrogen ions. Determine whether the solution is acidic, neutral, or basic.

What I Have Learned

Fill in the blanks.

1. The inverse of the exponential function is called _______________.
2. The _________________ is a logarithmic scale used to measure the magnitude of earthquakes.

3. ________________are logarithms to the base e (approximately 2.71828), and are denoted by "ln".
4. The logarithm of 16 to the base of one- half is equal to __________.
5. Common logarithm uses ____ as the base.
6. The logarithm is actually a/an _____________.
7. The equation of a logarithmic function **$y = \log_a x$** is read as ____.
8. The symbol used in logarithmic equation is _________________________.
9. The signs >, <, ≥, ≤ are the symbols used by the logarithmic _______________.
10. g(x) or f(x) commonly used by the logarithmic ______________________.

What I Can Do

Activity 6

1. This problem can help foster awareness on possible disaster management and risk reduction plans. Use a scientific calculator.

   Problem: The 2013 earthquake in Bohol and Cebu had a magnitude of 7.2, while the 2012 earthquake that occurred in Negros Oriental recorded a 6.7 magnitude. How much more energy was released by the 2013 Bohol/Cebu earthquake compared to that by the Negros Oriental earthquake?

2. Blood has a hydronium ion concentration of approximately 4×10^{-7} mol/L. Is blood acidic or alkaline?

3. Explain how to solve a logarithmic equation. Use $\log_2(x-3) = 5$.

Assessment

Multiple Choice. Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. Which of the following ***does not*** describe the use of logarithmic scales?

   A. When the range of values vary greatly, using a logarithmic scale with powers of 10 makes comparisons between values more manageable.

   B. Scales that measure a wide range of values, such as the pH scale, the Richter scale and decibel scales are logarithmic scales.

   C. Logarithmic scales more effectively describe and compare vast or large quantities than they do small or microscopic quantities.

   D. To compare concentrations modelled with logarithmic scales, determine the quotient of the values being compared.

2. Grunting while hitting the ball has become a controversial issue in professional tennis. Some people are concerned that such loud sounds are unfair distractions to the opposing player. Serena Williams's grunts have been measured at a sound intensity of $6.31 \cdot 10^{-4} \frac{w}{m^2}$. What is the relative intensity of the sound in decibels?

   A. 83 decibels
   B. 85 decibels
   C. 88 decibels
   D. 90 decibels

3. What is the inverse of the exponential function?
   A. Linear function
   B. Polynomial function
   C. Quadratic function
   D. Logarithmic function

4. Which of the following is NOT a logarithmic equation?
   E. $\log_2 32 = 3x$
   F. $\log_4(5x + 1) = 2$
   G. $\log_{x-2}(10 - 3x) < 2$
   H. $\log_4(3x - 1) = \log_4(2x + 3)$

5. Using the one-to-one, logarithmic equation $\log_6 2x = \log_6 24$ is equal to?
   E. $\log_6 2x - \log_6 24 = 0$
   F. $\log_3 x = \log_3 12$
   G. 2x = 24
   H. None of these

6. Which of the following statements regarding rates of change of exponential and logarithmic functions is ***NOT*** true?
   A. The average rate of change is not constant for exponential and logarithmic functions.
   B. The methods for finding the instantaneous rate of change at a particular point for logarithmic functions are different than those used for finding the instantaneous rate of change at a point for a rational function.
   C. The graph of an exponential or logarithmic function can be used to determine when the average rate of change is the least or greatest.
   D. None of these

7. The magnitude in the Richter scale of an earthquake that released 10^{12} joules of energy is 5.06. How much more energy does this earthquake release than that of the reference earthquake?

   A. 39810720 times
   B. 39810718 times
   C. 39810717 times
   D. 39810719 times

8. Given the formula $R = \frac{2}{3} \log \frac{E}{10^{4.40}}$, what is the magnitude in the Richter scale of an earthquake that released 10^{16} joules of energy?
   A. 7.5
   B. 7.7
   C. 5.7
   D. 7.6

9. You test some ammonia and determine the hydrogen ion concentration to be $[H^+] = 1.3 \times 10^{-9}$. Thus, the ammonia is ______.
   A. acidic
   B. neutral
   C. basic
   D. none of these

10. Which of the following is equivalent to $(125)^{\frac{1}{3}} = 5$?
   A. $\log_{125} 5 = \frac{1}{3}$
   B. $\log_5 125 = \frac{1}{3}$
   C. $\log_{\frac{1}{3}} 5 = 125$
   D. $\log_5 \frac{1}{3} = 125$

11. Determine the value of x if $\log_7 x = 2$

   A. 14
   B. $\frac{1}{14}$
   C. 49
   D. $\frac{1}{49}$

12. Which of the following is a solution to the logarithmic inequality $\log_5 x \geq 3$?

A. x>125
B. x<125
C. x≥125
D. x=125

13. Given $\log_6(x + 8) > 2$, what should be considered in the expression x + 8?

A. x + 8 must be greater than 2.
B. x + 8 must be less than 0.
C. x + 8 must be nonnegative.
D. x + 8 must be greater than 0.

14. If $\log_5 (3x + 2) < \log_5(2x + 5)$, what is the interval notation?

A. $(-\frac{2}{3} < x < 3)$
B. $(3 < x < \frac{2}{3})$
C. $(\frac{2}{3} < x < 3)$
D. None of these

15. The magnitude in the Richter scale of an earthquake that released 10^{12} joules of energy is 5.06. How much more energy does this earthquake release than that of the reference earthquake?

A. 39810720 times
B. 39810718 times
C. 39810717 times
D. 39810719 times

Additional Activity

Activity 7

Use a scientific calculator to answer this activity.

1. Considering that prolonged exposure to sounds above 85 decibels can cause hearing damage or loss, and considering that a gunshot from a 0.22 rimfire rifle has an intensity of about $I = (2.5 \times 10^{13})I_0$, should you follow the rules and wear ear protection when relaxing at the rifle range?

2. If lime juice has a pH of 1.7, what is the concentration of hydrogen ions (in mol/L) in lime juice, to the nearest hundredth?

Answer Key

What I Know

1. B
2. D
3. C
4. C
5. C
6. C
7. C
8. A
9. C
10. A
11. B
12. D
13. C
14. D
15. A

What's More

Activity 1

1. TRUE
2. FALSE
3. TRUE
4. TRUE
5. FALSE
6. FALSE
7. TRUE
8. TRUE
9. TRUE
10. FALSE

Activity 2

1. $\log_2 16=4$
2. $\log_{81} 9=1/2$
3. $\log_3 \frac{1}{9}= -2$
4. $3^2=9$
5. $5^{-2} = \frac{1}{25}$

Activity 3

1. LF
2. LE
3. LF
4. LF
5. LI

Activity 4

A. 1. 4
2. $\frac{1}{2}$
3. -1
4. -5
5. $\frac{1}{3}$

B. 1. 243	6. 10
2. e	7. 1
3. $\frac{7}{2}$ or 3.5	8. e
4. ± 6	9. 13
5. $-2, 1$	10. $\frac{e^3}{3}$

C. 1. $x > 57$
2. $x \geq 24$
3. $x \geq 19.5$
4. $x > 3$
5. $1 < x < 145$ or $(1,145)$

Activity 5

1. Magnitude R=6.4, 3981071706 times
2. 140 decibels, 10^{14} times
3. The solution is basic, since pH = 8.

What I Have Learned

1. logarithmic function
2. Richter scale
3. Natural logarithm
4. -4
5. 10
6. exponent
7. y is the logarithm of x to the base a
8. =
9. inequality
10. function

What I Can Do

1. The Bohol/Cebu earthquake released **5.62** times more energy than the Negros Oriental earthquake.

2. pH= 6.4.

Blood is acidic.

Assessment

1. C
2. C
3. D
4. C
5. C
6. B
7. C
8. B
9. C
10. A
11. A
12. C
13. D
14. A
15. D

Additional Activity

1. The rifle creates a noise level of about 134 decibels at which it can suffer hearing damage. Therefore, I should follow the rules and wear ear protection.

2. The concentration of hydrogen ions in lime juice is 0.02.

References

1. Department of Education-Bureau of Learning Resources (DepEd-BLR) (2016) *General Mathematics Learner's Material.* Lexicon Press Inc., Philippines

2. Department of Education-Bureau of Learning Resources (DepEd-BLR) (2016) *General Mathematics Teacher's Guide*. Lexicon Press Inc., Philippines

3. Oronce, Orlando A. (2016) *General Mathematics.* Rex Printing Company, Inc., Quezon City, Philippines

4. Santos, Durwin C. and Biason, Ma. Garnet P. (2007). *Math Activated: Engage Yourself and Our World General Math.* Don Bosco Press Inc., Makati City, Philippines

EDITOR'S NOTE

This Self-learning Module (SLM) was developed by DepEd SOCCSKSARGEN with the primary objective of preparing for and addressing the new normal. Contents of this module were based on DepEd's Most Essential Learning Competencies (MELC). This is a supplementary material to be used by all learners of Region in all public schools beginning SY 2020-2021. The process of LR development was observed in the production of this module. This is Version 1.0. We highly encourage feedback, comment, and recommendations.

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